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Designing learning-skills towards industry 4.0

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Abstract

The world is shrinking now more than ever due to new scientific and technological breakthroughs that expand the boundaries of human knowledge, resulting in improvements in transportation, communication, space exploration and educational technologies. Today's students will compete in a technological, diverse, multi-cultural world and must be prepared to thrive in this futuristic environment. Therefore, it is vital that today's pedagogy produce lifelong learners, who can succeed in a global pulpit. To ensure our educational technology progresses at the rate demanded by today's ubiquitous digital learners, we review emerging technologies and traditional teaching methods and propose desirable changes. Future companies will need employees with specific Internet of Things connected additive manufacturing skills across the value stream, including computer-aided design, machine operation, raw material development, robotics and supply chain management; but these are only island of excellence in industry 4.0 and not the consummate requirement of the manufacturing process.

Keywords: Industry 4.0, IoT, smart teaching, future skills.

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1. Introduction

Industry 4.0—employee skills have to cater to the process requirement by covering interactive intelligence system which encompasses Artificial Intelligence (AI) and Information Technology in the Production Process. Man–Machine interconnection is becoming very autonomous and highly complex plan incorporated for a collective communication among the inter-related processes. Intelligent Manufacturing Process connects and Interfaces with other gateways for data and information processing to be aligned with the Customer through a digital order receipt, where the supervisory control and contractual quality system facilitates individual planning & intervention for autonomous processing. Adapting education system and Industrial training requires optimised interactive Systems with human resource for both technical and IT work. Implementation of robotics and AI in industry has proposed to evolve new roles, which included core production process and enablement for innovative hands-off linkage at work. Transposing the skill requirements in a manufacturing organisation with mechanical engineering specialisation offers insight into the industry needs and the preoperational requirements for future. Nearly, 1 in 10 workers would be employed in jobs that do not even exist today; hence, the new workforce in future industry will have their career depended upon on Big data and automation bionics, thus leading to an amalgamation of core, IT and automation skills which are interdisciplinary leading to the illustrative designations akin to the manufacturing tradition, such as Process Design Engineer, Interface Process Engineer, Innovation & Development Engineer and Principal Architect. A combination of globalisation, demographic changes and new-age technologies will change the industries, jobs and work force requirements (Bhattacharya, 2017), as they hasten to stride of commerce throughout the world today in every industry, leading to a resultant of the disruptive phase shifting the business process to gain the competitive edge and become effective due to the change and change management processes in place (D’Ortenzio, 2012). Industry 4.0—HR skills provides to the manufacturing process the obligation to layer interactive astuteness into the system along with AI and information technology in the production methods. The skills taught in an institution vis-a-vis the skills required at workplace (Figure 1) is always to be guided for seamless necessities before application in industries. These new roles will open up mostly in areas such as Internet of Things (IoT), machine learning and AI in all the industry verticals.

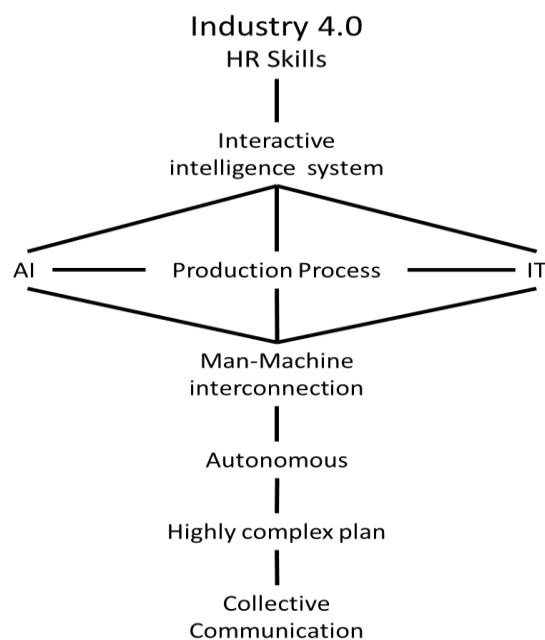


Figure 1. Industry 4.0—Human resource skills. Source: Umachandran (2018a)

Skills are not only for career progress (Figure 2) or for discern as competence to create opportunities, but a potential for bringing a common collective good which develops beyond money into a work interrelationship required for the organisation, customers and work colleagues. The significant gap bridging between the organisational expectation and the institutional offer can be easily met and processed out if the individual resource has a flexible attitude and adaptable learning self in them (Koka, 2016). To continuously assess the skills of the existing employees and ensuring that the new hires have the required skills and competencies, re-gigs to assess the effectiveness of the training and education programme for their staff (Medtech, 2017). Engineers require skills in Acquiring, Modelling, Storing and Sharing large volumes of Data (KJA, 2017).

2. Narrow disciplines and interdisciplinary contributions

Man–Machine interlinks fetches self-directed and extremely intricate designs become united for a shared communication among the inter-related manufacturing procedures. Intelligent Manufacturing Process (Figure 3) conduits and meshes with other gateways for data and information dispensation to be affiliated to the customer’s digital order receipt, wherever the supervisory regulation validates the quality system by easing the individual planning and interferences the autonomous delivery. Therefore, there is a great need of high-end manufacturing skills for the discrete manufacturing sectors which have a constant up-skilling requirement responding efficiently to emerging skills demands for global markets so that the industry can continue to compete and bring innovative technologies to market (Medtech, 2017).

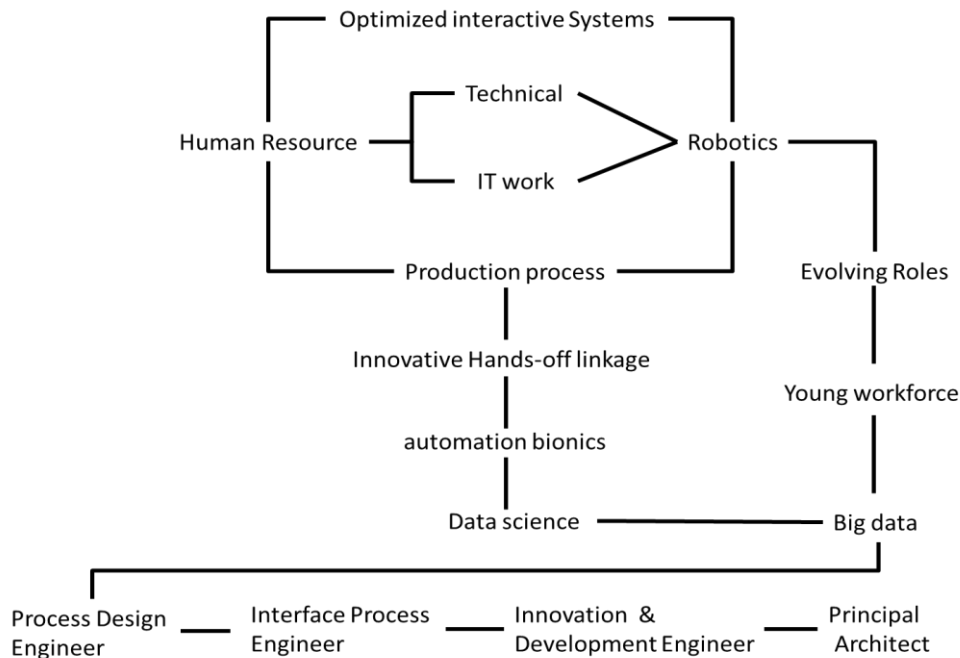


Figure 2. Positional career progression. Source: Umachandran (2018a)

3. Education system and industrial training

Objectivity remains regulatory with emphasis on the critical tradition and community of practice. Acclimatising the education and Industrial training system requires enhanced interactive arrangements of seamless transitioning of human resource to both technical and IT work. High degree of persistence and predictability in manufacturing workforce occupational skills depends on the young and well-educated workforce. Though they are the asset, it is essential that they have the right

employable skills for the careers of the future (Medtech, 2017). Industry 4.0 brings more opportunities to explore phenomena in significant depth and longitude, with the flexibility to discern and detect unexpected phenomena the ability to expose than impose meanings, emphasises a variety of situations effectively for greater chances of exploration and be sensitive to contextual factors and dimensions (D’Ortenzio, 2012). A core component of AI research lies in teaching machines how to communicate with humans collecting countless real time messages each day that transacted within one another, thus the learning inputs should cover the foundation skills, such as Probability and Statistics, Continuous Optimisation, Machine Learning and Data Visualisation; Computational skills on Advanced Data Science Programming, Scalable Systems for Data Science, Database Systems (SQL and NoSQL), Operating Systems and finally data acquisition (KJA, 2017).

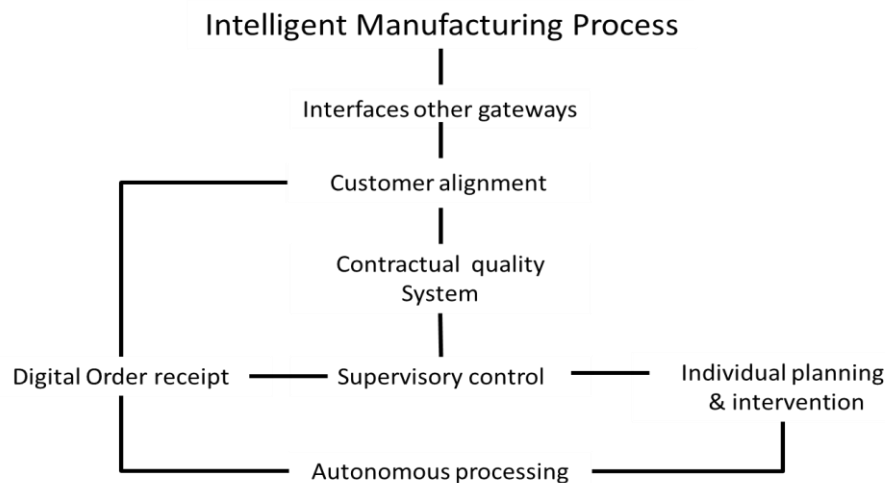


Figure 3. Framework of intelligent manufacturing process. Source: Umachandran (2018b)

4. Robotics and artificial intelligence

Application of robotics and AI in business consumes to improving the physical infrastructure and skill up gradation for project and change the existing roles to new one and include the core production process to permit intended innovative detached man–machine linkage effort. The technologies that can support these requirements and assist in ensuring sustainability and growth of the manufacturing sector also protect with highly integrated strategy on environment through cleaner production, renewable resources and advanced processes technologies. Robotics, 3D Printing and precision manufacturing are emerging as the ideal solutions for undertaking many repetitive and complex tasks with precision and least of errors in many areas of human life, such as ticketing; traffic control; assembly and integration; sanitation and cleansing; industrial activity and many other that where robotics are deployed in many industrial and complex manufacturing (KJA, 2017).

5. Explorative generation in industry

Young talented employees in the future industry will have their career determined by Big data and automation bionics, whereby leading to a merger of core, IT and automation skills which stand interdisciplinary primary to the succeeding positional titles vacillating from the core in Process Design Engineer and automation related Interface Process Engineer to become Innovation & Development Engineers through experience and conclude with a lead role of an account value stream Principal Architect. The common presumption for predicting occupational skills demand for industry 4.0 is feasible yet complicated. Skills continue to be in short supply and skills development are always a high priority as the design to deliver competency models in industry identifies knowledge, skills and competencies for occupations focusing on the key areas and disruptors leading to innovation, equally

in manufacturing process by developing a continuing professional development program for unceasing progression (Medtech, 2017). Robotics entails a multi-disciplinary method, fundamentally covering of machine learning—mechanics—Sensing Controls and spans wide over engineering disciplines, namely, Electrical, Computer Science and Mechanical. IoT and MI will usher in a new era of Smart manufacturing transforming human lives to dynamically reinvent and harness the full power of Machine Intelligence, engineering education in Universities are encouraged and driven to adopt Data Science and MI and Robotics courses (KJA, 2017).

6. Process flow of a core mechanical manufacturing engineering

With no limitations to the following production process as explained, but inclusive of adjoins to this a core mechanical manufacturing engineering would evolve to include as below.

Processing—metals and non-metals; Material removal method—conventional and non-conventional; Quality; Best Practices; Reordering the talent necessities in a manufacturing business with mechanical engineering focus (Table 1; Figure 4) could propose the comprehension and needs and the groundwork supplies for the forthcoming industry 4.0.

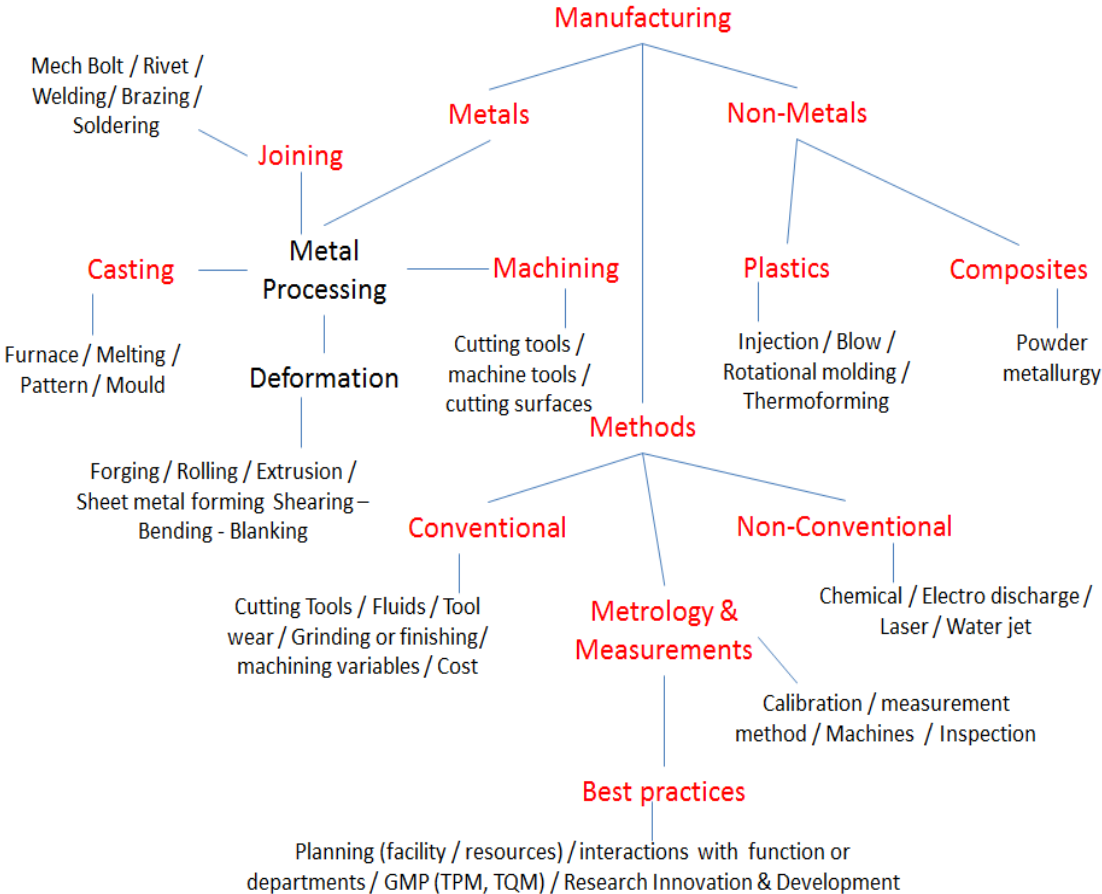


Figure 4. Manufacturing structure. Source: Umachandran (2018b)

6.1. Processing—metals and non-metals

Appendix A. Metals processing

This comprises of casting, joining, machining and deformation process. Casting processes go with furnace and melting practice, pattern making, moulds and casting types; the joining processes include mechanical joining methods, welding types, brazing and soldering; the machining processes comprise cutting tools, machine tools and process cutting surfaces, while finally the bulk deformation processes adopt all forging, rolling and extrusion, with annexing of sheet metal forming through shearing bending and blanking.

Appendix B. Non-metals processing

This forms part of all the materials which are non-metallic, such as plastics and composites. They take wider description of plastic forming and shaping by the way of injections moulding, blow moulding, rotational moulding and thermoforming, whereas in composites through forming and shaping plastics and composite materials.

6.2. Material removal method

Appendix C. Conventional method

The traditional mechanical engineering methods of machining process to remove materials using cutting tools, cutting fluids, tool wear, finishing process which, includes grinding, control of various machining variables and finally landing on the machining costs, is a major method and continues to exit.

Appendix D. Non-conventional method

The non-traditional or novel methods include quick chemical machining, electrical discharge machining, laser-beam machining and also water jet machining offer better surface finish but different from the normal setups as it is with new novel resources being applied during the process of intended change.

6.3. Quality

This segmentation of Metrology and Measurements in mechanical production reliability enforcement process includes calibration, various measurement methods using meticulousness measuring machines and ensures rigid inspection serving the true exchange of output as agreed with the customer requirements.

6.4. Best practices

These institutionalisation and growth process will keep the organisation to sustain and proceed for longevity in existence for a progressive growth through process planning and connecting with the nitty-gritties of the functional flow webbing through the various departments. Thus, the cross interactions of planning function evolve for better current good manufacturing practices and sparks the approach towards research, innovation and development of the product, process and people systems. Providing access to data has an embedded risk of violation of privacy compelling enforcement of Competition Law, the Consumer Protection Law or the Cross Border Law (KJA, 2017).

The manufacturing process would link with AI prevalence in applications and clerical functions, online and offline with autonomous mobility and intelligently coordinating with machines and logistics equipment. Industry 4.0 would connect the cloud-based AI systems and decide for optimised performance among manufacturing systems equipped with sync of robotic systems to operate with limited human intervention.

7. Educational fine tune for provisioning industry 4.0 and students skills development

In the past decades, computers have served to bridge the gap across countries and cultures, bringing increased equity in education. Educational aids such as multimedia and video lectures have helped students learn in a multimodal style with students as the centre, in the process and teacher as organisers assisted by service providers with the use of multimedia network environment resources through cooperative learning. Students play to self-initiated enthusiasm and spirit, to achieve the goal of construction of realisation (Qingsong, 2012). These aids have served accelerated learners and traditional learners alike. Accelerated learners could learn advanced concepts using such educational aids, whereas traditional learners could learn at their own pace. With the advent of multimedia, knowledge from the different parts of the world became accessible to any learner who had access to computers or multimedia players (Khan, 2010). Education has adopted and adapted technology over a long period of time (Saettler, 1990) but with advances in computer manufacturing, the cost of computers fell rapidly and more people had access to multimedia-based learning is a paradigm shift where the digital age distinguishes all the previous ages with the rapid pace of technology development and our immersion in technology-based activities in our daily lives. Although they have many advantages, several aspects of learning and long-term retention can be achieved by repeated reinforcement of principles, association with like-minded individuals, and constantly challenging students to achieve increasingly difficult tasks. Students are already subjected to varied pressures in classroom and academic climate, grades and conceptual understanding, self-efficacy and self-confidence, high school preparation, interest and career goals and race and gender (Geisinger & Raman, 2013). To end such negatives, the application of computer technology for education has now matured into fields, such as social media, including YouTube video-based learning (e.g., YouTube) and evaluation systems (Umachandran, 2017). In this work, we highlight the recent advances in educational technology that exemplify open innovations in the field of educational research.

8. ICT as cross-cultural integrator

The rapid advancement in technology has moved education beyond the walls of the classroom, allowing institutions to extend their reach to students globally. Most of this advancement is fuelled by the Internet and emerging technologies, such as cloud computing, mobile apps, social media, open-source learning management software, free online information and communication technologies (ICT) tools and educational resources. Data fusion in IoT focuses on mathematical methods, such as probabilistic methods, AI and theory of belief; and in specific IoT environments which are distributed, heterogeneous, non-linear and object-tracking environments (Alam, Mehmood, Katib, Albogami & Albeshri, 2017). Teaching, learning and researching are now ubiquitous, occurring anywhere and anytime. Consequently, classrooms, whether for F2F, online or blended courses are now more culturally diverse, requiring educators to accommodate for such diversity in making student learning more meaningful, potentially successful and problem solving assessment tools should involve providing the students with a real life situation to solve (Ferdinand-James, 2017). In addition, blending technology into our daily lives has become mainstream with students bringing their own devices that increasingly include smart phones and tablets. In integrating these emerging technologies into teaching and learning, 21st century educators must be mindful of cross-cultural factors (e.g., race/ethnicity, language/communication patterns, values, geographic location and religious beliefs) that impact their program content. It is the lived experience which carries the knowledge and skills as frames of reference for personally meaningful application (Gay, 2002) and, by extension, using technology to deliver such content. Overlooking students' culturally diverse backgrounds in the curriculum content can result in students experiencing cultural and intellectual bondage that do not allow them to master such content or prepare them for the global village in which we now live (Hogan, 2011). As such, educators should be culturally sensitive in choosing graphics, colours, videos, podcasts, websites, reading materials, etc. that would accommodate for the equitable representations of students cross-cultural backgrounds (Ferdinand-James & Umachandran, 2016). When interacting with

students online, they should also be tolerant of the differences in students' language and communication patterns and provide recordings of lecturers for future review. Faculty should focus on the key content (e.g., principles, concepts, theories and skills) in their delivery, while providing students with learning opportunities to think critically about this content such as in using asynchronous debates as recommended by award winning author Jose Bowen (Bowen & Watson, 2017). Their lessons and presentation of course content should cater to the increase use of mobile devices by digital natives in learning spaces. For example, the famous PowerPoints used to present lectures and administering of online quizzes should be more concise with shorter bullet points in accommodating the smaller screens on these devices.

9. Learning doesn't stop within campus

There are several social network apps followed by more than 7 billion users. Facebook is the most popular of them all, recording about 1.6 billion users a month. WhatsApp is next, recording about 1 billion users a month. Many other social network platforms, such as QQ (~800 million users), WeChat (~700 million users) and Qzone (~600 million users), connect the world, bridging gaps between cultures. Opportunities abound for harnessing these online connections for education and learning. Social networks can be used for exchanging knowledge, information and ideas almost instantly. Lectures and webinars can be broadcast with ease of access. Unlike a telephone conversation or video conferencing, many people can listen to a lecture or webinar instantaneously. Social networks help to maintain communication between teachers and students, making two way communications a reality. This affordance is great for education and knowledge transfer as feedback and correction can be provided quickly, improving knowledge retention. However, the sad part is social media are largely blocked in educational institutions due to privacy, security and copyright anxieties; while at the same time the demand 24/7 access and use of newer web technologies for learning and educational purposes is on the rise (Greenhow, 2011). Professional networks like LinkedIn offer opportunities for networking with professors, experts and businesses. ResearchGate offers opportunities for networking with professors and academicians across the world. Students can use ResearchGate to network with professors working in the field of research they are interested in, and collaborate for future opportunities. Twitter Microblogging platforms would empower students and translate into increased concept retention, course enjoyment, and student achievement, they now let users 'tweet' their thoughts with a maximum of 140 characters (Chamberlin & Lehmann, 2011).

10. Virtual assessments

Harnessing the power of today's Learning Management Systems includes online assignment submission, such as written essays, e-portfolios, and other types of assignments, that can be viewed asynchronously by the teacher. The teacher has the flexibility of grading these assignments with comments and suggestions later as well as enjoy the following benefits for online assignment submission: Students are able to access their writing at a later date, without the need to scramble through loads of paper. LMS packages are unique components with shared aims in formation of student record, regulate the registration processes, and the facility to build waiting lists, uploading and handling documents comprising curricular content, transfer of course-content over web-based interfaces, permit remote sharing by the teacher or student, design and publish activity calendars, collaborate through sms, email and chat forums and finally assess with a test which is multiple choice or quizz (Cavus & Alhih, 2014). Having access to assignments at a later date with teacher's comments helps the students reflect more deeply on their work. With ubiquitous electronic devices available today, they are able to view their work from their phones and tablets, whether they are home or on travel (Hrastinski, 2008), and Students are able to upload video projects reflecting their work, so they take considerable interest and initiative doing the work. Peer groups of students are able to easily view their peers' work in video format, so they are able to exchange knowledge, ideas and expressions that promote cross-cultural understanding.

11. Multimedia learning systems

Multimedia has played and continues to play an important role in improving physics education. Many physics concepts, such as rotational motion and three-dimensional dynamics, involve stereoscopic thinking. It is not possible to explain these concepts on a two-dimensional blackboard. By designing multimedia appropriate to the level of the target audience (students), it was shown that the effective learning can be achieved. Recent advances in multimedia authoring tools, such as Easy Java Simulations, have enabled physics teachers to make their own simulations or modify existing simulations for classroom use. To be applicable in a classroom, a computer-based tutoring system has to have several requirements for success. The user interface is the first step in student interaction with the computer system, so it has to be designed very carefully. The background and foreground colours of the interface screen should be selected for text clarity. The text font size should also be appropriate (Hong, Chen, Chang & Chen, 2007). With all these considerations in mind, and to ensure the tutoring system provides flexibility to the author in designing the interface, Cognitive Tutor Authoring Tools (CTAT), hosted by Carnegie Mellon University, provides a useful platform for hosting intelligent tutors designed by teachers. It offers great flexibility of design, and ease of use. The CTAT-based tutor is created using the HTML programming environment, and implemented on Tutorshop, a freely available platform for deploying CTAT-based tutors, also hosted by Carnegie Mellon University. Students can practice a complex cognitive skill and enhance learning in a range of domains using science experiments platform (Aleven & Sewall, 2010). Student-computer interaction data are streamed to Datashop (Koedinger, Baker, Cunningham & Skogsholm, 2010; Umachandran & Ferdinand, 2017), a big data repository for collecting anonymous student data, maintained by Carnegie Mellon University.

12. Smart and common classes

ICT are widely recognised as a great influencer in the area of education and the construct of ICT competence is the ability to locate, manage or process digital information to more creative and expressive forms of digital media production and social online activities (Aesaert et al., 2015). While there is a lack of a paradigm that connect the ICT to smart education, the focus is on the technology applications and solutions rather than on the outlying of models for the concept of smart education for bridging the digital divide and also in promoting economic freedom amongst all crises (Shirazi, Gholami & Anon Higon, 2009). Smart education contains a set of tools in delivering educational services and in fostering interactive learning by leveraging digital technologies and content, commonly defined as 'phenomenon of the modern e-learning' and is shaped by three dimensions: educational outcomes, ICT and organisational aspects. Literature on the role of ICT in education is huge. The importance of digital support is widely recognised for both students and teachers, even if the use of ICT *per se* is not sufficient because it requires the contextual implementation of a parallel pedagogic approach; hence, e-learning has to increase the speed of transferring knowledge commonly with philosophies and methodologies within the context of outcome-based education, in an ICT learning environment (Talebian, Mohammadi & Rezvanfar, 2014). Thus, ICT can be a great addition to teaching, but it cannot suffice as a teacher in itself. Particular interest is given to students and, more precisely, to the use of ICT and its connected affordability, critical issues, problem solving and team work perspectives. Some scholars are concerned about the aspect of 'self-efficacy' concerning the use of computers and internet. The concept of self-efficacy, which captures the relevance of a particular ICT teaching tool to a specific domain area, depends on many factors, such as gender, individual cognitive ability and familiarity with topic of interest. So, before using ICT for a specific knowledge domain including that of gender bias to information access and correctness, all these factors must be considered (Hafkin & Huyer, 2008).

13. Conclusion

In summary, smart technological utilisation offers the manufacturing industry with great potential along with the digital economy to positively transform business and society. As machine learning perfects language recognition and translation; satisfying the user to boosts its adoption along with neural networking; engineers can get instant feedback on process flow, its Interruption, and predictive controls. Thus, the traditional workplace communications of using log books and paper communications will become replaced by instant messaging tools. The manufacturing organisations, with core mechanical engineering focus continues using digital transformation to optimise their product offering, optimising resources and improving process utilisations with large IT platforms. We have reviewed some of the important aspects of education that relate to educational technologies that can be used to facilitate learning in a cross-cultural context. Latest technologies shape the future of education, so it is vital that they are used by teachers from all over the globe. As the world is shrinking in terms of transportation, information and communication, technology will play an important role in connecting world citizens in a hugely complex network of information. By reviewing state-of-the-art technologies that exist today, we provided an insight into the classroom of the future. We trust this will help teachers and innovators across the globe to harness today's technology for its utmost effectiveness, and catalyse future innovations that bridge gaps and cracks present in taking advantage of the affordances of today's emerging technologies.

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Table 1. People specialisation for progressing towards industry 4.0

#	Class	Sub- Class	Processes	Operations							People Specialization			
											Current		Industry 4.0	
				Core Discipline	Inter-discipline	Core Discipline	Inter-discipline							
A	Processing	Metals Processing	Casting	Furnace and melting	Patterns	Moulds and cores	Decorating	Fettling	Shot Blasting	Finishing	Process Function, Supervisory, Section Heads	Section coordination, Management Function	Mechanical	Mechanical, Electrical, Electronics, Information Technology
			Joining	Fastening - String tie, Bolt and Rivets			Permanant - Welding, brazing and soldering							
			Machining	Cutting tools		Machine tools		Cutting surfaces						
			Deformation	Forging	Rolling	Drawing and and extrusion		Fabrication - Sheet metal Shearing bending and blanking						
		Non-metals Processing	Plastic molding	Injection	Blow	Rotational		Thermo-forming						
			Composites Forming	Reinforced		Heat pressed		Powder Metallurgy						
B	Material removal Method	Conventional method	Cutting tools	Single point		Multi point		Special			Technical Process	General Operations (Line/Batch production)	Mechanical	Mechanical, Information Technology
			Cutting fluids	oils		oil-water emulsions		Gels						
			Tool wear	Tipped tool		Bits		Shank						
			Finishing	Internal		External		Grinding						
			Machining variables	Speed		Feed		Depth of cut						
			Machining costs	Fixed Cost	Variable Cost	Pricing	Discounts		Differential Pricing					
		Non-conventional method	Chemical machining	Reagents			Maskants							
			Electrical discharge	Spark erosion			Wire cut							
			Laser –beam	Drilling										
			Water jet machining	Abrasive micro blast										
C	Quality	Metrology and Measurement	Calibration	Accuracy standard							Product - Technical Experience	Customer interface & Technical Experience	Mechanical, Electronics	Mechanical, Electronics, Information Technology
			Measurement methods	Direct comparison			Indirect comparison to templates							
			Measuring machines	Cordinate Measuring Machines- Fixed/Flexible; Mechanical/optical /laser/white light										
			Inspection	Tests	Frequency	Data Capture	Charting	Analysis	Interpret	Corrective action				
D	Best Practices	Institutionalize for growth	Process Planning	Process Charts	Do's & Don'ts	Pictorial Instructions	SOP's	Trends - Production/Rejection	Suggestions scheme	Quality Circles & SGA's	Product & Process Technical Experience	Interdepartment & Management coordination Experience	Mechanical, Electrical, Electronics, Chemical, Plastics, Information Technology	
			Interrelated Planning function	Market driven Planning	Material Resource Planning	Inventory Management & WIP	Leadtime reductions	Touch study	Cost reduction	Product weight reduction				
			Good Mfg Practices	Bench Strength Analysis		5S	TQM - PDCA, Zero defects		TPM - Eliminate abnormalities/Hard to access, Overall Equip					
			Research, Innovation & development	Continuous improvement	Cost of Quality	Value Stream Mapping	Process Improvement	Product Improvement	People Development	New Products				

Source: Umachandran (2018c), Manufacturing template for people specialisation towards industry 4.0.