INDUSTRY 4.2 ™

Future of work and the worker

In the 21st century we are witnessing the fourth industrial revolution, as depicted in Figure 1. This fourth revolution of Internet of Things (IoT) and Internet of Services (IoS) has been coined Industry 4.0. At the Hannover Messe in 2011, Germany launched a project called *"Industrie 4.0"* to digitize manufacturing. The larger vision of Industry 4.0 is the digital transformation of manufacturing, leveraging third platform technologies and innovation accelerators in the convergence of IT (Information Technology) and OT (Operational Technology) to realize connected factories and industry, smart decentralized and self-optimizing systems and the digital supply chain in the information-driven cyber-physical environment of the fourth industrial revolution.[1]

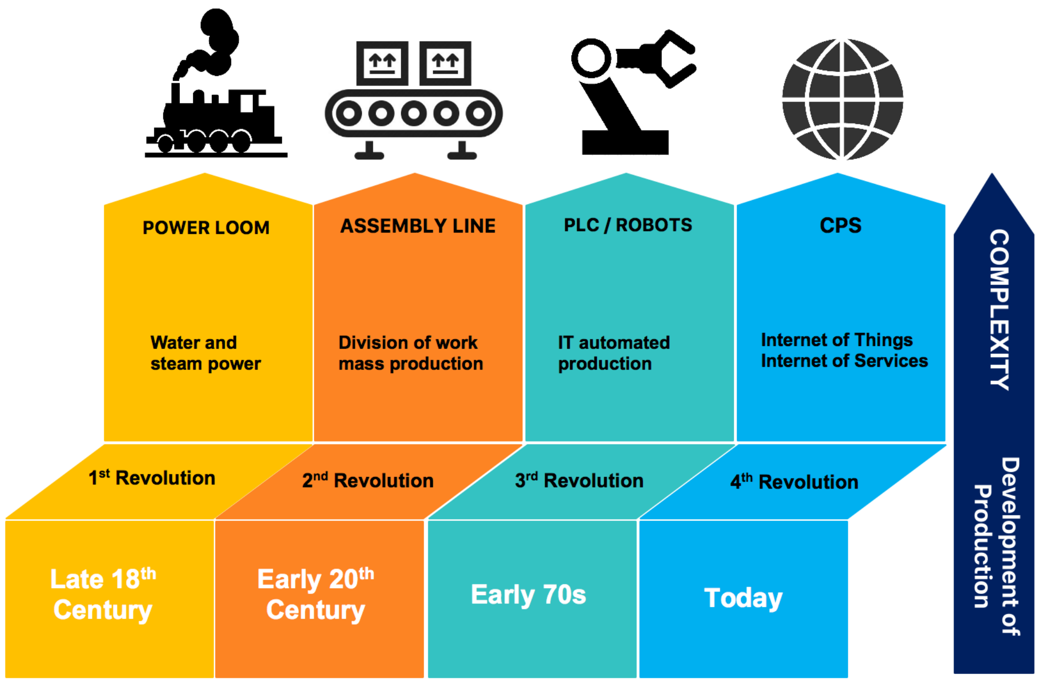

Figure 1. Four Industrial Revolutions[2].

The initial goals for Industry 4.0 are automation, manufacturing process improvement and productivity/production optimization. The more mature goals are innovation and the transition to new business models and revenue sources with information and services as cornerstones. The nine technologies reshaping production are given in Figure 2. As can be noted, the new era of manufacturing is very much cross-disciplinary and requires skill sets that are not within the traditional engineering curricula.

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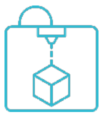
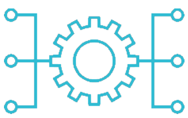
[1] Industry 4.0: the essence explained in a nutshell. www.i-scoop.eu/industry-4-0/#Industry_40_the_essence_explained_in_a_nutshell

[2] Thoben et al., Int. J. of Automation Technology, 2017

Figure 2. Nine Technologies Are Reshaping Production[3].		
	Advanced robots	• Autonomous, cooperating industrial robots, with integrated sensors and standardized interfaces
	Additive manufacturing	• 3D printers, used predominantly to make spare parts and prototypes • Decentralized 3D printing facilities, which reduce transport distances and inventory
	Augmented reality	• Digital enhancement, which facilitates maintenance, logistics and SOPs • Display devices, such as glasses
	Simulation	• Network simulation and optimization, which use real-time data from intelligent systems
	Horizontal and vertical system integration	• Data integration within and across companies using a standard data transfer protocol • A fully integrated value chain (from supplier to customer) and organization structure (from management to shop floor)
	The Industrial Internet of Things	• A network of machines and products • Multidirectional communication among networked objects
	Cloud computing	• The management of huge volumes of data in open systems • Real-time communication for production systems
	Cybersecurity	• The management of heightened security risks due to a high level of networking among intelligent machines, products, and systems
	Big data and analytics	• The comprehensive evaluation of available data (from CRM, ERP, and SCM systems, for example, as well as from an MES and machines) • Support for optimized real-time decision making
SOP – standard operating procedure. CRM – customer relationship management. ERP – enterprise resource planning. SCM – supply chain management. MES – manufacturing execution system.		

[3] Boston Consulting Group Analysis. www.zvw.de/media.media.72e472fb-1698-4a15-8858-344351c8902f.original.pdf

We are calling these developments advanced manufacturing. Moreover, this concept can be expanded by not only focusing on the future of work, but also on the future of the worker. In so doing, we are distinguishing our efforts by calling this initiative **Industry 4.2™**. The need is to have a strong collaborative partnership at all levels of education and research for the advancement of Industry 4.2™.

Traditional engineering education programs do not provide the skill sets required by 21st century knowledge workers, particularly those who will lead Industry 4.2™. We propose to address this need with a new multi-tiered paradigm for manufacturing engineering education, one that will help the industrial sector secure the manufacturing vocational and engineering employees at all levels it urgently needs today and tomorrow. The nation's economic competitiveness and the expansion of U.S. innovation will be in peril if we cannot attract a broad swath of our population into manufacturing engineering careers. In particular, it is imperative that we bring more women and underrepresented minorities into manufacturing engineering. A new paradigm is needed.

We are redesigning the manufacturing engineering curriculum by incorporating a project-based learning approach, with modules at the K-12, community college, four-year undergraduate (UG), and graduate (G) levels. This will provide a robust pipeline of human talent and resources across the continuum, from pre-K-12 to community colleges, to four-year colleges, and on to graduate programs. The output of this pipeline will assure an adequate supply of talented manufacturing engineers throughout industry at various levels: vocational, technicians, entry level engineers, engineers with advanced and specialized training and scientists with strong research and development skills.

The facts speak for themselves. More and more of our engineering graduates are placed in industry, about 70-74%,[4] and yet the educational experience that most engineering students receive is often isolated from industrial problems, manufacturing engineering as taught today is not multidisciplinary, students do not benefit from industrial exposure and many of the faculty members who teach and mentor our manufacturing engineering students have not had industrial experience. Moreover, we as a nation are losing a major opportunity by not attracting talent from sectors of our society that we have not done well in recruiting into engineering – women and underrepresented minorities. We need to build the workforce by assisting those poor in the pocket but rich in the brain and hands.

To work effectively in the 21st century, manufacturing engineers must understand the rudiments of business and be able to navigate and speak the language of the business world. For example, manufacturing engineering students should learn how supply chains function, understand logistics, and be well-versed in project management. They must have hands-on experience in manufacturing and be educated within the framework of theory and practice. Toward that end, student projects should be rooted in relevant and real industrial problems rather than esoteric theoretical topics. Finally, they must have a global emotional intelligence and excel in both oral and written communications.

[4] 2011 Post-baccalaureate Survey, Higher Education Research Institute, UCLA.