Chapter 3
Engineering Education:
Towards the Fourth Industrial Revolution

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ABSTRACT

The Fourth Industrial Revolution is affecting all disciplines and represents a new way of using technologies that are fusing the physical, digital, and biological worlds. An analysis of possible future applications of artificial intelligence, sensors, and robotics in industries suggests that different technological trends are reshaping the industrial production, in this way demanding a different workforce. This leads to the automation of processes and it demands a workforce with engineers possessing knowledge of disciplines like computing, mechanics, and process management. In this scenario, the main objective of this investigation was to study new ways to educate engineers in two perspectives: in small scale face-to-face education and in large-scale distance education. In both perspectives of small- and large-scale courses, the same discipline with the same lecturer is considered as a way to allow for better comparisons. The chosen discipline is simulation of systems.

INTRODUCTION

The globalized society moves towards the Fourth Industrial Revolution. An analysis of possible future applications of artificial intelligence (AI), sensors, and robotics in industries suggests that different technological trends are reshaping the industrial production, in this way demanding a different workforce. The main building blocks of Industry 4.0 are said to be nine (Gilchrist, 2016): (1) big data and analytics; (2) autonomous robots; (3) simulation; (4) horizontal and vertical system integration; (5) the

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industrial internet of things (IoT); (6) cyber-security; (7) cloud services; (8) additive manufacturing; and (9) augmented reality.

This leads not only to the automation of processes and to the use of technologies like AI (Davenport, 2019) but it also demands a workforce with engineers using knowledge of disciplines like computing, mechanics, and process management. As a result, emerging technologies may allow manufacturers to offer customized products within a different supply chain (Sodhi & Tang, 2017) that would apply the best practices of lean and agile. Part of the new challenges will be addressed by massive online courses of engineering that benefit from technologies like machine learning for personalization (Hollands & Tirthali, 2014; Brinton et al., 2015), an alternative to the traditional face-to-face courses offered in small scale inside of classrooms and laboratories. Still, the advent of the Fourth Industrial Revolution, with increasing automation and tight integration of various subsystems across diverse networks, suggests a review of the initial education of engineers. In this way, innovative educational strategies for undergraduate courses can be used to increase engagement, enhance teamwork, prioritize active learning and foster the development of critical thinking.

In this scenario, the main objective of this investigation was to study new ways to educate engineers in two perspectives: (i) in small scale face-to-face education and (ii) in large scale distance education. In the first perspective, the undergraduate course of Production Engineering was analyzed; this course lasts for five years, has 60 vacancies per year and asks the students to be full-time "on-site" at the dependencies of the university in the City of Limeira, Brazil. In the second perspective, another undergraduate course of Production Engineering was analyzed; in this case, the course lasts for five years as well but it has most activities happening "on-line" and with videos being delivered through digital television, with a maximum of 4900 vacancies for students in 273 different cities of the State of São Paulo, Brazil.

In both perspectives of small and large scale courses, the same discipline with the same lecturer is considered as a way to allow for better comparisons. The chosen discipline is Simulation of Systems, one of the many topics to be studied in an Undergraduate Course in Engineering. More specifically, this work discusses in greater detail how to teach concepts related to Digital Twins (Armendia et al., 2019; Shetty, 2017), an approach that is considered essential for the success of factories in the Fourth Industrial Revolution. Figure 1 illustrates the use of the Digital Twin concept for a factory.

This chapter is organized as follows. Section 1 presents the Introduction while Section 2 describes technologies for the Fourth Industrial Revolution. Section 3 discusses needs and strategies for Engineering Education. Section 4 focuses on small scale face-to-face education while Section 5 considers large scale distance education. Section 6 provides a discussion, in this way considering lessons learned and a preliminary comparison of advantages and disadvantages of the two perspectives: small scale face-to-face education and large scale distance education. Section 7 suggests future research directions and Section 8 presents the conclusion.

Technologies for the Fourth Industrial Revolution

Digital Transformation triggers industry disruption through innovations while using the newest technologies to support work in organizations. One example is the integration of computation, networking and physical processes in Cyber-Physical Systems like autonomous automobile systems and robotics systems. Even though "business transformation prompted by digital technologies is visible across diverse industries", Vukšić et al. (2018) suggest that "there is still a limited number of papers exploring the implementation of digital transformation in practice".