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## Learning Factory: The Path to Industry 4.0

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### Abstract

Nowadays, there are plenty of studies that seek to determine which are the skills that should be met by an engineer. Communication and teamwork are some of the most recurrent ones associated with a knowledge of the engineering sciences. However, their application is not straight forward, due to the lack of educational approaches that contributes to develop experience-based knowledge. Learning Factories (LF) have shown to be effective for developing theoretical and practical knowledge in a real production environment. This article describes the transformation process of a training-addressed manufacturing workshop, in order to structure a Learning Factory for the production engineering program at EAFIT University. The proposed transformations were based on the definition of three pillars (didactic, integrative and engineering) for the development of an LF.

We argue that a proper transformation process may contribute to ease the path towards new manufacturing trends such as industry 4.0 into an academic context that strengthens the engineering training process.

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### 1. Introduction

The manufacturing sector currently accounts for 14.7% of global GDP [1], as one of the most important activities to generate wealth in any nation. Colombia is not an exception, this sector represents 12% of GDP and it is the fourth productive activity of its economy [2]. Scenarios such as fierce competition, short life cycles, frequent product introductions and demand variations generate new challenges in manufacturing field [3]. For this reason, Colombian companies are now struggling to increase their productivity and competitiveness.

There is a worldwide movement in some of the most advanced economies seeking to improve the productivity and efficiency in industrial manufacturing by incorporating the latest advances in information and communications technology (ICT) [4]. The German approach to this trend is named “Industrie 4.0”. It aims to boost communication between people, machines and resources, in order to transform centralized production control processes to a decentralized and autonomous model [5]. The final report of the Industrie 4.0 Working Group [6], recommend training and continuing professional development as priority areas for actions within industry 4.0 implementation. Following

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this manufacturing trend and adapted to the situation of the Colombian industrial sector, The EAFIT University aims to develop a didactic scenario where the demanding skills required by the engineer can be formed. In this context, Learning Factories(LF) appear as highly complex learning environments that allow the development of high quality and autonomous competences [7], which are linked to training, education and research including the industry 4.0 [8].

This paper presents the development of a conceptual model that EAFIT University is applying to transform both the practices of production engineering curriculum and its physical infrastructure. The final aim is to construct a LF projected towards industry 4.0. The basis for this proposal are the observed experiences developing different learning factories and some conceptual models, architecture and key elements for the manufacturing strategies posed in the four model transformations.

## 2. State of the art

### 2.1. Engineering education

Engineering Education (EE) has a strong connection with global economic and social development [9]. To continue this synergy, previous research have been performed to align EE with the socio-economic needs [10][11]. These studies indicate that an engineer requires strong skills in human relations associated with knowledge of the engineering sciences [12]. Additionally, highlight the significant challenge of EE is the access to practical experiences in real contexts [13]. The situation in Latin America, specifically in Colombia, does not differ and engineering schools are intended to transform pedagogical practices in higher education to achieve a balance between social skills, science knowledge and technical training [14]. Based on this context, EAFIT University decided to reform its production engineering curriculum, in order to implement a new teaching-learning structure; with these transformation objectives:

- Implement new learning strategies for the practices of the curriculum of production engineering in the direction of active and experiential learning.
- Consider a transformation framework that integrates the latest industry global trends with academic content, physical infrastructure and engineering practices.

### 2.2. Learning Factories

Initiatives such as LF have sought to develop experiences through the inclusion of industrial projects under the active learning approach on the curriculum of some engineering programs [8]. Preliminary studies have shown a better performance in the development of skills and acquisition of knowledge than traditional approaches [15].

The LF concept was mentioned for the first time in an initiative of a group of universities from the United States in 1995, since then, there have been multiple proposals of LF; additionally, institutions such as the European government adopted as an official initiative for the education of engineers[8].

Currently, a LF is defined as an idealized replica of sections of the value chain industry where informal, non-formal and formal learning take place [7]. These LFs have been used for educational purposes, research and training in areas such as manufacturing (TU Darmstadt) [8], energy efficiency (Green Factory Bavaria) [16], service operations processes (McKinsey Capability Center Atlanta) [8] among others.

In Latin America, the concept of LF has been accepted and diffused [17]. However, initiatives are few; the Brazil Model Factory, which is a union between the SENAI (Serviço Nacional de Aprendizagem Industrial) and McKinsey & Company to build a functional factory with real products, operators, machines and a realistic performance management system [18].

### 2.3. Industry 4.0

The industry 4.0 concept was born from the initiative made by academics, industrials and the German Government, with the objective of strengthening the competitiveness of the manufacturing sector in the country through the convergence between industrial production and Information and Communication Technologies (ICT) [6]. This trend makes use of technologies as the Internet of Things (IoT) and services (IoS), Cyber Physical Systems (CPS), industrial

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