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The Teaching Factory: A Manufacturing Education Paradigm

G. Chryssolouris[a,*], D. Mavrikios[a], L. Rentzos[a]

[a]*Laboratory for Manufacturing Systems and Automation, Dept. of Mechanical Engineering and Aeronautics, University of Patras, Patras, 26500 Greece*

* Corresponding author. Tel.: +30-2610-997262; fax: +30-2610-997744. *E-mail address:* xrisol@lms.mech.upatras.gr

Abstract

The Teaching Factory paradigm aims to align manufacturing teaching and training to the needs of modern industrial practice. Future engineers and knowledge workers need to be educated with new curricula in order to cope with the increasing industrial requirements of the factories of the future. The Teaching Factory paradigm comprises the relevant educational approach and the necessary ICT configuration for the facilitation of interaction between industry and academia. The Teaching Factory aims at a two-way knowledge communication between academia and industry. Both knowledge channels of the paradigm are presented, in the context of this work, within real-life industrial applications. The Teaching Factory paradigm provides a real-life environment for students and research engineers to develop their skills and comprehend the challenges involved in everyday industrial practice.

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1. Introduction

Manufacturing enters a new era, where novel life-long learning schemes need to keep up with the rapid advances in production related technologies, tools and techniques [1]. Considering the importance of manufacturing as a wealth generating activity for any nation, the promotion of excellence will become a strategic target in the years to come. Manufacturing education will comprise a major driver towards that direction [2]. However, teaching and training have not kept pace with the advances in technology. The current practice is lacking a continuous delivery of engineering competencies and strong multi-disciplinary background [3]. The transformation of research results into new products and processes is inadequate. Modern concepts of training, industrial learning and knowledge transfer schemes can contribute to improving the innovation performance of European manufacturing [4]. Manufacturing is a subject that cannot be treated effectively only inside a classroom, whilst industry can only evolve through the adoption of new research results. New approaches are required for manufacturing education in order to i) modernise the teaching process and bring it closer to the industrial practice, ii) leverage industrial practice through new knowledge, iii) support the transition from the manual to the future knowledge workers and shorten the gap between resource-based manufacturing (labor and capital) and knowledge-based manufacturing (information and knowledge) and iv) establish and maintain a steady industrial growth.

To effectively address the emerging challenges for manufacturing education and skills delivery ([5], [6], [7]) the educational paradigm in manufacturing needs to be revised. Many educational institutions have tried to bring their educational practice closer to industry ([4], [8], [9], [10]) also with the concept of a Learning Factory. A drawback of this approach may be that the dedicated equipment, which is installed on the academic settings, may at some point become obsolete. Consequently, dedicated learning factories have the intrinsic limitation of narrowing down their scope, based on the existing equipment.

The Teaching Factory approach presented in this study aims at a much broader use of novel learning methods for the introduction of young engineers to a wide spectrum of manufacturing problems. At conceptual level, an extended Teaching Factory paradigm, based on the knowledge triangle

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notion, has been suggested ([11], [12], [13]). The aim is to effectively integrate education, research and innovation activities into a single initiative, involving industry and academia. Towards that end, the proposed Teaching Factory paradigm focuses on integrating industry and academia, through novel adaptations to the teaching / training curricula, achieved by the deployment of ICT-based delivery mechanisms.

2. Teaching Factory Concept

The Teaching Factory concept is based on the knowledge triangle notion [14] [11]. The concept of the Teaching Factory has its origins in the medical sciences discipline and specifically, in the paradigm of the teaching hospitals, namely the medical schools operating in parallel with hospitals. It aims to incorporate the learning and working environment from which realistic and relevant learning experiences arise.

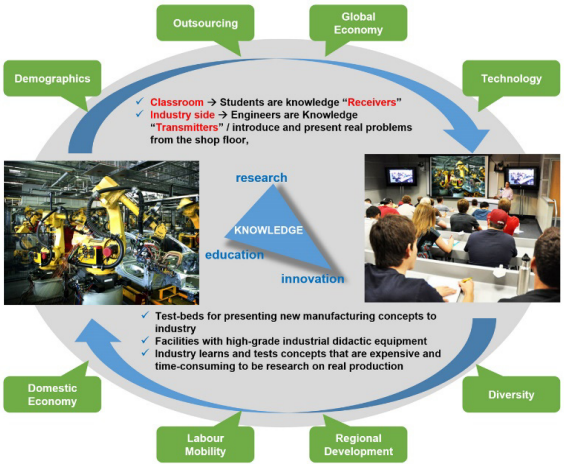

Fig. 1. The Teaching Factory concept.

The Teaching Factory follows a two-way knowledge transfer channel, where manufacturing topics are the basis for new synergy models between academia and industry (Fig. 1). The technological topics are independent of the Teaching Factory's operation and can be updated in order to provide the necessary knowledge foundation for the needs of manufacturing at any given time. The knowledge transfer channels are used for the exchange of novel ideas and solutions, balancing the time and cost required for learning and testing such solutions and deepening the knowledge of both industry and academia through production innovation or real-life problems.

This two-way knowledge transfer channel includes two different Teaching Factory operational schemes, namely, those of the "factory-to-classroom" and the "academia-to-industry". The "factory-to-classroom" concept of the Teaching Factory aims at transferring the real production/manufacturing environment to the classroom. The real life production site has to be used for teaching purposes in order to enhance the teaching activity with that of knowledge, existing in the processes of every day industrial practice. Delivery mechanisms that will enable classroom students to apprehend the production environment, in full context, need to be defined and developed. This concept mainly focuses on the "virtual enterprise" type of operations with training services delivered on a virtual basis. The configuration layout of the factory-to-classroom concept should follow a modular approach to allow flexibility on its application and operation. Multiple layout options are possible when different modules of the Teaching Factory are being combined. Moreover, such sessions could accommodate multiple knowledge receivers. The configurations of the Teaching Factory sessions could follow either a "one-to-one" approach that is one factory to one classroom, or, a "one-to-many" approach, which involves one factory, in a simultaneous interaction with many other classrooms.

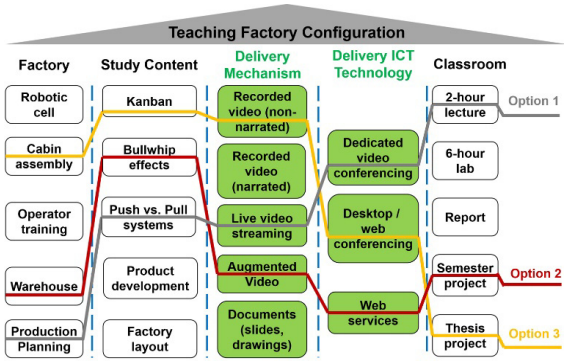

Fig. 2. Multiple layout options.

The modularity of the Teaching Factory concept, whose modules describe the options of the factory-to-classroom operation, is presented in four categories (see Fig. 2). The different modules listed in the four categories can be combined with various configuration layouts. The modules mentioned should be recognized as exemplary. The first category is the "Factory", which represents the different modules corresponding to the production areas and processes, involved in the Teaching Factory. The second category defines the curriculum / study content delivered in the Teaching Factory. The third category is populated by the delivery mechanism modules. The delivery mechanisms are responsible for the communication of knowledge and interaction capabilities between the factory and the classroom. The expression "Delivery Mechanism" does not imply a linear delivery of the knowledge. Knowledge, and particularly competency is constructed by the participants with the help of the IT-infrastructure and the teaching staff. The fourth category is the delivery ICT technology such as dedicated to video conferencing or web services. Finally, the fifth category includes the courses, corresponding to the configurations that will accommodate the Teaching Factory session, within the educational activities. The Teaching Factory will operate in different options allowing flexibility in order to avoid possible limitations. These limitations may result from the technological infrastructure available and can be time and cost