Making Lifelong Learning Accessible for Technical Employees

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Making lifelong learning accessible for production employees

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Abstract

Production employees struggle to attend continuing education which requires physical presence at an educational institution. To address this challenge, MADE initiated a research project on digital learning factories (LF) in October 2020 in collaboration with four university colleges and four universities in Denmark. During the next three years, we will establish four LFs each anchored at a university college. The purpose is to conduct learning experiments to analyze how we can utilize Industry 4.0 technologies to offer production employees greater access to effective lifelong learning through LF.
This paper explains the unique LF-collaboration between MADE, a platform for applied research, university colleges educating professionals and universities educating academics. It also reports on the progress of our four LF and lessons learned. The lessons learned include MADEs governance of the initiative, the onboarding of stakeholders, recruiting of course participants, and developing the four LF.
Learning Factory A will create and operate a virtual learning environment on 3D printing. Learning Factory B and C will digitalize different modules of a postgraduate course known as Innovation, Product and Production, and mix bachelor students with production employees. Learning Factory D will analyze the different didactic needs of bachelor students and production employees to develop a digital postgraduate course in simulation and production layout. The university colleges aim to strengthen their relations with local firms to play a more prominent role in training their employees through the LF.

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1. Introduction

As the Industry 4.0 paradigm unfolds the industry's workforce must learn to handle new technologies and manage new processes. The teaching factory paradigm [1] and learning factory paradigm [2] can build a bridge between academia and industry by offering students unique insight into current industry challenges and hands-on experience [3]. It is a promising way to equip engineers with the skills and competencies required to succeed in Industry 4.0 [2], [4], [5].

Industrial education has existed in many forms. Each industrial paradigm had its governing principles of education; in the second half of the 1800s, and until 1918, the focus was on general knowledge. From 1918 to 1945, the focus shifted towards narrow, specialized skills. After this, until 1982, the focus again went towards broader knowledge fields, so the learners gained competencies in many areas [9]. In recent years, task-based learning has been a new approach to reaching this goal, and authenticity has been a critical parameter for these tasks (Oura, 2001; Merrild 2015). Among the tools to create said authenticity, learning factories (LF) have proved to be a vital setup for creating factory-like settings that are both modular and scalable [10]. The learning factory approach enables the learners to engage with several technologies while producing a product. This likeliness with the industrial worker's everyday life enables a high degree of activation of prior knowledge. Hence, the interaction between the learners' background knowledge and the learning factory's academic content can lead to new reflections within several fields of the knowledge triangle [1]. Furthermore, the collaboration between full-time academic students and workers in the industry can further enhance the learning outcome,

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enabling the academia-to-industry interaction where knowledge flows between various stakeholders [11]. In the future workplace, automatization and digitalization minimize the need for constant human interaction. Thus, workers will have small breaks during their working day that are suitable for asynchronous learning independent of teachers and peers. ICT tools enable new forms of on-the-job and individual workplace learning, such as e-learning and serious games [6]. Trainers utilizing Industry 4.0 technologies actively involve the learners in realistic simulations. It is likely to boost the integration of Industry 4.0 technologies in manufacturing, as the learners will seek opportunities to consider these technologies in their work [7]. Small and medium-sized companies are known for having difficulty to be highly skilled in applications and technologies of Industry 4.0. They may lack the human resources to look ahead and beyond their product and production range to enter new areas and risk investing in emerging technologies, which may fail [8].

Enke, Glass and Metternich emphasize that learning factories developed and operated by technical experts may lack didactic quality [12]. As a result, the learning factory fails to fulfil its full potential. They further argue that a systematic, holistic approach is needed to assess a learning factory's current state to address possible weaknesses, prevent deterioration, and enable continuous improvement. Their maturity model can be used to analyze the initial state on which weaknesses can be designated, the potential for improvement can be shown, and specific steps for improvement can be initiated.

In this paper, we report on the progress of the MADE Learning Factory comprising four learning factories anchored at four university colleges through the lens of Enke et al.'s maturity model [12]. Four educational providers conduct four separate cases, and MADE will act as a facilitator towards aligning and enhancing the maturity of the learning factories. This alignment is performed on both purpose and didactics level, while the operating model is adapted to industry needs in the given setting.

2. Theory

Enke et al.'s maturity model [12] examines Design Dimensions (DD), Design Elements (DE), and Design Level (DL). DD covers “operating model”, “purpose & targets”, “process”, “setting”, “product “ and “didactics”. All dimensions are detailed in individual DE. For example, the DD “setting” has eight elements ranging from the changeability of the used equipment, to enable learners to experiment with the given factory environment. To the level of work system varying from single workplace up to a whole network of companies. There are three DL: the macro level concerning the socio-technical infrastructure and LF concept, the meso level where the learning modules and courses are depicted and the micro level, where single teachning-learning situations are analyzed. Their maturity index ranges from level 1 to 5: “Initial”, “managed”, “defined”, “Quantitatively managed” and “optimizing”.

3. MADE Learning Factory

MADE launched the Learning Factory initiative in October 2020 to address the challenge that production employees can have difficulty attending continuing education that takes place at an educational institution. During the next three years we will establish four LF’s utilizing ICT in collaboration with four university colleges, four universities and a number of manufacturing firms in Denmark. Following a kick-off event in October, MADE carried out bilateral discussions with the university colleages to learn about their preferences and needs. We then paired each university college with a university and identified common interests among the university colleges, universities and MADE to develop reasonable codes of conduct and define four research projects tied to the LF. We are now in the process of recruiting a resaearcher for each LF factory who will drive the development.

Within the four LF’s digital learning means and industrial knowledge are used to scope reflection sessions to develop the competencies of production employees. Each LF's effect will be tested through at least two training pilots with course participants from Danish manufacturing firms. These pilots generate empirical evidence for the research projects which will contribute to the literature on learning factory concerning the subjects taught, methodology, and education-industry collaboration.

LF A investigates 3D print as a part of the manufacturing industry. It aims towards demonstrating various additive techniques in virtually assisted settings. The course will be rooted in the 3D print of a well-known consumer polymer manufacturer to activate the learners' prior knowledge. At the same time, it will draw on a demonstration plant situated in the educational provider’s mini factory. LF B engages employees within innovation-ready enterprises in collaboration with full-time students on relevant bachelor educations. The topic of the course will be robotics. The case uses a process innovation approach to engage the students in work across both sector and disciplinary boundaries to achieve an overall transfer effect. The learners are expected to facilitate discussions with their enterprise setting and provide examples in the learning factory-based laboratory setting. LF C will give the learners tools to navigate the value chain and evaluate and estimate the general supply chain interactions and the supporting functions like research, H&R, and procurement. The learners will physically and virtually investigate the value chain within demonstration cases. After this, the learners will go into existing companies and find examples of the phenomena they encounter in these demonstration cases. The course will rely on small physical setups aided by factory simulation tools. These will serve as demonstration and application cases for the learners and enable them to achieve the final integration within their practice. LF D will analyze the different didactic needs of bachelor students and production employees to develop a digital postgraduate course in simulation and production layout It is rooted in production flow simulations and layout theory and utilizes both learning factory laboratories and industrial factory setups. Feedback from these factories is part of the LF, to provide feedback for reflection among the learners.

4. Concluding remarks

The four LF's are at the initial stage and aim to reach a maturity index defined by Enke et al., of at least 4 within the project period. Purpose and didactic content must be developed to meet the target group. As the target group is skilled workers in the industry, and reflection will be rooted in their prior knowledge, the collaboration with industry needs to be formalized. This is a requirement for high maturity level didactics-wise. All the described LF's are expected to resemble the value chain with a high didactical focus on reflection based on industry challenges. Hence, prior knowledge activation occurs initially, and the on-site or digital production facilities are then used to demonstrate and activate the knowledge that the learners are required to learn. MADE aims to ensure a high maturity and continuous improvement of the LF's through facilitation, constructive discussion and coordination. The education-industry collaboration will sharpen the authenticity and relevance of the LF's.

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