Textile Learning Factory 4.0 – Preparing Germany’s Textile Industry for the Digital Future

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Abstract

Germany’s Textile Industry with its hybrid and highly fragmented value chains is seen as both a future key supplier and adopter of digital operations technologies and Industry 4.0 solutions. Yet, companies hesitate to start their digital transformation process due to severe implementation barriers including uncertainties about financial benefits and the lack of specialist knowledge.

In order to overcome these challenges and to help textile manufacturers to kick-start their digital transformation, we are setting up the Textile Learning Factory 4.0 at the Institut für Textiltechnik der RWTH Aachen University in Aachen, Germany. The factory will become a central location to deliver capability building in a real-life demonstration and learning environment as well as a test base for piloting and scaling-up new digital solutions.

Therefore, an end-to-end value chain from order to delivery for the manufacturing of smart, customer-specific textile products will be set up within the factory. The line will feature two development stages (Lean and Industry 4.0). In the Lean stage participants are going to learn how to systematically conduct a digital transformation while the Industry 4.0 stage will serve as a demonstrator featuring state-of-the-art digital solutions.

In this paper, we want to present the initial motivation, the current status and the future prospects of the factory.

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Peer review under responsibility of the scientific committee of the 7th Conference on Learning Factories

Keywords: Learning factory; Industry 4.0; digital transformation; smart textiles; capability building; digital solutions; lean

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1. Motivation

The rapid advance of digital operations technologies and Industry 4.0 solutions represents a great opportunity to increase the competitiveness of Germany's manufacturing industry [1,2,3]. The increasing connectivity of functions across the value chain (smart factory and operations), smart connected products and data-driven services promise productivity increases of over 20 percent, savings in servicing and maintenance costs of 10 to 40 percent, as well as an increase in "time-to-market" of 20 to 50 percent [4]. In addition, smart connected products serve as a technological foundation for incorporating new business models such as platforms, "as-a-service" models, or data-driven business models and thereby exploit new revenue pools [4,5].

Germany’s textile industry will play a significant role in the digital transformation process of the German industrial sector in general as it is a future key supplier and adopter of digital operations technologies as well as Industry 4.0 solutions [6,7]. The industry provides key technologies – especially smart textiles – required for a successful transformation. Smart textile products hold large growth potential. According to market forecasts, the global market for smart textiles will grow from USD 0.1 billion in 2015 to about USD 3 billion by 2026 [8]. In order to produce smart textile products in large series or mass production scale and to unlock this potential, the hybrid and typically highly fragmented textile value chains will have to become increasingly interconnected.

Germany’s textile industry consists of about 700 predominantly small and medium-sized enterprises employing about 63,000 workers in total. Together they generated a total revenue of EUR 11.58 billion in 2014 [9]. Additionally, there are numerous companies from adjacent sectors handling and processing textile products such as textile machinery, automotive suppliers, and synthetic fiber manufactures.

In the past few years, German companies have increasingly focused on manufacturing high-quality and research-intensive technical textiles. As a result, they successfully strengthened their global leadership position while facing severe challenges resulting from increased cost and innovation pressure, ever shorter product and innovation cycles as well as increased customer demands [10,11]. Today, Germany is the global market leader for technical textiles with an annual revenue of about EUR 13 billion [12].

The implementation of digital operations technologies as part of the digital transformation process is the next logical step in maintaining and further strengthening the leading market position [5]. However, the majority of the mostly small and medium-sized enterprises in the industry seems rather reluctant to start the digital transformation process [13,15]. In today’s rapidly changing digital world this “wait and see” attitude poses a serious risk [11,13].

According to a McKinsey study, the hesitation has to do with a number of implementation barriers faced by manufacturers with no/limited progress in Industry 4.0 [14,15]:

- Uncertainties about financial benefits due to a lack of demonstrated business cases justifying investments
- No strategy to coordinate actions across different organizational units
- Missing talent and capabilities, e.g. data scientists
- A lack of courage to push through radical transformation
- Cybersecurity concerns with third-party providers

Currently we mainly see three key elements that are needed in order to support companies overcome these barriers:

- Access to state-of-the-art digital operations technologies with real business cases to allow the textile industry to experience the wide range of possibilities associated with the digital transformation
- Offering professional and hands-on capability building aimed at reducing the talent shortage in digital competences
- Strong collaboration among manufactures, key technology providers, and leading research institutes to allow creation of market-ready products and solutions with textile industry applicability
A central location or contact point covering all three elements would provide a major contribution in supporting companies overcome their implementation barriers and thereby accelerate the adoption of digital operations technologies in the textile industry.

2. Aim and scope

The Textile Learning Factory 4.0 at the Institut für Textiltechnik der RWTH Aachen University in Aachen, Germany is a world-class training, demonstration and research facility for digital transformation which is currently being set up and is continuously upgraded in collaboration with leading technology and industry partners. The factory is a central location for capability building in a real-life demonstration and learning environment as well as a test base for piloting and scaling-up new digital solutions. There are a broad range of services on offer tailored to the specific needs of company executives, managers, and digital “change agents” in charge of driving the digital transformation process within their companies. The service offering is divided in four main categories:

- **Inform** about Industry 4.0 and digital transformation topics and how to benefit from the various solutions
- **Experience** state-of-the-art applications and technologies of leading manufactures and technology providers
- **Learn** the tools, methods and technologies required to start the digital transformation process
- **Kick-start** the transformation and generate lasting impact with the support of experienced consultants and the use of the learning factory as an accelerator for building internal capabilities at scale

At the Textile Learning Factory 4.0, we address all three key elements mentioned in Section 1 with the aim of supporting manufactures in overcoming their implementation barriers and thereby accelerating the adoption of digital operations technologies across the industry. The key features of the Textile Learning Factory 4.0 are summarized in Fig. 1.
3. Practical implementation

The Textile Learning Factory 4.0 is set up in a building in close proximity to RWTH Aachen Research Campus (see Fig. 2). The building is currently being renovated and will open in March 2017. The factory will become a full-fledged learning environment for company executives, managers, and digital “change agents” featuring a complete end-to-end value stream (material and information) for the production of smart textile products, step-by-step teaching and implementation that results in measurable improvements, and interaction with real operators to detect management and mindset issues.

![Fig. 2: Factory building housing the Textile Learning Factory 4.0 in Aachen](image)

3.1. The curriculum – Learning modules on all key Industry 4.0 themes

At the Textile Learning Factory 4.0, we build awareness concerning the latest Industry 4.0 technologies and applications such as predictive maintenance, digital assistant systems, or digital performance management and how to evaluate their potential via tailored CxO workshops. In addition, we help companies build up the internal capabilities required to successfully drive the digital transformation process at scale by offering a holistic “digital transformation” curriculum that covers all key Industry 4.0 themes.

The curriculum consists of a standard set of learning modules that are developed for each relevant Industry 4.0 theme such as predictive maintenance, end-to-end product traceability, digitally enabled performance management or self-adjusting machines [17]. Each learning module will focus on delivering an answer to five key questions:

1. What is the technology about?
2. How relevant is it, and what is the business case?
3. How can the technology be implemented in real-life?
4. How can it be scaled up across lines and multiple sites?
5. How can sustainability be ensured?

Based on a standard set of learning modules, workshops and trainings can be tailored to the participants’ individual requirements and needs. Theses workshops and trainings enable anticipation of change required along the three dimensions of a digital transformation:

- **The technical system (processes & tools)**, with a paradigm shift towards smart, connected plants leading to a shift to real-time, data-driven decisions across networks, integrated process optimization, and changes in the physical process execution (e.g., collaborative man-machine interaction, and smart, in-line quality control)
- **The management system (organization, IT, performance management)**, with a need to not only focus on identifying visible waste on the shop floor but also “digital waste” along the end-to-end process
- **The people system (capabilities and mindset & behaviors)**, with significant changes in job profiles across all plant functions, as well as new roles (e.g., data analysts, IT integrators)
A sample agenda of a half-day CEO overview workshop at the factory can be found in Fig. 3.

### 3.2. The product – The smart, customizable wristband

In order to allow experimental capability building we are setting up a hands-on, realistic factory environment that features an integrated end-to-end value chain for the production of a smart, customizable wristband. The wristband can be individually configured by the participants prior to a training or workshop, and will be produced during the course of the workshop. The smart, customizable wristband is a real-life product that has many potential applications in different areas such as industry, sports, lifestyle or medical; specific applications include distance measurement for machine operator safety, health monitoring, and sleep tracking (see Fig. 4).
3.3. The process – the end-to-end value chain, from customer order to service

The Textile Learning Factory will feature an integrated end-to-end value chain covering Industry 4.0 topics across all operations-related functions and departments and not just focus on manufacturing-related Industry 4.0 solutions (see Fig. 5). The factory will therefore showcase how a company of the future will operate along its entire value chain.

Workshop participants can personalize their own wristbands as well as purchase them from home by using an online product configurator. After the order is placed, the development and adjustment of the product is initiated, followed by production planning and operation scheduling. The next step is the manufacturing of the product from yarn production to final assembly. Manufacturing includes weaving, coating, thermosetting, printing and cutting of the main strap, as well as the final assembly, which includes sewing, testing and packaging of the final product (see Fig. 6).
3.4. The learning environment – Convertible process from Lean to Industry 4.0

The main aim of the factory environment is to foster hands-on, experimental capability building. Hence, the factory infrastructure needs to meet certain requirements that differentiate it from a real-life factory. One of the key differentiators is the ability to change between two implementation levels of the process: Level 1 – Current State Operation (Lean) and Level 2 – Future State Operation (Industry 4.0). Level 1 serves as a realistic, good practice industry environment in which main Lean tools and methods such as SMED, value stream mapping, Five S, Kanban (pull systems) and poka-yoke (error-proofing) have been implemented, but the potential of Industry 4.0 applications has not been utilized. Level 1 is used to train and teach participants the required methods and tools to conduct a digital transformation in a realistic factory environment. Level 2 on the other hand is used to showcase the potential of state-of-the-art Industry 4.0 applications directly after the hands-on trainings in Level 1.

![Diagram of Level 1 and Level 2](image)

<table>
<thead>
<tr>
<th>Industry 4.0 applications</th>
<th>Description</th>
<th>1st wave implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Condition monitoring</td>
<td>Real-time status of the process steps parameters</td>
<td></td>
</tr>
<tr>
<td>2 Product shadow</td>
<td>Tracking of a product production cycle</td>
<td></td>
</tr>
<tr>
<td>3 Digital assistant system</td>
<td>Digital Work instruction for operators</td>
<td></td>
</tr>
<tr>
<td>4 Digital performance mgmt</td>
<td>Digital KPI board with enabled problem solving</td>
<td></td>
</tr>
<tr>
<td>5 AGV in logistics</td>
<td>Automated material supply</td>
<td></td>
</tr>
<tr>
<td>6 YET</td>
<td>Advanced analytics for Yield, Energy &amp; Throughput</td>
<td></td>
</tr>
<tr>
<td>7 iCycle time</td>
<td>Real-time line balancing</td>
<td></td>
</tr>
<tr>
<td>8 Real-time WIP</td>
<td>Real-time tracking of the stocks (incl. WIP)</td>
<td></td>
</tr>
<tr>
<td>9 Predictive maintenance</td>
<td>Advanced analytics for breakdown prevention</td>
<td></td>
</tr>
<tr>
<td>10 Smart routing &amp; work station setup</td>
<td>Self-adjusting work stations</td>
<td></td>
</tr>
<tr>
<td>11 In-line QC &amp; adaptive machining</td>
<td>In-Line quality control with machines feedback</td>
<td></td>
</tr>
<tr>
<td>12 Human machine collaboration</td>
<td>Human Robot collaboration</td>
<td></td>
</tr>
<tr>
<td>13 3D printing</td>
<td>Tailored production components</td>
<td></td>
</tr>
</tbody>
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Fig. 7: Two development levels and selected Industry 4.0 applications in the future state

4. Current developmental status

Over the past year, the overall concept of the Textile Learning Factory 4.0 was developed, the factory’s location selected, and an initial consortium of industry and technology partners formed. Currently, we are implementing the physical setup of the shop floor including setting up equipment and machinery, specifying the material and information flow, and developing initial Industry 4.0 applications that will be integrated in Level 2. Initial applications include condition monitoring, product shadow, digital assistance system, and digital performance management (see Fig 7). In order to integrate these applications into the factory environment, we are also setting up the required IT infrastructure, including sensors and servers, and we are initializing and connecting multiple IT systems such as an MES system, an IoT platform, and RFID middleware.

We have also developed initial workshop formats for use after the factory’s grand opening in March 2017.
5. Conclusion and outlook

The next logical step towards maintaining and further strengthening the leading market position of Germany’s textile industry are the implementation of digital operations technologies and the initiation of the digital transformation process. However, the majority of companies are hesitant to begin their digital transformation processes due to serious implementation barriers that include uncertainties regarding financial benefits and a lack of specialist knowledge. At the Textile Learning Factory 4.0 in Aachen, we will address these challenges by offering a broad array of services tailored to the specific needs of company executives, managers, and digital “change agents” responsible for driving the digital transformation process within their companies (inform, experience, learn, kick-start).

The factory will become a central location to deliver capability building in a real-life demonstration and learning environment as well as a test base for piloting and scaling-up new digital solutions. An end-to-end value chain for a smart, customizable wristband that starts with an order and ends at delivery will therefore be set up within the factory. The line will feature two development stages (Lean and Industry 4.0). In the Lean stage, participants learn how to systematically conduct a digital transformation, and the Industry 4.0 stage serves as a demonstrator for state-of-the-art digital solutions.

The factory’s opening is scheduled for March 2017. Until then, the physical setup will be built up, the IT infrastructure will be implemented, and the first Industry 4.0 applications and workshop formats will be realized. Over the course of the next few years, we plan to continuously develop the physical set-up, our service offerings, and partnerships. The primary focus will be to further integrate state-of-the-art Industry 4.0 applications and develop the holistic “digital transformation” curriculum and respective learning modules as described in Section 3.1.

References