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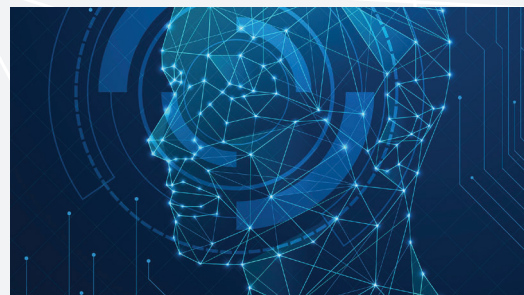


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Knowledge Valorisation in the Age of Digitalization



30 January 2019 – 1 February 2019
Stellenbosch, South Africa

Organised by
Department of Industrial Engineering
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Methods and Tools for SMEs to Support Digital Transformation in Production and Logistics

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Abstract

Changing requirements and qualification profiles of employees [1], increasingly complex digital systems up to artificial intelligence, missing standards for the seamless embedding of existing resources [2] and unpredictable return on investments [3] are just a few examples of the challenges of an SME in the age of digitalisation. In most cases there is a lack of suitable tools and methods to support companies in the digital transformation process in the value creation processes, but also of training and learning materials. A European research project (BITTMAS - Business Transformation towards Digitalisation and Smart systems, ERASMUS+, 2016-1-DE02-KA202-003437) with international partners from science, associations and industry has addressed this issue and developed various methods and instruments to support SMEs. Within the scope of a literature search, 16 suitable digitalisation concepts for production and logistics were identified. In the following, a learning platform with a literature database with multivariable sorting options according to branches and keywords of digitalisation, a video gallery with basic and advanced knowledge and a glossary were created in order to provide the user with consolidated and structured specialist knowledge. The 16 identifying concepts for transforming value-added processes in the context of digitalisation were transferred to a learning platform using developed learning paths in coaching and training to online course modules including test questions. A maturity model was developed and implemented in a self-assessment tool for the analysis to identify the potential of digitalisation in production and logistics in relation to the current technological digitalisation level of the company. As a result, the user receives one or more of the 16 potential digitalisation concepts suggested or the delta for the necessary, not yet available enabler technologies is presented as a spider diagram. For a successful implementation of the identified suitable digitalisation concepts in production and logistics, a further tool was developed to identify supplementary requirements for all company divisions and stakeholders in relation to the "digital transformation" in the form of a self-evaluation. This paper presents the methods and tools developed, the accompanying learning materials and the learning platform.

Keywords

digital transformation, enabler technologies for digitalisation, digitalisation potential

1 INTRODUCTION

On March 10th 2016, the Strategic Policy Forum on Digital Entrepreneurship stated very clearly - digital transformation is not an option – it is a must! [4] By 2030, global expenses of 15 trillion USD are forecasted in the area of industrial networking and digitalisation [5] [6] - eventually more than 80 % of the industrial companies in major industrial countries consider increased use of data along the value chain as a top priority and see opportunity for growth through both optimized processes as well as design and implementation of new business models [7].

Emerging technologies, the increasing availability of information and communication technology (ICT) and the simultaneous diffusion into industrial application, with the visionary final state of continuously and fully networked and virtualized entities inside and outside industrial complexes, along an holistic value chain within an "Internet of Things", commonly referred to as the "digital revolution", show potentials with regard to improved efficiency, raised productivity as well as additional profits from new business models [8].

However, to create value through the "Internet of Things" and seize the opportunity for a technological

change the commitment of each enterprise to identify and quantify its individual potential is required [9]. The new approaches of digitalisation and smart systems are often barely validated and potential impact is mostly not proven. Transformation towards digitized, smart systems is not a one-off activity but rather an ongoing process and could be describe as a lifelong learning process for an enterprise.

In comparison to big companies with the financial strength to either hire consulting companies or to run own departments with a number of experts working on digitalisation and smart systems, especially SMEs do not have the same financial possibilities and therefore are facing a lack of expertise, overview, knowledge with regard to technologies, methods, approaches their mutual interaction as well as potential and risks [10] [11]. SMEs run the risk of waiting too long with the migration towards smart systems and their digitalisation, or pursue no holistic approach for operational improvements or possible impacts on their business model [12].

2 SPECIFICATIONS OF THE BITTMAS PROJECT

2.1 Target group & end-users

Europe 2020 as a strategy intends to focus the European Union (EU) and its member states on the important task of improving the EU's competitiveness. According to the strategy, its goal is to transform the EU into "a smart, sustainable and inclusive economy, delivering high levels of employment, productivity and social cohesion." At the heart of competitiveness is the level of productivity of an economy. According to the executive summary of "The Europe 2020 competitiveness report", the EU continues to under-perform in comparison to the United States and other advanced economies in terms of building a smart, innovation based, knowledge-driven economy [13]. More starkly, the EU is increasingly falling behind globally in building the digital infrastructure and innovative capacity that would allow its economies to unlock new sources of growth [14].

The European SME needs to explore the future potential of ICT, automation, sustainable and clean as well as human-centred work systems and processing technologies. According to Gunther Oettinger, EU Commissioner for Digital Economy and Society, within the High-level conference on the digital transformation of industries and enterprises on February 16th, 2016, European business leaders' areas like big data, the Internet of Things, cyber-physical systems and robotics offer great opportunities for industry. At a recent roundtable in Brussels on the digital transformation of Industry, ways to energize the digital transformation of Europe's industrial sector across Europe were discussed, to raise the potential for increasing flexibility, efficiency, productivity, competitiveness – all helping to create jobs and growth trans-nationally - especially within SMEs.

After all, Europe is a continent of SMEs — where nine out of ten companies are SMEs and two out of three jobs are in SMEs [15]. They have to be part of the digital journey; they are crucial to Europe's growth and competitiveness [16]. Together, sectors (C) Manufacturing 9,33%; (H) Transport and Storage 5,09%; (J) Information and Communication 4,44% and (M) Professionals Science and Technical Administration 18,13% comprised 37% of the 22,3 million SME in 2016 [17]. Most of the 8,25 million SME are not yet aware of the implications of being not prepared for this business transformation in order to emphasize on improvements, growth and competitiveness [18] [19]. Increased sense of initiative and entrepreneurship of owners, managers and staff can only be expected if sensitization and tailored measures are applied within these companies.

2.2 Scientific objectives and project goals

For exactly this purpose, to improve the achievements in the relevant and high-level basics and transversal competence of "business transformation toward digitalisation and smart systems", BITTMAS is working on a solution to provide information, develop methods and solutions to gain knowledge and expertise that is required to assess existing technologies, processes and structures regarding improvement potentials and develop new business models, derive a road map with corresponding measures and implement an improvement process for trainers of VET organizations as well as staff and management of SMEs.

Major aim of BITTMAS is a user (VET trainers, staff and managers of SME) orientated approach guided by self-information, self-learning via web-based training modules, self-assessment of the maturity grade of the SME, self-identification of existing potentials, self-derivation of a road map and required measures as well by self-planning and implementation of the improvements. The BITTMAS Release Candidate consisting of the learning platform, coaching and training modules, a self-assessment to analyse digitalisation potentials and a self-assessment to consider further requirements focused on nine criteria based on the EFQM Model, improve and extend the range of high quality learning offerings for adults and strengthen the key competences in VET curricula. Digitalisation and smart systems do not only appear in the industrial and economic environment but also in the daily social life and the respectively required competencies can therefore be referred to as transversal.

For easing this business transformation and to keep pace with the rapid developments the BITTMAS supports training and self-driven processes for the required business transformation through employees and managers of SME by providing:

- a literature library, video gallery and glossary to inform and sensitize the users with regard to digitalisation and smart systems.
- a self-assessment to determine the potentials for process enhancements and new business solutions based on a tailored maturity model.
- online coaching and training modules to learn or to enhance knowledge regarding to 16 digitalisation concepts.
- a self-assessment to determine further supporting requirements for digital transformation.
- a free entry version of the developed BITTMAS Release Candidate.

2.3 Project consortium

The international consortium consists of an appropriate number of partners who contribute to the related work packages and support the successful

development of BITTMAS according to their competences. One German University of applied Science (Reutlingen University, project leader), one University from Turkey (Sabanci University), two research institutes from Austria (Fraunhofer Austria Research GmbH, Vienna) or Romania (IPA SA, Craiova), one German software developer company (IBK - Management Solutions GmbH, Wiesbaden), a consulting company from Germany (IIC - International Industrial Consult AG, Frankfurt), an association of Electronics and Information Technology Industries from Spain (GAIA, Bilbao), a Chamber of Commerce from Ireland (Waterford Chamber of Commerce) and one University from Kosovo (University for Business and Technology, Pristina) as an associated partner, have taken up the challenge to identify digitalisation potentials and concepts, to structure them and to develop suitable tools for sensitization as well as to support the analysis of SME's own potentials for digitalisation.

3 BITTMAS METHODS AND TOOLS

3.1 Literature research and derivation

The implementation of the BITTMAS project started with an extensive literature research, on the one hand to collect, derive and define information and learning materials in digitalisation and smart systems on the other hand to sensitize each partner to the subject of digitalisation itself. The collection of documents reflected the state of the art in industry and the scientific discussions about Digitalisation and Industrie 4.0 concepts. The main aim was on studies, articles and standard references, use cases and best practice examples. The quantitative and qualitative analysis (including the use of the MAXQDA analysis tool from Verbi GmbH and expert interviews) of over 170 literature and 32 video sources, which the BITTMAS partners were able to identify, resulted in a ranking list of relevant topics for the BITTMAS target group. Based on the frequencies of the key words of the researched literature, the subsequent discussions within the BITTMAS consortium and the feedback of external experts, the following 16 core topics/concepts could be derived within the framework of digitalisation and smart systems: (1) Digital twin of the facility, (2) Digital twin of the assets, (3) Smart Factory, (4) Decentralised & Flexible value creation, (5) Digital Assistant systems, (6) Technical Assistant systems, (7) Integrated transparent value chain, (8) Autonomous intralogistics, (9) Predictive maintenance, (10) Data driven decision making, (11) Data-enabled resource optimisation, (12) Track and trace, (13) Smart Product, (14) Digital Human Resource Management, (15) Digital Marketing, (16) Digital Procurement.

3.2 Learning platform

Adequate Learning Management Systems were researched and resulted in 8 of 15 software programs, which were compared by functions and

costs. Main focus was on an open source solution with a wide active community for continuous free support and sustainable development as well as a high level of user friendliness (e.g. navigation, upload/download of material, easy allocation of roles/permissions, different menu languages, etc.) and functionality (e.g. closed/public area, glossary module, search options, personal desktop). Regarding all requirements for BITTMAS project the comparison of the Learning Management Systems resulted in two favourites: ILIAS and Moodle. Since certain optional peripherals and support from third parties can cost money regarding the use of Moodle and there is already an expertise in using ILIAS at Reutlingen University (host of the BITTMAS platform), project partners decided to choose ILIAS as BITTMAS Learning Management System.

3.3 Information and training material

3.3.1 Literature library

To provide the BITTMAS users with topic specific up-to-date literature sources, researched and collected documents were categorised into the following three divisions and were implemented at the learning platform as a data table including filter option for each criteria:

- Application Guides: Technologies, Business models, Available resources (funding etc.), Good practice
- Studies: White papers / Standards, Strategic papers, Applied statements
- Sectors: Automotive, Logistics, Health care, Electronics, Agriculture, Maintenance, Knowledge, Economy, IT, Finance

It was originally planned to provide free available documents as downloads, but copyright reasons prevented the implementation. As a consequence a web link, which refers to the original source of the respective publication, was added to the library.

3.3.2 Video gallery

Additional to the identified documents in the different areas the partners decided to make use of other sources of information which are available and complement the SME specific approach. All partners were looking for videos which are useful to pass on basic or advanced knowledge concerning Industry 4.0. and Internet of Things aiming for an improved understanding of digitalisation processes. 32 videos were categorised in basic and advanced knowledge and were implemented in the BITTMAS learning platform.

3.3.3 Glossary

A glossary of terms with definitions in the frame of digitalisation and smart systems was agreed upon the partners as a by-product to contribute to a common understanding by developing definitions. The glossary includes so far 40 definitions of terms in the fields of Digitalisation and Industrie 4.0.

3.3.4 Coaching and training modules

Once the user has identified a suitable concept, he can acquire, refresh, expand and test knowledge about the concept with the help of the 16 coaching and training modules provided by the learning platform. In order to ensure an optimal and individual knowledge transfer to the potential BITTMAS users regarding to the 16 digitalisation concepts, the partners designed a tailored user-oriented learning path. Starting with an introduction including definitions and demonstration of the benefits or advantages and disadvantages, the user should gain a rough understanding of the terms and areas of application of the respective digitalisation concept. Furthermore, a meaningful use case and the corresponding respective enablers are illustrated, so that the user gets a first impression regarding to the scope, the effort, the chances and challenges of an exemplary implementation of the digitalisation concept. Additionally use cases, road maps, references and literature sources as well as a final test to review and monitor the learning progress round off the coaching and training modules.

4 SELF ASSESSMENT DIGIPOTAS

BITTMAS solution to determine potential for digitalisation and smart systems of SME is based on a Maturity Model that led to a self-assessment tool named "DigiPotAS" (= Digital Potential Assessment).

4.1.1 BITTMAS Enabler

The basic idea of the BITTMAS potential self-assessment is based on a comparison of the technological requirements (status quo) of a company with the "enabler" technologies still required to enable the application of innovative concepts of digitalisation, which subsequently leads to a recommendation for action. In order to determine the influencing technologies (enabler) of a digitalisation potential, a common definition of each individual digitalisation concept must exist. In this respect, BITTMAS consortium has developed a description for each concept, which indicates the necessary technologies for implementation.

- 1) Digital twin of the factory: The digital twin of the factory helps to plan, design and construct the factory building and infrastructure.
- 2) Digital twin of the production asset: A digital twin of one or more production assets is used for design, virtual start-up and ongoing operation.
- 3) Smart Factory: Smart Factory refers to a production environment that ideally organizes itself without human intervention. This includes production facilities and logistics systems. Core components are cyber-physical systems and intelligent networking based on the Internet of Things (IoT).
- 4) Decentralised & Flexible value creation: Use of flexible, modular production assets instead of traditional production lines.
- 5) Digital assistant systems: Visualisation and automation of factory processes, for example with mobile applications (apps) combined with virtual and augmented reality solutions like tablets or digital glasses.
- 6) Technical assistant systems: New technical assistance systems like exoskeleton suits can be used to aid workers on the assembly line or warehousing.
- 7) Integrated transparent value chain: Integrated planning and scheduling systems within the factory from machine level over Manufacturing Execution System (MES) to Enterprise Resource Planning (ERP) systems.
- 8) Autonomous intralogistics: Factory systems capable of operating and performing logistics activities without human intervention.
- 9) Predictive maintenance: Remote monitoring of dynamic condition of machines with help of sensor data and big data analytics to predict maintenance and repair situations.
- 10) Data driven process/quality optimisation: Big data analyses can help to detect patterns in production or quality data and provide insights to optimise processes or product quality.
- 11) Data-enabled resource optimisation: Data-enabled optimisation of energy and resource consumption through intelligent data analyses and controls, e.g. energy or pressurised air management in facilities based on actual demand and/or supply.
- 12) Track and trace: Location of products and raw material within the factory is tracked via sensors and integrated into a data platform connected to internal systems such as MES/SES or ERP systems.
- 13) Smart Product: Smart products are products that are capable to do computations, store data, communicate and interact with their environment.
- 14) Digital Human Resource Management: Human Resource Management is strongly influenced by increasing flexible production systems as well as by new services offered.
- 15) Digital Marketing: Improving sales by the use of new technologies and concepts for example in the area of Marketing Automation.
- 16) Digital Procurement: Use of Internet technology for facilitating operative procurement processes, such as ordering, as well as sourcing tasks, e. g. web-based supplier search or eAuctions.

After the 16 potential concepts were determined, it was necessary to define suitable enablers. An extensive research and coordination approach with all partners led to the following 10 enabler technologies as requirement for the application of the

identified concepts: (1) Additive Manufacturing, (2) Big Data & Analytics, (3) Cloud / Edge computing, (4) Cyber-physical system (CPS), (5) Cyber Security, (6) Product & Machine data, (7) Internet of Things (IoT), (8) Horizontal / Vertical system integration, (9) External data, e.g. environmental, economic data, (10) Augmented Reality / Virtual Reality.

Next step was to research/determine the correlation of the identified 10 enablers to the identified 16 digitalisation concepts.

4.1.2 BITTMAS Maturity Model

The BITTMAS Maturity Model serves to make a holistic statement about the degree of progress of the digitalisation process related to a company or an organization on the basis of a self-assessment in different categories. To determine the maturity levels and based on the 10 enablers, the project partners have developed 42 criteria, e.g. "level of implementation of operational / environmental data & sensors", that can be assigned to the categories Enabling Technologies, Data & Information, Value Creation Process, Products & Services and Customers & Partners. The selected individual categories of the BITTMAS Maturity Model are derived from the Industry 4.0 Maturity Model by [20] and oriented on the one hand to the question of the existence of various technological and process-related prerequisites for penetrating digitalisation in the company and on the other hand to their comprehensive use in the areas of the company relevant to sales and thus success - namely value creation, product and service design and customer and supplier communication.

- Specifically, the Enabling Technology category examines the presence and coverage of basic technologies in the company, including identification and communication technologies, IT infrastructure and end devices.
- The category Data & Information queries the digitalisation status of company information and the use of data for company management, in particular corporate decision-making.
- The Value Creation Process examines the degree of implementation of value-added digitalisation applications, including automation, remote control and machine-to-machine communication.
- The Products & Services category deals with the use of digitalisation approaches by the product or services offered by the company.
- The Customers & Partners category essentially asks whether and to what extent the integration of external stakeholders takes place using digitalisation.

4.1.3 BITTMAS Maturity Levels and Evaluation

Each criterion, e.g. "the level of implementation of operational / environmental data & sensors", has 4 possible criteria values, whereby the respective

applicable one is determined by the evaluating company. Each of the four criteria values represents one of the four delinearized BITTMAS maturity levels (0-3). All questions, answers as well as the logic, defined by the correlation matrix and the maturity model, were transferred into a self-developed online tool, which was developed and optimized from the beginning for the usage with mobile devices (tablets, mobile phone) in addition to a conventional use of a desktop or notebook. An evaluation of all 42 criteria leads to the determination of the digitalisation maturity level of the organization in each of the individual digitalisation-relevant categories and also allows the determination of the overall maturity level, represented by spider web diagrams.

5 SELF ASSESSMENT DIGISURA

If the BITTMAS user decides to implement one of the concepts, he can use the additional BITTMAS self-assessment Digital Transformation Support Requirements Assessment (=DigiSuRA) to determine further supporting requirements for digital transformation. The assessment of specific support needs for the digitalisation transformation of the given organisation is a self-assessment designed along the Criteria and Part-Criteria (Enablers: Leadership, People, Strategy, Partnerships & Resources, Process, Products & Services, Results: People Results, Customer Results, Society Results, Business Results) of the European Excellence Model, as propagated by CAF and EFQM [21]. It uses a strongly reduced set of questions compared to the original Model and allows a fast overview of the organisations current position with a focus on those areas and activities that are important for or involved in the upcoming digital transformation projects. Identified areas with support requirements can be supplemented with support project/process suggestions and these then subsequently priorities for implementation and expanded into project assignments for realisation by the designed project.

6 SUMMARY AND OUTLOOK

The BITTMAS tools presented within this publication enables the user:

- to determine a suitable digitalisation concept by carrying out a self-assessment for potential analysis (BITTMAS self-assessment DigiPotAS).
- to generate knowledge on digitalisation, especially in relation to SMEs, via the BITTMAS learning platform and the literature library, video gallery and glossary provided with it (BITTMAS learning platform).
- to learn 16 digitalisation concepts via trainings and coaching modules with definitions, benefits, enabler description, example uses cases and review or test (BITTMAS coaching and training modules).

- to self-assess and determine further requirements for digital transformation at company or process level (BITTMAS self-assessment DigiSuRA).

The three-year project BITTMAS will be completed in August 2019. After the creation, implementation and fine-tuning of the various BITTMAS tools, further projects steps are focused on pilot user support as well as the validation and fine-tuning aiming the final BITTMAS release candidate and conducted by dissemination activities.

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8 BIOGRAPHY



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