

Module 14

Digital Transformation and Innovation for Enabling Reconfigurable Production Systems

Welcome to Module 14, Digital Transformation and Innovation for Enabling Reconfigurable Production Systems. This module consists of 5 parts as follows:

1. Manufacturing Digital Transformation
2. Modapto under the lens of Digital Transformation
3. Innovations in Manufacturing Business Models
4. Assessment Questionnaire for Reconfigurable Manufacturing Maturity of SMEs
5. Business Models of MODAPTO
6. References – Extra Reading Material

Each has its own set of slides and accompanying explanations that you can read in parallel. To do so in this series of accompanying texts the Reference Slide is presented in line with the supportive text.

14.1. Manufacturing Digital Transformation

[Slide #4]

Digital transformation remains an uncharted journey for many organizations, with its potential still unfolding. Leading publications (from the business community) like Harvard Business Review and Forbes emphasize its role as a catalyst for growth. Despite the buzz, the practical path to successful transformation continues to evolve.

[Slide #5]

The digital transformation market is expanding at a rapid pace, with a projected compound annual growth rate (CAGR) of 23.9% through 2030. Within this trend, the artificial intelligence segment stands out as the fastest-growing technology, expected to achieve a CAGR of 35.7%.

[Slide #6]

A new shift is underway as organizations move beyond digital transformation toward AI-driven transformation. Businesses are shifting focus to embedding artificial intelligence at the core of operations to enable smarter decision-making, automation, and innovation,

paving the way for a new era of competitive advantage and growth. This shift is also evident from ongoing discussions in business communities, where AI adoption is increasingly seen as the next strategic imperative.

[Slide #7]

Despite significant investment, many digital transformation projects fail, with an estimated \$2.3 trillion wasted globally due to costly and overly complex strategies. One key challenge is that digital transformation still means different things to different people, leading to misaligned objectives and poor execution. Success requires clearer definitions, realistic strategies, and a focus on aligning transformation efforts with actual business needs.

[Slide #8]

A strong digital culture is a cornerstone of successful digital transformation. Without the right mindset, values, and behaviors embedded across the organization, even well-funded transformation initiatives are likely to fail. To achieve lasting impact, companies should also invest in people and organizational transformation, with employees having the skills, support, and environment needed to embrace change and maximize the benefits of new technologies.

[Slide #9]

Many businesses still equate digital transformation with simply adopting digital technologies. However, as highlighted by Harvard Business Review, true transformation goes beyond digitizing processes or deploying new tools—it requires rethinking business models, operations, and customer experiences. The real challenge lies in aligning technology adoption with strategic objectives, cultural change, and organizational capabilities.

[Slide #10]

Digital transformation is often triggered by major disruptions such as shifting consumer behavior and expectations, changes in the competitive landscape, and the growing availability of data. These disruptions fuel the adoption of digital technologies—such as social, mobile, analytics, IoT, and digital platforms—which in turn shape strategic responses like digital business strategies and transformation roadmaps.

[Slide #11]

Verhoef et al. (2021) support that digital transformation has three stages: digitization, digitalization, and digital transformation. Digitization involves converting analog information into digital form for storage, processing, and transmission. Digitalization

focuses on using digital technologies to improve or modify existing business processes. Digital transformation is the most extensive stage, driving enterprise-wide change and reshaping how organizations operate and deliver value.

[Slide #12]

Digital transformation is defined as a fundamental change process driven by the innovative use of digital technologies. According to Gong and Ribiere (2021), it involves strategically leveraging key resources and capabilities to radically improve an entity and redefine its value proposition for stakeholders, such as employees, customers, and partners. Digital transformation can occur within an organization, a business network, an industry, or even across society.

[Slide #13]

Digital readiness refers to an organization's preparedness to undergo digital transformation and its capacity to create value through digital technologies. It involves building the skills, infrastructure, and mindset needed to effectively respond to technological change for a more impactful transformation journey.

[Slide #14]

Organisations face numerous challenges when undergoing digital transformation.

Fear of change can paralyze progress, with employees and leaders alike worrying about uncertainty, job security, or their ability to adapt. Financial constraints can limit investments in new tools, training, and infrastructure, slowing or stalling projects. The leadership team plays a significant role; without clear vision, commitment, and alignment, transformation efforts can quickly lose momentum. Employee status influences engagement—when workers feel undervalued or excluded from the process, adoption remains limited. A lack of digital and building infrastructures means organizations may struggle to integrate modern solutions or scale effectively. Previous bad experiences with failed initiatives create skepticism, making teams reluctant to try again. Resistance to change often stems from deeply ingrained processes and mindsets, while the constant challenge of responding to new requests can stretch resources thin. Finally, the intangible nature of many digital transformation benefits, can make it harder to justify investments, especially to stakeholders focused on short-term returns.

When combined, these factors create a high-stakes environment where careful planning, clear communication, and sustained leadership are essential for success.

[Slide #15]

The digital leadership gap refers to the disconnect between leaders' perceptions of their organization's digital maturity and the actual capabilities. While leaders may believe they are effectively exploiting and utilizing digital technologies, the actual readiness, depth of transformation, and strategic investment often fall short. Digital leadership gap can result in missed opportunities, misaligned priorities, and an overestimation of progress, slowing or derailing digital initiatives. Closing this gap requires a holistic approach to digital transformation.

[Slide #16]

Gong and Ribiere (2021) propose a theory-oriented framework that conceptualizes digital transformation as a fundamental change process enabled by the innovative use of digital technologies—such as AI, blockchain, cloud computing, IoT, and robotics—combined with the strategic leverage of resources and capabilities.

The transformation can lead to two main types of outcomes:

Economic-driven outcomes: process automation, productivity improvement, cost reduction, risk mitigation, and customer experience optimization.

Capability-driven outcomes: business model innovation, organizational alignment, leadership transformation, cultural openness, agility, and ecosystem collaboration.

Ultimately, these outcomes either reinforce an existing value proposition through digitalization or redefine it entirely, reshaping how organizations create value for customers, employees, and partners.

[Slide #17]

Digital transformation is powered by a range of technologies, often summarized by the SMACIT acronym: social media, mobile, analytics, cloud, and IoT. Beyond these, platforms, artificial intelligence, software solutions, digital twins, robotics, and blockchain play critical roles. The actual impact emerges when these technologies are combined, creating integrated solutions.

[Slide #18]

This slide depicts the key enabling technologies of Industry 5.0 along with their envisaged benefits. Each technology—such as AI, cobots, big data analytics, edge computing, IoT, blockchain, digital twins, and 6G—is shown with the specific advantages it can bring. In a nutshell, AI supports automation, quality checks, and quick decisions. Cobots work with people to improve productivity and precision. Big data and edge computing give faster insights with lower delays. IoT tracks assets and improves supply chains, while blockchain

adds transparency. Digital twins help predict issues and customize designs. With 6G, systems become even faster, more reliable, and better connected.

[Slide #19]

Digital technologies deliver a range of business benefits.

- **Improved decision-making** through data-driven insights.
- **Increased productivity** and operational efficiency.
- **Enhanced competitiveness** in the market.
- **Better customer relationship management** and service.
- **Remote work enablement** and flexible collaboration.
- **Better task scheduling** and workflow optimization.
- **Effective communication** across teams and stakeholders.
- **Better resource control** and utilization.
- **Increased sales** through new channels and improved targeting.
- **Cost reduction** via process automation and optimization.

[Slide #20]

The DigComp Framework outlines key digital competences essential for effective exploitation of digital technologies. Digital competence, as defined by the framework, is the confident, critical, and responsible use of digital technologies for learning, work, and participation—combining knowledge, skills, and attitudes to engage effectively in a connected world. These competences can be categorized into **data analysis, digital communication and collaboration, digital security, digital content creation, and problem solving.**

[Slide #21]

The five areas of digital competences, as shown in the slide and defined by the DigComp Framework, are broken down into specific dimensions:

Information and Data Literacy – browsing, searching, and filtering data; evaluating information and digital content; managing digital data and resources.

Communication and Collaboration – interacting through digital tools; sharing and engaging online; collaborating digitally; applying netiquette; managing one's digital identity.

Digital Content Creation – developing, integrating, and reworking digital content; respecting copyright and licenses; programming.

Safety – protecting devices, personal data, and privacy; safeguarding health and well-being; protecting the environment.

Problem Solving – solving technical issues; identifying and applying technological solutions; creatively using digital tools; recognizing and addressing digital skills gaps.

[Slide #22]

Beyond the innovative use and exploitation of digital technologies, organizations must develop **dynamic capabilities** to navigate digital transformation. Warner and Wager (2019), in their seminal study, define 3 specific categories of them.

Firstly, organizations need to develop digital sensing capabilities. This involves staying attuned to new tech trends, monitoring competitors' actions, and identifying shifts in customer preferences. It's also about taking those insights, imagining the future, and mapping out strategies before the wave hits. And none of that works without the right mindset—leaders and teams who share a bold vision, think like entrepreneurs, and see change as an opportunity rather than a threat.

[Slide #23]

Secondly, digital seizing refers to an organization's ability to effectively capitalize on identified digital opportunities. This capability rests on three interrelated pillars.

First, *rapid prototyping*, the disciplined creation of minimum viable products, deployment of lean start-up methodologies, and utilization of digital innovation labs, enables firms to quickly test concepts and iterate before full-scale investment. Second, *balancing digital portfolios* requires managers to judiciously weigh internal and external innovation options, scale promising business models, and calibrate the pace of execution to market conditions and organizational capacity. Finally, *strategic agility* involves the rapid reallocation of resources, readiness to redirect efforts in response to emerging information, and pacing strategic.

[Slide #24]

Lastly, beyond sensing and seizing digital opportunities, organizations should also be transformed. Digital Transforming capability represents the organization's capacity to reconfigure itself in response to emerging digital opportunities.

It entails three critical dimensions: Firstly, Navigating innovation ecosystems – actively participating in digital networks, engaging multiple external partners, and exploiting new

ecosystem capabilities to extend reach and accelerate innovation. Secondly, Redesigning internal structures – appointing leadership roles such as a Chief Digital Officer, rethinking business models, and creating agile, team-based structures that foster cross-functional collaboration. Thirdly, improving digital maturity – assessing the digital readiness of the workforce, attracting digital-native talent, and building the internal knowledge base necessary to sustain transformation.

[Slide #25]

Warner and Wäger (2019) also propose that **contextual factors** act as the environment in which dynamic capabilities are deployed, directly influencing the success or failure of digital transformation efforts.

They identify three main categories:

External triggers – disruptive competitors, changing customer behaviors, and emerging digital technologies that create the pressure and urgency for transformation.

Internal enablers – organizational characteristics that support change, such as cross-functional teams, fast decision-making processes, and committed executive leadership.

Internal barriers – structural and cultural obstacles, including rigid strategic planning, excessive hierarchy, and resistance to change, which can slow or derail transformation initiatives.

[Slide #26]

The relationship among dynamic capabilities and contextual factors is highlighted in Warner and Wäger's (2019) framework, which shows that the effectiveness of digital sensing, digital seizing, and digital transforming is strongly influenced by the surrounding environment. Dynamic capabilities do not operate in isolation; they are embedded within, and shaped by, the specific market, organizational, and cultural context in which a firm competes.

[Slide #27]

Gong and Ribiere (2021) provide a solid theoretical framework for understanding digital transformation. However, it lacks the industry perspective, limiting its practical applicability. Hence, Doukidis, Spinellis, and Ebert's (2020) primer can complement our understanding in this direction. When examined at a firm level and from a practitioner's perspective, the fundamental changes derived from digital transformation can affect business processes, customer experience, business models, and overall organization, as depicted in this Figure.

In more detail, customer experience transformation includes changes that enable the company to understand the customers, elevate their experience, and automate the sales process. The business process transformation includes redesigning and digitalizing processes, employee support, and business performance management. Business model transformation encompasses changes to incorporate key digital innovations and modifications, new digital activity, and changes that enable international expansions. Nevertheless, it is also important to consider that companies make changes at the organizational level by adjusting their strategy, setting new organizational structures/functions/alliances, and engaging proper human resources.

In the next slides, examples are presented for each dimension of the framework.

[Slide #28]

This slide presents practical examples of customer experience transformation across three key areas:

- Comprehension of Customer's Needs and Behaviour – Companies like Bosch use IoT data for B2B loyalty programs, Michelin applies predictive analytics to optimize tire performance, and Caterpillar delivers personalized maintenance plans based on IoT-driven performance insights.
- Upgrading the Customer's Experience – Tesla employs a direct-to-customer model with highly personalized interactions, John Deere integrates dealer networks with online and mobile services, and Siemens offers seamless omnichannel integration for sales and service.
- Automation and Digitization of Sales Processes – ABB provides AI-powered predictive maintenance reports, Schneider Electric equips sales teams with real-time IoT product data, and BMW enables online car customization and purchasing.

[Slide #29]

This slide provides examples of business process transformation across three main areas:

- Business Processes Digitalization and Redesign – General Electric (GE) uses digital twin technology to optimize industrial processes, Airbus employs cloud-based collaboration for supply chain optimization, and Honeywell delivers IoT-based industrial automation services.
- Support and Improvement of Employees' Daily Tasks – Volkswagen applies AI to monitor production floors, Boeing uses digital workforce planning tools for

personalized services, and Bosch offers AI-powered decision support for smart factories.

- Business Performance Management – Daimler leverages data-driven KPIs and balanced scorecards for manufacturing performance tracking, while Tesla applies AI-based forecasting and continuous integration for supply chain management.

[Slide #30]

Additionally, are presented examples of business model transformation across three strategic areas:

- Digital Organizational Modifications – Philips transitioned from hardware to digital healthcare solutions, BASF embedded digital tools into chemical manufacturing, and Siemens created MindSphere, an industrial IoT platform.
- Establish New Digital Activity/Service and Business Model – Michelin introduced a tire-as-a-service subscription, Bosch developed AI-powered predictive maintenance solutions, and Airbus launched Skywise, a data-sharing platform for airlines.
- Digital International Expansion – ABB unified its digital strategy across automation subsidiaries, Caterpillar offers IoT-enabled global equipment monitoring, and Siemens set up localized digital manufacturing hubs to balance global reach with local responsiveness.

[Slide #31]

Finally, this slide provides examples of organizational transformation in three key domains:

- Integrated Business Strategy – Bosch ensures AI compliance in industrial applications, Tesla invests heavily in Gigafactories to support digital-driven production, and GE integrates digital and industrial operations into a unified strategy.
- New Organizational Structures, Functions, and Alliances – Volkswagen restructures operations to focus on electric and software-driven vehicles, Boeing implements AI-powered quality control in aircraft production, and Daimler partners with Nvidia to advance AI-driven vehicle manufacturing.
- Human Resources Development, Talent Acquisition, and Exploitation – ABB trains employees in industrial AI, Airbus uses digital twin technology for skills development, and Siemens establishes dedicated AI research labs to drive manufacturing innovation.

[Slide #32]

Overall, Real digital transformation means moving beyond surface-level adoption. It requires shifting from mere use of tools to fully exploiting them for competitive advantage, and from limited experimentation to broad, organization-wide utilization. Occasional deep dives must give way to a constant state of readiness for change, while isolated IT projects evolve into enterprise-wide transformation. Finally, success depends on replacing minimal budgets with the right strategic investments that deliver lasting impact.