# Guest editorial: Lean and learning in the age of digitalization

## Abstract
Research on the integration of lean and digital has gained greater traction in recent years, given widespread interest in and adoption of Industry 4.0. The learning perspectives of lean transformations have also recently become more prominent in the extant literature. Therefore, in this editorial, we discuss contemporary learning perspectives of lean in the digital era, presenting an overview of the main findings of the papers that were selected for publication in this special issue and providing our reflections for future digital lean research.

## Introduction

The lean world is becoming more and more digital, given increased exposure to *Industry 4.0* and a plethora of key enabling technologies such as extended reality and the Internet of Things (Alsadi *et al.*, 2023). At the same time, recent emerging interest in *Industry 5.0* has reoriented academics, practitioners and policymakers on the importance of developing a resilient and sustainable, human-centric industry (Breque *et al.*, 2021). As such, lean maintains just as important a position on the research agenda today as it did two or three decades ago – albeit now with a much greater focus on the continuous development of people and the enhanced capabilities that may be gained through combining this with digital technology adoption (Hines *et al.*, 2023).

This special issue of the *International Journal of Lean Six Sigma* (*IJLSS*) presents extended versions of ten select papers from the Seventh European Lean Educator Conference (ELEC), which was held in Trondheim, Norway, in October 2021. The theme of the conference was learning in the digital era, which consequently inspired the theme for this special issue: *Lean and Learning in the Age of Digitalization*. The full conference proceedings can be found in Powell *et al.* (2021).

## Lean and learning in the age of digitalization

In this section, the guest editors provide a short overview of the ten papers that are included in this special issue:

- Virtual reality supported trainings for lean education: conceptualization, design, and evaluation of competency-oriented teaching-learning environments.
- Teaching a lean masterclass in the metaverse.
- Improving the impact of remote playing lean workshops through action inquiry and critical reflexivity.
- Designing online delivery of lean education during COVID-19.
- The growing gap between lean production and digital lean tools.
- Learning of quality improvement theory – experiences with reflective learning from a student perspective.
- Critical success factors of lean in higher education: an international perspective.
- The financial implications of XPS: an organizational learning perspective.

- Toyota Kata for continuous improvement; an action research project in the construction industry.
- Lean monitoring: action research in manufacturing.

In the first article, Riemann and Metternich (2022) present an approach for the structured conceptualization and implementation of competence-oriented virtual teaching–learning environments, based on the application of virtual reality (VR) in a learning factory environment. The authors provide practical insights as to how VR can open up different learning spaces that can enrich lean education. Also exploring the use of VR for teaching lean, Hines and Netland (2022) explore the benefits and challenges of teaching lean in the metaverse. Both Riemann and Metternich (2022) and Hines and Netland (2022) conclude that VR presents lean educators with a useful and useable means of supplementing traditional classroom teaching methods, particularly when adopted as a hybrid/blended teaching approach.

Pešec (2022) describes how the adoption of action research practices (action inquiry and critical reflexivity) improved the learning outcomes of remote lean startup workshops during the COVID-19 pandemic. The author was required to digitalize the delivery of Playing Lean – a board game designed for teaching lean startup methodology – without sacrificing learning outcomes; and provides generic insights for other educators to improve remote workshops that are intended to teach people new skills. McDermott (2023) also presents practical insights from converting classroom-based teaching of lean education to online delivery during COVID-19 and highlights the importance of using practical examples and problem-based learning for more effective realization of student learning outcomes.

Holmemo and Korsen (2023) presents empirical insights into the relationship between lean production and digitalization from a process–theoretical perspective. The authors suggest that the centralized nature of digitalization initiatives is contradictory to the decentralized nature of lean production, which creates challenges for organizations. Presenting the results of a longitudinal study in the Norwegian production industry, the paper calls for better coordination of lean and digitalization efforts in manufacturing organizations. This then has specific implications for both lean and digital educators, who should also attempt to reduce these professional barriers before graduates reach the workplace. In investigating the student perspective of learning quality improvement theory, Hellberg and Fauskanger (2022) also uncover the importance of adopting an interactive, practical approach to teaching (lean) and quality management – to explore fundamental theories applied to real business problems. The study shows that for professional students, problem-oriented teaching is motivating, and when coupled with reflective learning in the form of recurring feedback on interim reports from both teachers and fellow students, it provides a high degree of learning of lean and quality improvement methods. Finally, on the theme of lean in higher education (HE), Kokkinou and van Kollenburg (2022) explore continuous improvement initiatives in HE institutes and discuss a significant gap between empirical and conceptual studies of lean in HE institutes. They present three specific critical success factors for lean in HE: employee empowerment, sharing success stories and training.

The three remaining articles in this special issue present important learning perspectives for the successful adoption of lean thinking and practice. For example, in discussing the financial implications of implementing a company-specific production system (XPS), Hekneby and Powell (2023) illustrate how the development and deployment of an XPS through individual and orchestrated learning subsequently creates a common platform for institutionalized learning within and across multinational organizations. Drawing on insights from a longitudinal single-case study of a Norwegian multinational firm, the

authors uncover the importance of considering these three cumulative learning perspectives when designing and implementing XPS to drive the improvement of a firm's financial performance. Likewise, Lodgaard *et al.* (2023) present the results of an action research project in the construction industry, in which the Toyota Kata framework was adopted as an enabler for developing a learning-to-learn capability in organizations. The study reveals that transitioning from a reactive, firefighting culture to a proactive, scientific problem-solving culture takes time and requires certain structures that enable problem identification and resolution. Despite the importance of digitization to improve efficiency in an organization, the authors also discovered the importance of writing manually on the Kata storyboard as an enabler of the learning process. Finally, Kassem *et al.* (2023) adopt action research to investigate the adoption of a lean action plan during the monitoring phase of continuous improvement projects. The work showcases the importance of dedicating time and effort to a CI cycle in the monitoring phase and demonstrates how the adoption of a simple digitalized KPI dashboard simplified the process and made project follow-up more streamlined and efficient.

## Conclusion

The ten works presented in this special issue can be summarized as two broad research themes within the field of teaching, learning and implementing lean in the digital era. In this section, we describe them in more detail and challenge the lean research community to pursue them as exciting avenues for future research.

### Role of digital technologies in teaching and learning lean

Digitalization has become a megatrend. Not just in industry, but in society in general. As such, schools, colleges and universities have also witnessed rapid developments in the digitalization of training courses and educational programs. Such digitalization efforts were accelerated because of the COVID-19 pandemic and are set to remain as the new normal. In this special issue, we present two articles that illustrate the use of VR technology for teaching lean (Riemann and Metternich, 2022 and Hines and Netland, 2022). They identify three specific uses: simulating a virtual factory where lean can be applied, using a virtual platform (or conference center) for teaching lean and using 360° cameras to take the student to real factories. All of these approaches either singularly or in combination offer interesting possibilities for learning, although there are a range of issues that need to be addressed.

Virtual mobility technologies such as Microsoft Teams and Zoom have also provided a means of offering lean courses online, as demonstrated in Pešec (2022) and McDermott (2023). However, there remains a vast array of other Industry 4.0 technologies that may (or may not) prove useful for teaching and learning lean, such as artificial intelligence, digital twins and cyber-physical production systems. Future research should examine the emerging roles of these technologies in lean education. The benefits of adopting a problem-based learning approach should also not be underestimated when designing future lean and digital education programs.

### Importance of adopting a learning perspective when embarking on a digital lean transformation

Recent research on lean implementation has uncovered an important connection between lean success and the adoption of lean as a learning system (Powell and Reke, 2019; Powell and Coughlan, 2020; Saabye *et al.*, 2023). This perspective has been emphasized in several works in this special issue, including Hekneby and Powell (2023) and Lodgaard *et al.* (2023). As such, we encourage current and future lean scholars to explore digital lean transformation through the lens of action learning. How might firms adopt digital

technologies to accelerate and enhance the creation of organizational *learning-to-learn* capability? Though this current SI offers some answers to this question, further empirical research is required to offer more actionable knowledge to assist firms with sustainable, digital lean transformation.

Traditionally, lean proponents have avoided the adoption of digital technology in favor of simple, analogue devices. This is as true in the classroom as it is on the factory shopfloor. However, current global trends suggest that lean educators, scholars and practitioners must now embrace digitalization – not only as a means of solving contemporary problems but also to discover them, understand them and explore them, contributing to the acceleration and enhancement of learning capabilities within and across organizations.

As a concluding remark and reflecting on the works presented in this special issue, we revisit our title, "Lean and learning in the age of digitalization," and, in hindsight, wonder whether "Lean and digitalization in the age of learning" may rather have been more fitting.

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**1101**