


## Editor-in-Chief

*Kai Rannenber, Goethe University Frankfurt, Germany*

## Editorial Board Members

TC 1 – Foundations of Computer Science

*Luis Soares Barbosa , University of Minho, Braga, Portugal*

TC 2 – Software: Theory and Practice

*Michael Goedicke, University of Duisburg-Essen, Germany*

TC 3 – Education

*Arthur Tatnall , Victoria University, Melbourne, Australia*

TC 5 – Information Technology Applications

*Erich J. Neuhold, University of Vienna, Austria*

TC 6 – Communication Systems

*Burkhard Stiller, University of Zurich, Zürich, Switzerland*


TC 7 – System Modeling and Optimization

*Fredi Tröltzsch, TU Berlin, Germany*

TC 8 – Information Systems

*Jan Pries-Heje, Roskilde University, Denmark*


TC 9 – ICT and Society

*David Kreps , National University of Ireland, Galway, Ireland*

TC 10 – Computer Systems Technology

*Ricardo Reis , Federal University of Rio Grande do Sul, Porto Alegre, Brazil*


TC 11 – Security and Privacy Protection in Information Processing Systems

*Steven Furnell , Plymouth University, UK*

TC 12 – Artificial Intelligence

*Eunika Mercier-Laurent , University of Reims Champagne-Ardenne, Reims, France*

TC 13 – Human-Computer Interaction

*Marco Winckler , University of Nice Sophia Antipolis, France*

TC 14 – Entertainment Computing

*Rainer Malaka, University of Bremen, Germany*

## **IFIP – The International Federation for Information Processing**

IFIP was founded in 1960 under the auspices of UNESCO, following the first World Computer Congress held in Paris the previous year. A federation for societies working in information processing, IFIP's aim is two-fold: to support information processing in the countries of its members and to encourage technology transfer to developing nations. As its mission statement clearly states:

*IFIP is the global non-profit federation of societies of ICT professionals that aims at achieving a worldwide professional and socially responsible development and application of information and communication technologies.*

IFIP is a non-profit-making organization, run almost solely by 2500 volunteers. It operates through a number of technical committees and working groups, which organize events and publications. IFIP's events range from large international open conferences to working conferences and local seminars.

The flagship event is the IFIP World Computer Congress, at which both invited and contributed papers are presented. Contributed papers are rigorously refereed and the rejection rate is high.

As with the Congress, participation in the open conferences is open to all and papers may be invited or submitted. Again, submitted papers are stringently refereed.

The working conferences are structured differently. They are usually run by a working group and attendance is generally smaller and occasionally by invitation only. Their purpose is to create an atmosphere conducive to innovation and development. Refereeing is also rigorous and papers are subjected to extensive group discussion.

Publications arising from IFIP events vary. The papers presented at the IFIP World Computer Congress and at open conferences are published as conference proceedings, while the results of the working conferences are often published as collections of selected and edited papers.

IFIP distinguishes three types of institutional membership: Country Representative Members, Members at Large, and Associate Members. The type of organization that can apply for membership is a wide variety and includes national or international societies of individual computer scientists/ICT professionals, associations or federations of such societies, government institutions/government related organizations, national or international research institutes or consortia, universities, academies of sciences, companies, national or international associations or federations of companies.

More information about this series at <https://link.springer.com/bookseries/6102>

Daryl John Powell · Erlend Alfnes ·  
Marte D. Q. Holmemo ·  
Eivind Reke (Eds.)

# Learning in the Digital Era

7th European Lean Educator Conference, ELEC 2021  
Trondheim, Norway, October 25–27, 2021  
Proceedings

*Editors*

Daryl John Powell  
SINTEF  
Trondheim, Norway

Marte D. Q. Holmemo  
Norwegian University of Science  
and Technology  
Trondheim, Norway

Erlend Alfnes  
Norwegian University of Science  
and Technology  
Trondheim, Norway

Eivind Reke  
SINTEF  
Trondheim, Norway

ISSN 1868-4238

ISSN 1868-422X (electronic)

IFIP Advances in Information and Communication Technology

ISBN 978-3-030-92933-6

ISBN 978-3-030-92934-3 (eBook)

<https://doi.org/10.1007/978-3-030-92934-3>

© IFIP International Federation for Information Processing 2021

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG  
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

# Preface

In this book of proceedings, we share the papers that were presented at the 7th European Lean Educator Conference (ELEC 2021), which was hosted online from Trondheim, Norway, during October 25–27, 2021. This year’s conference was special in that it was sponsored by the International Federation for Information Processing (IFIP) for the first time in its history, having been organized in close collaboration with the IFIP Working Group 5.7 Special Interest Group (SIG) on the Future of Lean Thinking and Practice.

The ELEC community is dedicated to fostering knowledge exchange within academia as well as between academic institutions and industry, which we believe is especially important. As such, ELEC 2021 provided a platform for professors, teachers, trainers, and coaches from academia, industry, and public sector organizations to share their knowledge and experiences and learn from one another.

ELEC conferences distinguish lean thinking as a broad management and operations improvement philosophy, fully grounded in science and supported by a continually growing set of methods, techniques, and tools. Given that this year’s conference theme was ‘learning in the digital era’, ELEC 2021 made a special effort to highlight the role of digital technologies in the emerging digital lean manufacturing paradigm.

As such, this volume includes the 42 full papers that were presented at ELEC 2021. The papers were double-blind peer-reviewed to ensure quality. The topics which emerged at ELEC 2021 were:

- Learning Lean
- Teaching Lean in the Digital Era
- Lean and Digital
- Lean 4.0
- Lean Management
- Lean Coaching and Mentoring
- Skills and Knowledge Management
- Productivity and Performance Improvement
- New Perspectives on Lean

In addition to the technical program, ELEC 2021 featured four keynote talks:

- Torbjørn Netland, ETH Zurich, Switzerland, “Teaching Lean in the Digital Era”.
- Eva Helen Rognskog, SATPOS, Horten, Norway, “Fail Fast, Learn Faster”.
- Rose Heathcote, University of Buckingham, UK, “Forget business as usual. We’ve work to do”.
- Torbjørn Gjerdevik, Laerdal Medical, Stavanger, Norway, “People First”.

On behalf of the Conference Committee, We would like to thank all contributors for the high standard of work presented at ELEC 2021. This of course would not have been possible without the support of our International Scientific Committee and peer

reviewers, so we would also like to thank these members for their efforts in reviewing and selecting the papers to be presented at ELEC 2021.

To conclude, We hope that ELEC 2021 has stimulated the exchange of both research results and practical experiences to enhance the state of the art of lean thinking and practice.

October 2021

Daryl John Powell  
Eivind Reke

# Organization

ELEC 2021 was organized by SINTEF Manufacturing AS with support from the Norwegian University of Science and Technology.

## Conference Chair

Daryl John Powell                      SINTEF Manufacturing AS, Horten, Norway

## Program Chair

Eivind Reke                                SINTEF Manufacturing AS, Trondheim, Norway

## Conference Co-chairs

Erlend Alfnes                              Norwegian University of Science and Technology,  
Norway

Marte Daae-Qvale  
Holmemo                                      Norwegian University of Science and Technology,  
Norway

## International Advisory Board

Constantin May                            Ansbach University of Applied Sciences, Germany  
Pia Anhede                                 Revere AB, Sweden  
Joakim Hillberg                            Revere AB, Sweden  
John Bicheno                                University of Buckingham, UK  
Christoph Roser                            University of Applied Sciences, Karlsruhe, Germany  
Jannes Slomp                                HAN University of Applied Sciences, The Netherlands  
Dinis Carvalho                            Universidade do Minho, Portugal  
Monica Rossi                                Politecnico di Milano, Italy  
John Shook                                 Lean Global Network, Boston, USA

## International Scientific Committee

Erlend Alfnes                              Norwegian University of Science and Technology,  
Norway

Jos Benders                                Norwegian University of Science and Technology,  
Norway

Dinis Carvalho                            Universidade do Minho, Portugal

Eivind Arne Fauskanger                University of South-Eastern Norway, Norway

Peter Hines                                 Waterford Institute of Technology, Ireland

Poul Houman Andersen                Aalborg University, Denmark

Olivia McDermott	National University of Ireland, Galway, Ireland
Torbjørn Netland	ETH Zurich, Switzerland
Daryl John Powell	SINTEF Manufacturing AS, Horten, Norway
Eivind Reke	SINTEF Manufacturing AS, Trondheim, Norway
Christoph Roser	University of Applied Sciences, Karlsruhe, Germany
Matteo Rossini	Politecnico di Milano, Italy
Henrik Saabye	Velux, Denmark
José Carlos Sá	Instituto Superior de Engenharia do Porto, Portugal
Jannes Slomp	HAN University of Applied Sciences, The Netherlands

## Peer Reviewers

Erlend Alfnes	Norwegian University of Science and Technology, Norway
Anabela Alves	University of Minho, Portugal
Jos Benders	Norwegian University of Science and Technology, Norway
Chris Buckell	University of Warwick, UK
Jenny Bäckstrand	Jonkoping University, Sweden
Federica Costa	Politecnico di Milano, Italy
Torgeir Dingsøy	Norwegian University of Science and Technology, Norway
Jose Dinis-Carvalho	Universidade do Minho, Portugal
Heidi Dreyer	Norwegian University of Science and Technology, Norway
Eivind Arne Fauskanger	University of South-Eastern Norway, Norway
Torbjørn Hekneby	Storform, Norway
Peter Hines	Waterford Institute of Technology, Ireland
Marte Daae-Qvale Holmemo	Norwegian University of Science and Technology, Norway
Poul Houman Andersen	Aalborg University, Denmark
Natalia Iakymenko	SINTEF Manufacturing AS, Trondheim, Norway
Jonas Ingvaldsen	Norwegian University of Science and Technology, Norway
Bassel Kassem	Politecnico di Milano, Italy
Wilfred Knol	HAN University of Applied Sciences, The Netherlands
Alinda Kokkinou	Avans University of Applied Sciences, The Netherlands
Eirin Lodgaard	SINTEF Manufacturing AS, Trondheim, Norway
Olivia McDermott	National University of Ireland, Galway, Ireland
Maria Flavia Mogos	SINTEF Manufacturing AS, Trondheim, Norway
Torbjørn Netland	ETH Zurich, Switzerland
Mirco Peron	Norwegian University of Science and Technology, Norway
Bruno Pešec	Pesec Global, Norway
Daryl John Powell	SINTEF Manufacturing AS, Trondheim, Norway



Eivind Reke	SINTEF Manufacturing AS, Trondheim, Norway
Thomas Riemann	TU Darmstadt, Germany
Christoph Roser	University of Applied Sciences, Karlsruhe, Germany
Matteo Rossini	Politecnico di Milano, Italy
Henrik Saabye	Velux, Denmark
Sourav Sengupta	Norwegian University of Science and Technology, Norway
Fabio Sgarbossa	Norwegian University of Science and Technology, Norway
Jannes Slomp	HAN University of Applied Sciences, The Netherlands
José Carlos Sá	Instituto Superior de Engenharia do Porto, Portugal
Gabriela Witeck	Universidade do Minho, Portugal
Ton von Kollenburg	Avans University of Applied Sciences, The Netherlands
Mitchell van Roij	HAN University of Applied Sciences, The Netherlands

# Contents

## Learning Lean

Sustaining Continuous Improvement Through Double Loop Learning . . . . .	3
<i>Chris Buckell and Mairi Macintyre</i>	
Learning Spaces for Engineering Education: An Exploratory Research About the Role of Lean Thinking . . . . .	13
<i>Maira Callupe and Monica Rossi</i>	
The Learning Way to EBITDA Improvement . . . . .	21
<i>Torbjørn Hekneby and Daryl John Powell</i>	
Top Down or Bottom Up: Perspectives on Critical Success Factors of Lean in Institutes of Higher Education . . . . .	32
<i>Alinda Kokkinou and Ton van Kollenburg</i>	
The Production Cultural Biorhythm as a New LEAN Learning Process . . . . .	42
<i>Bernd Langer, Bernd Gems, Yannik A. Langer, Maik Mussler, Christoph Roser, and Timo Schäfer</i>	
Proposing VSM as a Tool to Compare Synchronic Online Teaching and Face-to-Face Teaching . . . . .	50
<i>Felipe Martinez</i>	
Hybrid Learning Factories for Lean Education: Approach and Morphology for Competency-Oriented Design of Suitable Virtual Reality Learning Environments . . . . .	60
<i>Thomas Riemann, Antonio Kreß, Liane Klassen, and Joachim Metternich</i>	
Fostering Insights from Real-Time Data . . . . .	68
<i>Henrik Saabye and Daryl John Powell</i>	
Shaping Lean Teaching Methods: Recognizing Lean as a Journey vs. A Set of Tools . . . . .	77
<i>Khavitha Singh and Guy Bowden</i>	
Learning a Lean Way . . . . .	86
<i>Signe Syrrist</i>	
Lean Learning Factories: Concepts from the Past Updated to the Future . . . . .	100
<i>Gabriela R. Witeck and Anabela C. Alves</i>	

The Impact of Different Training Approaches on Learning Lean:  
A Comparative Study on Value Stream Mapping . . . . . 109  
*Matteo Zanchi, Paolo Gaiardelli, and Daryl John Powell*

**Teaching Lean in the Digital Era**

Lean Courses in Process Form - Do as We Learn, Success or Not?. . . . . 121  
*Eivind Arne Fauskanger and Roland Hellberg*

The Digitalisation and Virtual Delivery of Lean Six Sigma Teaching  
in an Irish University During COVID-19 . . . . . 132  
*Olivia McDermott*

A Lean Six Sigma Training Providers Transition to a 100% Online  
Delivery Model. . . . . 144  
*Olivia McDermott, Patrick Walsh, and Lorraine Halpin*

Teaching in Virtual Reality: Experiences from a Lean Masterclass . . . . . 155  
*Torbjørn Netland and Peter Hines*

**Lean and Digital**

When Digital Lean Tools Need Continuous Improvement . . . . . 165  
*Marte D.-Q. Holmemo, Jonas A. Ingvaldsen, and Eirik B. H. Korsen*

Discovering Artificial Intelligence Implementation and Insights for Lean  
Production . . . . . 172  
*Bassel Kasseem, Federica Costa, and Alberto Portioli Staudacher*

Breaking Out of the Digitalization Paradox . . . . . 182  
*Sourav Sengupta, Heidi Dreyer, and Daryl John Powell*

**Lean 4.0**

Mapping the Terrain for Lean Six Sigma 4.0 . . . . . 193  
*Jiju Antony, Olivia McDermott, Daryl John Powell, and Michael Sony*

Learning Through Action: On the Use of Logistics4.0 Lab  
as Learning Developer. . . . . 205  
*Mirco Peron, Erlend Alfnes, and Fabio Sgarbossa*

Blended Network Action Learning – A Digital Lean Approach to Solving  
Complex Organizational Problems Across Space and Time . . . . . 213  
*Daryl John Powell, Melanie de Vries, Mitchell van Roij,  
and Jannes Slomp*

## Lean Management

- 'Fake Lean'; On Deviating from an Ambiguous Essence . . . . . 227  
*Jos Benders, Marte Daae-Qvale Holmemo, and Jonas A. Ingvaldsen*
- Toyota Inspired Excellence Models . . . . . 235  
*José Dinis-Carvalho and Helena Macedo*
- Quantum Lean: The Next Step in Lean Systems . . . . . 247  
*Sean Fields and Michael Sanders*
- What Comes After the Transformation? Characteristics of Continuous  
 Improvement Organizations . . . . . 259  
*Ton van Kollenburg and Alinda Kokkinou*

## Lean Coaching and Mentoring

- Developing Middle Managers with Gemba Training . . . . . 271  
*Eivind Reke and Nadja Böhlmann*
- Towards Effective Lean QRM Yellow-Belt Training Programs:  
 A Longitudinal Analysis . . . . . 278  
*Mitchell van Roij, Martin Linde, and Wilfred Knol*

## Skills and Knowledge Management

- 14 Steps Toward Lean Knowledge Management . . . . . 291  
*Olve Maudal and Torgeir Dingsøy*
- Taking the Playing Lean Experience Online: The Case of Using a Board  
 Game to Teach Lean Startup Remotely . . . . . 299  
*Bruno Pešec*
- Bloom Taxonomy, Serious Games and Lean Learning: What Do These  
 Topics Have in Common? . . . . . 308  
*Gabriela R. Witeck, Anabela C. Alves, and Mariana H. S. Bernardo*

## Productivity and Performance Improvement

- Lean Monitoring: Boosting KPIs Processing Through Lean . . . . . 319  
*Bassel Kassem, Federica Costa, and Alberto Portioli Staudacher*
- A Simulation-Based Performance Comparison Between Flow Shops  
 and Job Shops . . . . . 326  
*Christoph Roser, Daniel Ballach, Bernd Langer,  
 and Claas-Christian Wuttke*

A Framework and Qualitative Comparison on Different Approaches to Improve the Lean Skillset. . . . .	333
<i>Christoph Roser, Bernd Langer, and Claas-Christian Wutke</i>	
Lean Warehousing: Enhancing Productivity Through Lean. . . . .	339
<i>Matteo Rossini, Bassel Kassem, and Alberto Portioli-Staudacher</i>	
<b>New Perspectives on Lean</b>	
Lean Office in a Manufacturing Company . . . . .	351
<i>Federica Costa, Bassel Kassem, and Alberto Portioli Staudacher</i>	
Lean Thinking Application in the Healthcare Sector . . . . .	357
<i>Federica Costa, Bassel Kassem, and Alberto Portioli-Staudacher</i>	
Lessons Learned from Toyota Kata Implementation in the Norwegian Construction Industry . . . . .	365
<i>Eirin Lodgaard, Maria Flavia Mogos, and Natalia Iakymenko</i>	
Lean Translated from a Manufacturing Industry Context to Municipality Service Production: A Case Study. . . . .	373
<i>Eirin Lodgaard and Maren Sogstad</i>	
Challenges in Prototyping a Problem-Solving Practice . . . . .	381
<i>Christina Villefrance Møller</i>	
Leonardo da Vinci: Lean Educator or Lean Sensei?. . . . .	391
<i>Gianpaolo Perlongo and Monica Rossi</i>	
Lean Contribution to the Companies' Sustainability. . . . .	400
<i>Pedro Teixeira, José Carlos Sá, Francisco José Silva, Gilberto Santos, Pedro Fontoura, and Arnaldo Coelho</i>	
<b>Author Index</b> . . . . .	409