



# Parallel Sessions at ELEC 2018

Lean Educator's Role in Lean  
Development

14-15 November  
Braga



## Content Parallel Sessions:

<b>ROUND 1 - WEDNESDAY 14TH NOVEMBER 13.30 - 15.00</b>	<b>4</b>
<b>1.1. University – Industry Collaboration</b>	<b>4</b>
University and Spin-off Cooperation Fosters the Technology Transfer to Industrial Companies <i>Paulo Peças, Portugal</i>	4
The new Brazilian legal framework of science & technology, and its role as an inductor of the introduction of lean processes in micro and small enterprises <i>Sicy Melo, Brazil</i>	4
A3-thinking in student projects and its impact on developing continuous improvement in industrial practice <i>Gerlinde Oversluize, The Netherlands</i>	5
Lean School: an example of industry-university collaboration <i>Jose Antonio Pascual Ruano, Spain</i>	5
<b>1.2 Sustainable Lean Manufacturing: factors of success</b>	<b>7</b>
Lean leadership: systematic literature review <i>Susana Duarte, Portugal</i>	7
Why developing supervisors' TWI skills is fundamental for your Lean Journey? <i>Agata Pawlukojs, Spain</i>	7
The Problem with 'Tools and Techniques'; Why Becoming a 'Learning Organisation' is Vital to a Successful Lean Transformation <i>Graham Canning, United Kingdom</i>	8
TRIZ as a support methodology for new product development <i>Helena Navas, Portugal</i>	8
<b>1.3 Lean Training</b>	<b>9</b>
Teaching and Implementing Lean Construction in the Construction Industry	9
Implementation of Lean Development in industry <i>Sebastian Allegretti, Germany</i>	9
How Geographic and Cultural Factors Influence Lean Training & Implementation <i>Maria Pia Caraccia and John Homewood, United States</i>	10
Effectiveness of a Lean Simulation Training: Challenges and Insights into Different Didactical Concepts <i>Martin Adam, Austria</i>	10
<b>1.4 Approaches to Lean</b>	<b>11</b>
Big Lean Deployment : A comparison of 3 different approaches across 3 multinational organisations <i>Neil Trivedi, United Kindgom</i>	11
Lean Global Network: A global network of sharing, collaboration and development <i>Sérgio Caldeirinha, Portugal</i>	11
Strength-based lean: a different way <i>David Shaked, United Kingdom</i>	13
<b>ROUND 2 - WEDNESDAY 14TH NOVEMBER 15.30 - 16.45</b>	<b>14</b>
<b>2.1 Value Flow and Process Mapping</b>	<b>14</b>
Industrial Case Study based on Master Thesis as a way to develop New Lean applications – The case of Material Flow Cost Accounting combined with Lean-based performance indicators <i>Helena Cecílio, Portugal</i>	14
Improving the physical arrangement of Production line through value stream mapping: a contribution of the company's effective lean culture <i>Joaquim Craveiro, Brazil</i>	14
A Game for Process Mapping in Office and Knowledge Work <i>Rui Sousa, Portugal</i>	15
<b>2.2 Lean Games</b>	<b>16</b>
Experience based recommendations for the development of serious games <i>Ignace Martens, Belgium</i>	16
Lego Serious Play as a Business Innovation enabler <i>Mandy Tawalbeh, The Netherlands</i>	16
Capital Flow Design – Management Accounting's Role in a Lean Enterprise <i>Mathias Michalicki, Germany</i>	16
<b>2.3 Lean Training</b>	<b>18</b>
A proposal for developing competencies through lean culture for maintenance teams <i>Marcelo Oliveira, Brazil</i>	18

Train the Trainer – what does it really mean? <i>Frida Egerlid and Pia Anhede-Bengtsson, Sweden</i> .....	18
Different approaches to teach LEAN <i>José António de Sousa Barros Basto, Portugal</i> .....	19
<b>2.4 Lean at Universities</b> .....	<b>20</b>
Lean Education: what academy know and what importance they give to it? <i>Anabela Alves, Portugal</i> ...	20
The future of Continuous Improvement <i>Ton van Kollenburg, The Netherlands</i> .....	20
The Lean and Environmental (Green) Imperative in Lean Education <i>Mark Fillingham, United Kindgom</i>	21
<b>ROUND 3 - THURSDAY 15TH NOVEMBER 11.00 - 12.30</b> .....	<b>22</b>
<b>3.1 Detecting and Elimination Muda</b> .....	<b>22</b>
Application of lean education for the elimination of waste in a company of the stamped products sector <i>Gustavo Guimarães, Brazil</i> .....	22
Towards Reducing Queues: Muri, Mura, Muda <i>John Bicheno, United Kingdom</i> .....	22
A New Approach to Developing Lean Understanding in Higher Education <i>Ralph Kriechbaum, Germany</i> .....	22
Monitoring and controlling real-time production using waste identification diagram <i>Rogério Santos Menezes, Brazil</i> .....	23
<b>3.2 Industry 4.0</b> .....	<b>24</b>
Industry 4.0 as a way to enhance Lean Manufacturing and Six Sigma <i>Farid Mendonça Júnior, Brazil</i> ..	24
Industry 4.0-based improvement of the Lean game by using the innovative decision support system <i>Nikola Gjeldum, Croatia</i> .....	24
Industry 4.0: Knowledge and capabilities needed for workers, middle-managers and top managers <i>Carina Pimentel, Portugal</i> .....	24
Learning Lean in High-Variety/Low-Volume: Lessons Learned from the EuroLean project and the learning model in the Lean4.0 project <i>Menno Herkes, The Netherlands</i> .....	25
<b>3.3 Lean Applications</b> .....	<b>27</b>
Lean practices to improve the learning process and production document control: a case study <i>Marcelo Pereira, Brazil</i> .....	27
Operations Management and Lean Production – an overview based on publications in journals <i>Rui Lima, Portugal</i> .....	27
Application of Kaizen philosophy to increase productivity: a case study in an electronics industry <i>Décio Reis, Brazil</i> .....	28
Improving healthcare quality in an oncology public day hospital <i>Julio Garcia Sabate, Spain</i> .....	28
<b>3.4 Lean Games</b> .....	<b>29</b>
An Educational Game for Mixed Model Assembly Line Design Using Lean Concepts <i>Can Yukselen, Turkey</i> .....	29
The contribution of simulation games in learning Lean Education in students of production engineering <i>André Aquere, Brazil</i> .....	29
Use of gamification as a tool for developing competences - a proposal of application for analysis and prevention of failures <i>Simone Sarges, Brazil</i> .....	29
Would you like some Wine? Introducing Variants to the Beer Game <i>Christoph Roser, Germany</i> .....	30

# ROUND 1 - WEDNESDAY 14TH NOVEMBER

## 13.30 - 15.00

### 1.1. University – Industry Collaboration

Room: Ponte de Lima  
18 presentation+4 discussion

#### **University and Spin-off Cooperation Fosters the Technology Transfer to Industrial Companies** *Paulo Peças, Portugal*

(Wednesday / November 14)

The Lean origins come from academic realm, from Frederik Taylor, to Womack, Jones and Roos. The continuous search for better ways of production managing and control fostered a permanent development of methods and its enhancement by the academic community. One of the main reasons for this is the fantastic combination of accumulated and structured knowledge existent in university faculties and researchers, with the energetic, fearless and open-minded characteristics of highly skilled master and doctoral students.

In this paper the authors show that this combination can be strengthened by the creation of spin-offs based in the university community. In fact, the knowledge derived from scientific work can be quickly and truthfully transformed into products or services to the society by the agility of processes and resources management of a spin-off company. The case of a spin-off company offering its expertise to companies in the areas of Lean manufacturing & services and 'continuous improvement' - based on problem-solving, is presented and discussed. Four successful projects ran by the spin-off on manufacturing companies, in close collaboration with the university, are described in terms of objectives, elements involved, duration and results.

All the projects were developed by three elements of the spin-off company and one Mechanical Engineering Master Student (developing his/her Master thesis).

One of the projects consisted in the lead time reduction from plastic part design to the injection of the plastic part, including the mould manufacturing, by the application of Lean design throughout several processes of design and manufacturing, and meetings in order to integrate both processes. The second project consisted in a production system diagnosis. The spin-off elements and the Master student developed a customized and replicable Lean Assessment model and its improvement solutions. The third case was the adaptation of several Lean tools, like VSM, SMED and others to the industry 4.0 environment. The fourth project consisted in an efficiency-based diagnosis to assess the operator's procedures, machines capability and planning reliability. The work was accomplished by the application of time and methods studies, spaghetti diagrams, etc. and the efficiency was increased using 5s, SMED, TPM and other tools.

#### **The new Brazilian legal framework of science & technology, and its role as an inductor of the introduction of lean processes in micro and small enterprises** *Sicy Melo, Brazil*

(Wednesday / November 14)

The purpose of this article is to analyze the applicability of Law No. 13,243 of January 11, 2016, known as the Legal Framework of Science and Technology, which provides for stimuli to scientific development, research, scientific and technological training and innovation. The recognition of science and technology as a risk activity, focusing on results rather than on procedures, means that researchers are more effectively engaged in activities involving innovation. The text also deals with Decree No. 9,283, dated February 7, 2018, which regulated the Legal Framework, since it brought

the forms of concessions of benefits and incentives to R & D activities, the legal formatting appropriate for the achievement of these instruments, and established the tools that allow Public Entities to grant legal privileges for research, development and innovation in the technological field. The article was constructed with bibliographical support seeking to contribute to a different view of the control organs regarding the research. This new legislation brings with it the expectation that research and market have a process of approximation, reducing the distance between the knowledge produced in universities and their transformation into wealth. The old legislation did not allow the paid work of researchers from public institutions in projects related to the productive sector, and the new legislation allows private initiative, research institutes, academy members and public educational institutions to work together, in order to place in the market the advanced scientific production developed, which, in many cases, remained restricted to research laboratories, losing its meaning and practical importance for society.

This approach tends to make it possible for knowledge restricted to the academic environment and larger organizations to be effectively incorporated into small and medium-sized enterprises, which tend to have greater difficulties in incorporating knowledge into their operations. The possibilities arising from the new legislation tend to have effects in solving problems of quality, productivity, cost reduction, with the possibility of incorporating benefits to production and competitiveness, with the introduction of technology, methods and processes aligned with Lean production. It concludes that the Legal Framework for Science and Technology, with its specific purpose of reducing bureaucracy in the country's research and innovation activities in general, is an important instrument in the integration of the academic and scientific community at all levels, and companies, representing a new path to lean education.

### **A3-thinking in student projects and its impact on developing continuous improvement in industrial practice** *Gerlinde Oversluize, The Netherlands*

(Wednesday / November 14)

In this paper, we study the value of using the A3-method in student projects which are performed in industry. We performed a survey among 98 students about their experience with the use of the A3-method. Students appreciated the problem solving structure of the A3-method and how it supported communication with people of the company in which they performed their projects. Weaknesses of the A3-method, mentioned by the students, related to a certain extent, to a lack of experience. It is not easy to present all relevant information on one, readable, Other weaknesses of the A3-method, mentioned by several students, related to the industrial context of the project. The lack of clear vision in the company and the missing of an improvement structure complicates the development of a good A3-project. In the paper, we also performed two longitudinal case studies at companies where already a number of students performed their A3-projects. We focused on the impact of the applications of the A3-method by students on the development of Continuous Improvement in the companies. We found that both companies embraced the concept of the A3-method and extended its' use to all improvement projects in the company. Furthermore, both companies developed Hoshin Kanri to align the various improvement projects. The need to do so was triggered by several issues that came up by using the A3-method in the companies. Next, both companies also invested in training of their employees in order to gain a culture of learning. In general, we can conclude that the A3-method is a strong tool which supports the lean journey of companies and students. It also creates fruitful synergy between the teaching and learning activities at applied universities and the development of continuous improvement in companies.

### **Lean School: an example of industry-university collaboration** *Jose Antonio Pascual Ruano, Spain*

(Wednesday / November 14)

The aim of this paper is to contribute to the lean education topic through the presentation of the "Lean School". The "Lean School" is a learning factory laboratory developed in conjunction with an industry partner (Renault-Nissan Consulting) to improve the capabilities of students of the Faculty of Engineering of the University of Valladolid, the employees of its factories and other workers of companies in the region of Castile and León. It can be used for educating academic students as well as to train industrial participants thereby improving knowledge transfer between universities and industry.

The "Lean School" does not focus on teaching manual skills. We use a simulated manufacturing environment to teach lean manufacturing tools and concepts using learning-by-doing didactic concepts to help us train engineers with high employability and adapted to the needs of the companies in the environment.

In the "Lean School" different configurations can be used depending on the learning objective: quality, stock management, flow management, balancing, sequencing, 5S, kitting, etc. But in general, the learning practice is very similar: we start from an initial configuration where we show the students/workers the starting situation focused on detecting the problem to be studied taking into account the tools/concepts that have been previously explained in the theory classes.

The modular configuration of the laboratory production area allows for a quick transition from one configuration to another depending on the evolution in the learning process of the students/workers (different depending on their training and/or abilities). So we can transform a traditional factory into a lean factory in a three-stage to six-stage process, going from a disorganized and low standardized push flow where we are only able to manufacture one version of a product to an optimized pull flow with a wide variety of manufactured versions.

At each stage, with a certain configuration, a production of between 15 and 30 pieces is made. Once completed, the students/workers (teacher guided) are responsible for redistributing the workstations, rebalancing the activities (in each workstation), proposing corrective actions and designing elements to help in manufacturing, to improve quality and delivery times.

In this paper we will use the experience acquired over the last years, in the Production Flows Improvement training programme, to present the "Lean School" fundamental principles, as well as to provide some insights about the lessons learned.

## **1.2 Sustainable Lean Manufacturing: factors of success**

Room: D.Afonso Henriques  
25 presentation+5 discussion

### **Lean leadership: systematic literature review** *Susana Duarte, Portugal* (Wednesday / November 14)

Many studies over time have been recorded as fundamental research for lean management system transformation and understanding. It is widely accepted that the role of leadership is of great importance for a lean manufacturing sustained implementation. However, studies that truly investigate its role to a sustained lean implementation are still limited. With the purpose of contributing to a better understanding of the lean leadership topic and its relationship with sustained lean implementations, in this paper a preliminary analysis is provided through a systematic literature review (SLR). The methodology adopted to conduct the SLR included the following steps: (1) planning and formulating the problem; (2) searching the literature; (3) data gathering and source evaluation; (4) data analysis, synthesis and interpretation; and (5) results presentation. A search in numerous publishers' electronic databases was performed to find relevant publications. In this paper, a presentation and discussion of a synthesis of the literature is firstly included. Secondly, the lean leadership alternative approaches and the influence of the organizational structure/levels of management on lean leadership are also scrutinized.

### **Why developing supervisors' TWI skills is fundamental for your Lean Journey?** *Agata Pawlukojs, Spain* (Wednesday / November 14)

Lean improved the competitiveness of many companies and the value they deliver to customers. Despite these achievements, many companies are stuck after their initial Lean efforts. There are many reasons for this, one of them is lack of skills of front line leaders. Managers and supervisors are not able to create conditions for performance in changing environment.

Operators are afraid of change, they don't clearly understand its purpose and goals. They do not trust their leaders. They do not follow the standards. Lean implementers are familiar with these problems. What could we do to overcome these obstacles? We need to ask ourselves if the leaders have knowledge and skills needed for implementing Lean. Many of them have good knowledge of Lean principles and tools. However having knowledge is not enough, leaders need to develop skills that will help them in creating the right conditions for their team members performance.

What are the fundamental skills needed by front line leaders when implementing Lean?

Training Within Industry Program lists them as: skill in Leading, in Instructing and in Improving Methods. There is a skill development program for each skill: Job Relations, Job Instruction and Job Methods. When supervisors develop the 3 TWI skills, they are able to solve the obstacles that raise at the shop floor.

Respect for People is one of Lean principles. How can supervisors demonstrate Respect for People? Job Relations helps supervisors to understand what are the specific actions they can take daily to create a trustful environment that will enable their teams performance.

"Without standards, there cannot be improvement" but operators do not follow the standards. What can supervisors do to help team members to follow the standards? Job Instruction teaches supervisors how to instruct workers so that the standards reflect in their performance.

"How can I improve the work?" Job Methods helps supervisors to focus on the processes in their area, analyze jobs, generate ideas and implement them together with their team members.

TWI program develops new behavioral routines of the leaders, so that they can create the right conditions for their team members performance every day.

## **The Problem with 'Tools and Techniques'; Why Becoming a 'Learning Organisation' is Vital to a Successful Lean Transformation**

*Graham Canning, United Kingdom*

(Wednesday / November 14)

This paper explores underlying reasons why, after many decades of attempted Lean improvement programmes, so few organisations have managed to reach the levels of success exhibited by Toyota.

A review of recent literature suggests that critical elements of the Toyota Production System have been over-looked; the less tangible elements that engage and support the workforce in structured improvement activity (or 'Kata'). This activity is core to Toyota's efforts in becoming a 'Learning Organisation', and this paper details research from outside the 'Lean' environment showing how organisations can enable or inhibit their ability to excel at this.

The paper also explores how 'western' leaders differ in their approach to problem-solving than those in 'eastern' regions. This may be a significant factor in why 'linear thinking' is prevalent in the application of 'Lean', resulting in a greater focus on the 'tools' than on the human elements of the approach.

A survey has been done of leaders and Continuous Improvement professionals from 22 organisations to support the above research. Findings from this survey suggest that very few organisations currently use the 'Kata' approach. Also, there is often very little appetite to support either a 'learning from mistakes' or a 'trial-and-error' approach to problem-solving, both of which form part of the 'Scientific Method' at the core of the 'Kata' improvement process.

The report concludes that there needs to be a much stronger focus given to the promotion of the 'Kata' approach through Lean training and coaching. And that promotion of the 'tools and techniques', developed by Toyota, as potential 'solutions' to other organisation's issues needs to stop. More effort should be spent developing appropriate solutions which move the organisation towards its 'Vision', and these could be very different from recognised Lean tools. This also addresses the need to look at the whole 'system' that makes up an organisation, and challenges some of the 'linear thinking' paradigms that have developed due to the way that Lean has often been implemented.

## **TRIZ as a support methodology for new product development**

*Helena Navas, Portugal*

(Wednesday / November 14)

Growing demands and rapid changes in markets compel organizations to think more about innovation and continuous improvement. Nowadays, any growth strategy, and even its own survival in the markets, is increasingly being applied by new approaches and management methodologies. The study developed in the scope of this paper focused on the approach and interpretation of the use of the TRIZ methodology, in search of new ways of solving problems, identifying their support tools. Another concept explored and related to TRIZ is the New Product Development (NPD). The present paper aims to approach the concept of TRIZ regarding NPD and the way they are related by following innovative doctrines appealing to creativity. Within this paper and through the analysis of the different fields investigated, a diagrammatic model was proposed contemplating concepts and relations between them. In order to analyze the feasibility of the implementation of this same diagrammatic model in an industrial environment, a case study was presented in a company that uses TRIZ, and through a conclusive analysis, it is verified that the proposed model can be used as support in solving problems of an innovative and creative nature inherent to the implementation of new management processes and their improvement.



## 1.3 Lean Training

Room: Braga  
18 presentation+4 discussion

### **Teaching and Implementing Lean Construction in the Construction Industry** *Janni Tjell and Kajsa Simu, Sweden*

(Wednesday / November 14)

Lean Construction is a deviation from Lean Production in terms of being project based and focused on the building industry. Lean Construction was introduced in 1992 by Lauri Koskela, who identified the importance of taking the three parameters: Transformation, Flow and Value (TFV) into account in the construction industry. Even though the development of the theoretical framework for Lean construction as well as practical implementation has been going on for almost three decades, the concept is still only implemented in a fraction of the construction companies in the world. One of the benefits of applying Lean construction, is that it provides tools and methods for project teams to be adjustable and capable of identifying and mitigating late and unpredictable changes which are very common in the construction industry and at the same time hold the focus on producing value for the client.

The aim of this contribution, is to share the experience gained from having worked with teaching and implementing Lean Construction principles in one of the biggest Scandinavian construction companies. The company neither is nor have been a declared Lean company. This embraces that initially; the teaching and implementation was not directly supported from the executive management. The interest of working with Lean principles comes from the bottom up. Throughout the last two decades many initiatives have been initiated, mostly with focus on implementing tools and processes in the production phase. Since 2011 an initiative was taken to address how Lean construction principles could be applied in the design phase. Since then, practical training has been given to design managers in applying lean tools, support has been given to the management level just above the design managers (middle management level) coaching has been given to top (regional) management and information has been directed at the executive management level. This approach has been fruitful in terms of having developed an internal Lean design concept which has become a strategic development area for the company. We obviously still have many challenges, in terms of developing a more throughout understanding of the methodology. With this presentation we will share our experiences from this journey in terms of having worked with developing building industry specific concepts as well as teaching and implementing Lean throughout the organization for the past 7 years. Moreover, we will give an outlook on teaching and implementation strategies including which current challenges that we are facing.

### **Implementation of Lean Development in industry** *Sebastian Allegretti, Germany*

(Wednesday / November 14)

Many companies are using lean management methods in their production to reduce waste and focus on value-adding processes. However, product development or other indirect creditable Cost-Centers stash a huge potential to improve their performance through applying lean management principles. Whilst exploring the implementation barrier in the product development area, there is a lack of quantified empirical studies which analyse the coherency between the implementation of lean methods and the importance of the lean educator's role. This paper provides an introduction of how a lean educator can prepare and do a training that participants and potential users of lean management methods adopt these principles and methods to their own working environments. This paper tries to point out which factors are important for users to understand the elementary principles

of lean management and the potential to be effective and efficient in doing their own product development business. It shows different approaches to train participants, the intention, as well as the motivation of the trainer, how to handle with external influences and how to implement this knowledge in enterprises. The study is based on partial least squares regression analysis and comprises an Europe-wide survey in collaboration with educators, consultants and lean management users in industrial companies.

## **How Geographic and Cultural Factors Influence Lean Training & Implementation** *Maria Pia Caraccia and John Homewood, United States*

(Wednesday / November 14)

Globalisation has led to the creation of many pan-national companies that deliver their products and services on every continent. When these organisations develop a corporate continuous improvement (CI) approach, it has to be deployed regionally in an effort to ensure that a common methodology is used to help drive improvements in service delivery and quality. Having a common CI approach also enables inter-regional staff interaction and collaboration.

Evidence suggests there are several challenges in such deployments due to geographic and cultural factors that mitigate against the advantages of a singular global approach and the challenge is to find in the right balance between uniformity and allowing some variation to cater for local conditions that does not become too much of a compromise.

The presentation will examine the impact that geographic and cultural factors have on the development and delivery of lean training in organisations and on the implementation approach adopted.

Drawing on the experiences of global logistics company Panalpina and data from experienced practitioners, it will discuss how factors such as language, technology, social norms, diversity, natural environment, learning styles and location can impact a CI programme's effectiveness, support and level of engagement.

It will highlight barriers to the development of effective workplace learning, suggest good practices that ensure that learning is applied effectively in the workplace and indicate avenues for further research.

## **Effectiveness of a Lean Simulation Training: Challenges and Insights into Different Didactical Concepts** *Martin Adam, Austria*

(Wednesday / November 14)

Teaching adults in Lean Management faces certain challenges. A well-known concept to deal with them is activity-based learning as it is provided by Learning Factories. This paper explores the main challenges and its influence as well as learning methods in the context of a Lean Learning Lab. The effectiveness of the training is evaluated by how easy it was to understand the theory, how simple it was to apply it in the Lab and how whether the participants dared to transfer the content into their working environment.

The study was conducted in the Lean Lab of the University of Applied Sciences in Kufstein during the years 2016 – 2018 with a sample of 250 participants from different local companies. The study showed that participants had difficulties with the theory and the terminology of Lean Management. This was significantly influenced by the participants' job positions or rather their level of education. Of major help during the training was primarily the "doing yourself approach". Important was also the support of a coach as well as peer-learning. Here, too, the level of education determined the choice of support significantly. When it comes to the effectiveness of the training with regard to understandability and transfer, not all of the Lean tools were evaluated similarly. Transfer to real life was significantly influenced by how understandable the Lean tools were and how easy it was to implement them in the Lean Lab.

This study gives statistically proven insights into how to organize a Lean Basic training for adults in order to gain the required effectiveness.

## 1.4 Approaches to Lean

Room: Guimarães  
25 presentation+5 discussion

### **Big Lean Deployment : A comparison of 3 different approaches across 3 multinational organisations** *Neil Trivedi, United Kindgom*

(Wednesday / November 14)

This project aimed to compare:

The different approaches taken by the 3 organisations, in terms of the relative strengths and weakness of top down and bottom up approach, as seen in the organisations. In addition, the different types of organisational structure and use of external resources were compared and evaluated.

Over the period of deployment all 3 organisations experienced significant business change. The impact of these changes on the programmes was evaluated.

The overall impact of the differing programme approaches by evaluating their relative merits and also their relevance to each organisation.

The scope of the evaluation was limited to the 3 organisations. The data and information were limited to the experience of the author working as part of the operational excellence teams of the organisations. Additionally, data was gathered from interviews from key individuals from the Lean teams to provide real life feedback on the challenges and merits of the different approaches.

The results of the investigation proved revealing. All 3 approaches can claim success in terms of capability building, longevity of the programme and business results. All 3 organisations experienced major change and business environment change through the life of their Lean programmes. Within the life spans of their programmes they all experienced significant changes, succeses and failures. All 3 organisations used external resources to a varying degree. This varied from being a “top up” for internal resource or specific situational reasons – e.g. top execs, to full blown creation and support for the programme provided externally.

The different methods to deployment have been created through adaptation of the approach to the perceived organisational culture and style. Each deployment has been designed to fit the way of working as well as the culture of the organisation. For example, where top level support was more important, more effort was spent training and coaching these individuals. Where the work environment was more programme based, the projects tended to be more specific rather than site wide or function wide deployment.

### **Lean Global Network: A global network of sharing, collaboration and development** *Sérgio Caldeirinha, Portugal*

(Wednesday / November 14)

LGN was formally chartered as a Massachusetts not-for-profit legal entity in September 2007 with 14 member institutes. Today, LGN is a consortium of not-for-profit organizations dedicated to advancing lean thinking and practice throughout the world to make things better and is comprised of 28 institutes or partners and dozens of co-learning partners across the globe, Portugal included.

Through co-learning action research partnerships with universities and leading companies and organizations across all sectors, and an online community of over 300.000 persons, LGN members gather the best in lean thinking and share it with the lean community and beyond in three

fundamental ways: Share knowledge on lean thinking and practice to develop skills within the community; Collaborate on joint projects and events; and Develop new educational materials such as publications and training.

LGN consist of Education, Action Research through Co-Learning Partnerships and Projects. LGN run experiential on-site learning activities. Over the past 20 years, LGN institutes have: Hosted 25,000 attendees at 100 conferences or “summits”; Published 34 book titles, some Shingo Award Winning, that have sold approximately 100.000 copies; Created content for websites that receive over 1 million visitors per day ([www.lean.org](http://www.lean.org)); Summits reaching several hundred to over 1,000 attendees; and Published more than 600 articles in Planet Lean website (<http://planet-lean.com>).

Lean Academy Portugal proposes to share the outcome of decades of research and learning, within LGN and their co-learning partners by showing one of it's major breakthroughs: *The Lean Transformations Framework* (figure 1)

Observing efforts in the community over many years we have learned that successful transformation calls for a situational approach that is based on innovating key dimensions of any organization through addressing a series of questions.

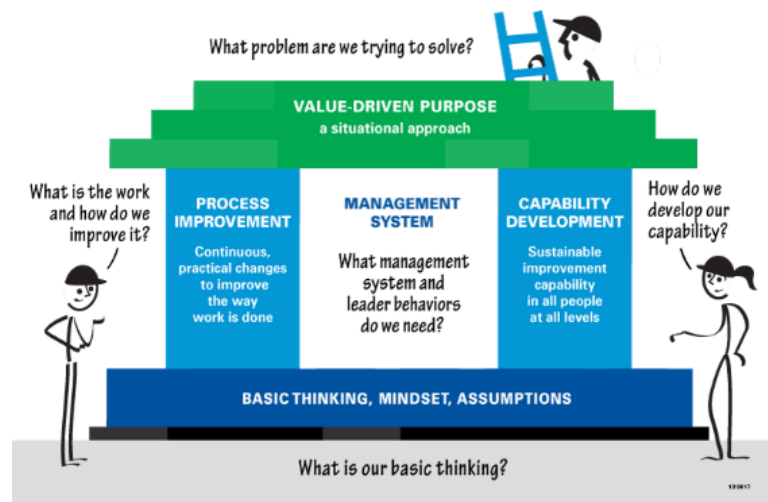


Figure 1- The Lean Transformation Framework

These questions are fractal—meaning that the same questions apply whether working at the macro enterprise level or the level of individual responsibility as you dive progressively deeper into each dimension. But, while the transformation model that has emerged through years of experience is situational, the nature of the questions represent a clear point of view: if an organization fails to address each question, and with a sense of how each relates to the others, the transformation will struggle to sustain its momentum.

#### Questions of the Lean Transformation Framework

1. What is the purpose of the change: what problem are we trying to solve?
2. How are we improving the actual work?
3. How are we building capability?
4. What leadership behaviors and management systems are required to support this new way of working?
5. What basic thinking, or assumptions comprise the existing culture, and are driving this transformation?



We believe that there are certain approaches to answering each of the 5 questions that will yield greater success in a lean journey.

## **Strength-based lean: a different way** *David Shaked, United Kingdom*

(Wednesday / November 14)

Most applications of Lean Thinking assume that there is a 'perfect state' for each organizational process, and that the current state deviates from the 'perfect state' due to inefficiencies and waste. This way of thinking means that, in order to improve processes, we have to focus on the identification of gaps between the current state and the desired/perfect state (this is called 'deficit focus'). Then we find root causes for these gaps and fix them in the hope of making a sustainable improvement. At best, this approach takes you back to a state of status quo ('good') where expectations are met but rarely exceeded.

The strength-based approach to process improvement has a different focus. Instead of focusing on what is defective and inefficient, it helps management and staff identify what is already working efficiently and generates value in existing processes and systems (this is called 'strength focus'.) They then define ways to grow and expand those parts and implement good practices elsewhere.

This focus on the search for and growth of existing efficiency enables new ideas to emerge and supports implementation of process improvements by raising confidence, energy and engagement levels. The strength-based approach to Lean is more natural to work with and more sustainable in the long term. The deficit focus of traditional Lean tends to weaken the system - even when it is successful - because it instills doubt and despair by giving unbalanced attention to waste and by amplifying inefficiencies.

In every organization, there is a wealth of knowledge and practical experience about efficient and value-adding ways to work. This approach has better chances of success as it relies on existing good practices and internal knowledge rather than introducing 'solutions from elsewhere'.

Teaching improvement teams and all members of the organization how to find what is value-generating for customers drives them to consciously and unconsciously seek ways to deliver even more value - isn't that what we're all about?

Strength-based Lean combines the rigour of Lean with the innovation and energy of Appreciative Inquiry and other strength-based approaches to organizational change, creating a more successful, inclusive and sustainable result.

In this Presentation, I will provide an overview of the various strengths-based approaches to organizational change, highlight the links between them and the classic practice of Lean, share a story of applying the approach, its value-add and a few ideas for possible first steps.

## **ROUND 2 - WEDNESDAY 14TH NOVEMBER**

### **15.30 - 16.45**

#### **2.1 Value Flow and Process Mapping**

Room: Braga  
20 presentation+5 discussion

#### **Industrial Case Study based on Master Thesis as a way to develop New Lean applications – The case of Material Flow Cost Accounting combined with Lean-based performance indicators** *Helena Cecílio, Portugal*

(Wednesday / November 14)

The last course of the Integrated Mechanical Engineering Master Programme at Instituto Superior Técnico (Universidade de Lisboa) is the development of a Master thesis for a period of a semester. In the Production Management group of the Mechanical Department, the Master theses under industrial environment are stimulated as a consequence of the strong network of this group in the industrial Portuguese Sector. Each student has to develop a work that is pertinent to the company, with applicable results and, at the same time, respect all the requirements of a Master thesis: be scientifically framed; applies existent knowledge or methodology; define or model the problem with some abstract level; define a formal strategy (hypothesis) to solve/understand the problem and apply it to a case (real or simulated) to assess the proposed strategy. To accomplish these two aims at the same time, the resulting Master thesis often proposes the customization or even adaptation of the original method to the specific industrial reality. This is usually the case when the topic of the Master thesis is in the realm of Production Management and Lean Manufacturing. These theses begin usually with a Lean-based diagnosis to identify the main incidence of Muda and its quantification. After the identification of the root causes, the students propose the use of several tools simultaneously and in several cases the adaptation and integration of Lean tools and/or integration of Lean tools with conventional methods of production management. Examples of that are the integration of SMED with VSM, the application of VSM to multiple products, the extension of VSM to multi-streams, the application on Visual Management to the product production mapping, the application of Lean-based indicators after a Material Flow Cost Accounting (MFCA) assessment, among others.

In this paper, these type of Mater thesis are described and the referred examples are briefly explained. The integration of MFCA with Lean is presented in more detail. The MFCA combines physical flows and monetary units and presents the results as product cost and waste cost, focusing on the material and energy losses. Beginning with MFCA, the approach identifies the causes of high-cost values in specifics process/phases of the production system. With this quantitative diagnosis, the thesis proposes a matrix-solution based on Lean management tools. This approach allows a clear and quick identification of critical cost and energy-related problems, allowing an early problem-solving phase.

#### **Improving the physical arrangement of Production line through value stream mapping: a contribution of the company's effective lean culture** *Joaquim Craveiro, Brazil*

(Wednesday / November 14)

The analysis of the physical arrangement has allowed identifying alternatives of improvements in the production process. In association with the principle of Lean Manufacturing (LM) and applicable tools, companies have been implementing LM practices in order to achieve their goals in the most efficient and effective way possible. The contribution of this study was to apply the Value Stream Mapping (VSM) tool to improve the productivity of the production line of an assembly industry, comparing the results of the pushed production strategy (before) with those achieved through pull production (after) aiming to achieve potential benefits, such as reducing production lead time, eliminating waste and simplifying the flow. A current state map is designed to document the physical arrangement on the shop floor. Next, a future state map is developed to design a multiproduct production process flow, allowing two simultaneous products. In addition, the results allowed to identify possible improvements, such as quality control capable of detecting a problem closer to origin, traceability, visual control in the process, multifunctional function and the participation of all involved in the process, promoting the culture of continuous improvement in the organization.

## **A Game for Process Mapping in Office and Knowledge Work *Rui Sousa, Portugal***

(Wednesday / November 14)

Regardless of the company type, the processes of office and knowledge work play a determinant role in terms of the company's overall performance and, naturally, they must be object of continuous improvement. It is true that improving such processes is not an easy task, but the justification that is usually pointed for that is the workers' rooted habits / resistance to change. However, most likely, workers are not given opportunities (nor tools) to stop and think about the processes they execute so they can improve them. Nevertheless, in order to be effective and efficient (i.e. to be really useful in practice), these tools (and associated methodologies) must be simple (i.e. easy to learn and apply).

This paper describes a project that provides workers (or students) the opportunity (gamified training session) to learn how to map and improve office and knowledge work processes, that includes a simple graphical tool with a reduced set of symbols. In the training session the participants will map and improve a specific process (based on an industrial scenario). The session is conducted as a serious game and involves competition, which are elements usually recognized by their potential to increase motivation and engagement, as well as knowledge retention. In fact, the main purpose is not the mapping and improvement of the specific process presented by the game, but the learning of a graphical tool to map processes that participants can apply to their own scenarios, identifying thus improvement opportunities.

In terms of methodology, the work encompasses the (i) realization of a training session with 18 professionals of Industrial Engineering divided in 3 teams, (ii) application of a questionnaire to all participants about their perception / opinion about the session (7 questions using a five-point Likert Scale and 2 open questions), and, (iii) analysis / discussion of the gathered results.

Regarding the structure, the paper begins with a brief review about the concept of office and knowledge work itself, process mapping and gamification, followed by the presentation of the simple graphical tool. Then, the training session is described, followed by the analysis / discussion of the gathered results. The paper ends with the main findings and some directions for future work. In summary, one may say that the participants considered the training session as useful and that they feel able to conduct in their companies a session on mapping and improvement of processes of office and knowledge work.

## 2.2 Lean Games

Room: D.Afonso Henriques  
20 presentation+5 discussion

### **Experience based recommendations for the development of serious games** *Ignace Martens, Belgium* (Wednesday / November 14)

Since 2010, several serious games have been developed and used at the Lean Learning Academy of the University of Leuven in Belgium (a lean design game, a lean production game, a lean office game, a quick response manufacturing game and a lean healthcare game). These games are non-computer-based simulations of real but simplified processes from different work environments. This article stipulates the issues and the pitfalls encountered during the development and coaching of serious games and based on personal experiences. The aim of this article is to let you reflect about whether or not serious gaming is the right teaching method to learn about a topic and to guide you through the different successive steps of the development of a serious game. Finally, the article describes how a serious game can show companies how to transform into a learning organization and how the effectiveness of serious gaming can be measured.

### **Lego Serious Play as a Business Innovation enabler** *Mandy Tawalbeh, The Netherlands* (Wednesday / November 14)

Improvements in innovation and quality processes can be achieved through the use of novel approaches such as LSP, which enables abstract thinking and advocates an open-mind for unconventional solutions. Within the scope of business processes and structures, the LSP methodology enables collaborative reflection on both single and complex procedures (regardless of rank) in the form of a 'thinking space' based on a flat hierarchy. The employment of total engagement using games and virtual worlds are used to change the working world and businesses activities. The collaborative nature of the work necessary for creating a Lego model establishes a shared comprehension of a certain problem or issue.

Hence, LSP is found to be a suitable methodology for identifying improvements by delineating the actual situation and procedures in the business structure. These initial steps involve the development of learning and comprehension of the current system through consideration of varying stakeholders' perspectives and understanding of the challenges associated with the existing conditions and structures. LSP acts as a learning enabler by creating clarity and support mechanisms for innovation developments and improvement.

In this paper, the authors present how the LSP method can enable Business Innovation based on case studies from the authors' own experience in industry. Therefore, the participants compose two different target groups – either a mixed group consisting of employees from different SME respectively multipliers or a group of employees from one enterprise. The group composition and the participants' background influence the LSP workshop related to structure, procedure and results. Conditions, challenges and factors for successful LSP workshops are evaluated.

### **Capital Flow Design – Management Accounting's Role in a Lean Enterprise** *Mathias Michalicki, Germany* (Wednesday / November 14)

Problem statement



"Standard-cost accounting systems are incompatible with Lean. They are antithetical to Lean practice because they encourage and reward precisely the behaviors that you want to eliminate. In fact, I think of standard-cost accounting as "the anti-Lean".[1]

Despite distinct developments in production systems towards Lean, traditional management accounting systems are widely used unmodified in companies [2]. The basic structure and principles of traditional accounting were developed to support Tayloristic mass production systems in sellers markets about 100 years ago [3].

Most companies do not adapt or question their management accounting systems during the Lean transformation, which results in heavy conflicts. In the literature, there exist many examples of top management stopping Lean turnarounds, because their organization's accounting system is unable to show a financial benefit[4].

The presentation will give detailed insights into four years of applied research in the field of accounting for Lean. Necessary knowledge and capabilities for a supporting accounting function in Lean companies are shown.

#### Approach

The authors, both researchers and Lean consultants, will present a novel holistic management accounting system for Lean named "Capital Flow Design". It has developed in intensive cooperation with partners of the manufacturing industry and is part of their interdisciplinary concept for optimizing production and logistics systems called "Lean Factory Design" [5].

According to the conference's topic, the two speakers will present an approach to extend a typical Lean simulation game by an accounting module. It unveils problems that traditional accounting faces during a Lean transformation as well as a solution [first ideas presented at ELEC 2016: 6]. Lean simulation games play an important role in Lean education but are usually not addressing the controller's or accountant's role. This accounting module for Lean simulation games contributes to overcome educational barriers to Lean Accounting as described in [7] and extends the Lean educator's role to convince finance functions of necessary changes.

#### Literature

[1]Byrne, A. (2013): The Lean Turnaround. How business leaders use lean principles to create value and transform their company. New York: McGraw-Hill.

[2]Rao, M. H.; Bargerstock, A. (2011): Exploring the Role of Standard Costing in Lean Manufacturing Enterprises: A Structuration Theory Approach. Management Accounting Quarterly 13:47–60.

[3]Darlington, J. (2016): Thinking Allowed Part Two: "Inactivity Based Costing". The University of Buckingham.

[4]DeLuzio, M. C. (2006): Accounting for Lean. Conventional accounting must adapt to accommodate the lean movement. Manufacturing Engineering 137:83–90.

[5]Schneider, M. (2016): Lean Factory Design. Gestaltungsprinzipien für die perfekte Produktion und Logistik. München: Hanser.

[6]Michalicki, M. (2016): Using a Simulation Game in the PULS Learning Factory for Teaching Main Principles of Accounting for Lean. Buckingham, England.

[7]Grasso, L. (2006): Barriers to Lean Accounting. Cost Management 20:6–19.

## 2.3 Lean Training

Room: Ponte de Lima  
20 presentation+5 discussion

### **A proposal for developing competencies through lean culture for maintenance teams** *Marcelo Oliveira, Brazil*

(Wednesday / November 14)

The purpose of this paper is to analyze the implementation of training sessions in the maintenance area of the industrial hub of Manaus in Brazil and to propose a competency mapping process with the concept of lean culture. The data analyzed were obtained through a questionnaire sent to the companies of the industrial hub and the information received was explored to identify the behavior of the human resources management in the companies. The results of the study showed that the investment for competence development of maintenance teams is low and is related to characteristics such as business segment and use of Total Productive Maintenance (TPM). Furthermore, another finding is that local and international companies have different approaches to training their teams, especially in training of equipment, production process and mode of operation. This work emphasizes that the action plan of training programs for the maintenance team should be aligned with the strategies of the organization to show positive results and an effective way to get this is to connect the training sessions with each pillar of lean culture.

### **Train the Trainer – what does it really mean?** *Frida Egerlid and Pia Anhede-Bengtsson, Sweden*

(Wednesday / November 14)

An essential part of Lean is training. Many organizations find it simple to outsource the whole training to external trainers who are experts. It is a quick, easy and reliable way but skills often do not remain within the organization and off-the shelf training is often not adapted to the organizational setting. Another way is to use the concept of “Train the Trainer”. Their internal competence is developed by training internal trainers that then do the training. Unfortunately, there are pitfalls also here and even though internal competence is developed, quality can be harder to secure and thus it does not always support lean implementations in the way we want.

One interesting organization that has practiced and developed their way of “Train the Trainer” is BillerudKorsnäs, a global paper and packaging provider. Instead of simply outsourcing the lean training to external experts they have trained and developed their own trainers. How did they think? What did they do?

On-the-job training of trainers, carefully observed by experts and individually coached is one of the main success factors.

Frida Egerlid, head of Business Process & Operational Excellence will share her thoughts and experiences with you. She will go through not only how the training was built, but also the struggling on an individual level, what is required to succeed, how the individuals developed and last but not least the results.

Pia Anhede, who is the other presenter has been working as a management consultant with lean transformation in over 25 years and in over 15 counties. Pia will set the scene by describing the structure of the trainings and the role of coaching. Pia was the external trainer/coach during the process.

## **Different approaches to teach LEAN** *José António de Sousa Barros Basto, Portugal*

(Wednesday / November 14)

Training students of engineering, production managers, supervisors and workers in the concepts, tools and skills set of LEAN is a diverse and demanding task.

The different challenges presented to the trainers, the prerequisite to assess the current level of knowledge of the majority of the students and the need to use different approaches given the multiple target learners, alongside with the pedagogical tools used to achieve the objectives of the formation and the desired learning outcomes will be described.

A resumed survey of the existing principal approaches to teach LEAN will be presented. A preliminary discrimination on what are the common methods to all “targets” and what are the specific approaches that must be “tailored” to singular types of learners will be listed.

The level of “know-how” and “know-why” for the major concepts and tools of LEAN to be applied to each major “target” of learners will be debated, depending of the “tool box” and work experience of the trainees.

Success examples will be presented as “case studies”, alongside with failures on training programs that fell short of expectations.

Particular coverage will be given to the empirical evidences of the results of LEAN implementations by final year graduation projects of Engineering students in industrial and services companies that may be a real world “proving ground” for the dissemination of the approach to improve the efficacy of the operations in the “hosting” companies.

New opportunities for transmitting knowledge to learners using simulators and content freely available on the internet are discussed.

## 2.4 Lean at Universities

Room: Guimarães  
20 presentation+5 discussion

### **Lean Education: what academy know and what importance they give to it? *Anabela Alves, Portugal***

(Wednesday / November 14)

Lean Thinking (LT) has been applied in different contexts, from production to education. Whereas its application in the production sector is well-recognized, mainly due to the economic benefits it brings, its application in the education sector is still confused and/or unaware by most people, particularly, educators. Perhaps because LT in education can be applied in different contexts: 1) in the administrative processes of schools and universities; 2) in the classroom and 3) in the pedagogical projects curricula. In all of them, with the same purpose: improving the process and/or the learning methodology by using LT principles and tools. LT has been recognized more and more as a philosophy and a way of life, however, most people heard or think about Lean as a production methodology/model. Few people are aware of strong turn that Lean could allow when naturally embed in our way of thinking. When considered seriously, this philosophy leads us to a whole new world of thinking. In this new world, it will be necessary to think always with the heart, heads and hands (3H) through the processes, independently of which we are talking about. More than technical knowledge, the fourth industrial revolution demands thinkers that have a whole system-thinking, a sustainable conscious and an ethical behavior. The authors of this paper believe that Lean Thinking provides these competencies to the new professionals, independently of their professional activity. So, several workshops have been promoted to disseminate this paradigm. Some workshops in different contexts were settled and operationalized, involving more than 30 participants. This paper reports and discusses the results of assessment of such workshops collected through a questionnaire. The workshop participants profile will also be presented to show the heterogeneity of academy interested in the topic, stressing the increasing interest in this topic.

### **The future of Continuous Improvement *Ton van Kollenburg, The Netherlands***

(Wednesday / November 14)

How fast is the world changing in the current times of digitalization, automation, aging of society, sustainability and internalization? How will this affect continuous improvement? How should we prepare students for this?

Some of these changes do not occur as fast others. Especially the aging of society can become a serious problem if labor productivity does not improve faster. Continuous improvement, like Lean Six Sigma, can support speeding up the improvements in labor productivity. Research shows there is a need for bachelor students to learn about continuous improvement. More than ever do they have to learn about leadership and culture, because these elements are said to be increasingly important in today's continuous improvement. It is crucial they don't only learn about the improvement tools, but also about realizing improvement, which means being able to do a thorough analysis in combination with the implementation of the solutions found. Aside from this, it is important to pay attention to standardization, because this remains difficult for companies. Instead, they fall back in their previous patterns, and fail to realize improvements in labor productivity. Furthermore, students must learn to become better at analyzing data, for instance, by using process mining or other tools to analyze big data.



## **The Lean and Environmental (Green) Imperative in Lean Education** *Mark Fillingham, United Kingdom*

(Wednesday / November 14)

In May 2015 Roche announced that they would be divesting the site in Clarecastle. From May 2015 through to April 2016, the site was actively for sale with a potential buyer entering a due diligence process in late 2015. Unfortunately, this process proved unsuccessful, resulting in the site downsizing its' headcount by 50% (125 people) between May to Dec 2016. At the end of 2016, the site leadership team were posed with the question: how do we engage all employees remaining on site for the following three years until closure at the end of 2019? This led to the creation of our site vision "to ensure the flawless supply of our product (CellCept) while building our people for their future lives outside of Roche". This was the genesis of the *Lean into Our Future* (LIOF) programme.

Roche Clarecastle started its' lean journey in 2009. Between 2009 to 2013 their lean program was heavily focused on the deployment of lean tools (kaizen, production level loading, business process management, goal deployment and A3 problem solving). From 2013, the focus of the lean program shifted to more systemic change such as TQM, TPM and material flow (examples of key initiatives during this period include: discrepancy reduction; 5S; operator asset care; and, lead-time reduction). The incremental implementation of lean tools throughout the period from 2009 to 2016 created a strong foundation of internal lean knowledge and capability. This was the landscape and foundation for our LIOF programme.

Recognising that the previous lean implementation had been focused solely on tools, systems and performance improvement, the LIOF programme made a promise to employees to be 'better for the business and better for you' and placed leadership behaviour at its core. In this paper we explore the magic that happens when leaders 'turn the mirror on themselves' and when the interest of the learner rather than organisation lies at the centre of a lean transformation effort. That magic consists of a remarkable level of engagement, step changed financial performance and a depth of continuous improvement experience aligned perfectly to future employability.

## **ROUND 3 - THURSDAY 15TH NOVEMBER**

### **11.00 - 12.30**

#### **3.1 Detecting and Elimination Muda**

Room: Guimarães  
18 presentation+4 discussion

#### **Application of lean education for the elimination of waste in a company of the stamped products sector** *Gustavo Guimarães, Brazil* (Thursday / November 15)

The present work was carried out in a company of the sector of Metal Imprints that provides parts for automakers of the Two Wheels Sector that needed to improve the productivity of the process of stamping and welding in the year of 2017. Also, it intends to present the process of development of the professionals of a company of printed products according to the philosophy of lean manufacturing, aiming to carry out activities that reduce the waste in the productive process. For this, the methodology used was a case study, in addition to bibliographical research on the themes of lean manufacturing and lean education. The main results achieved were the absorption of the knowledge obtained that enabled the generation of activities that contributed to the reduction of wastes within the analyzed processes. In the end, we can conclude that for companies to remain competitive in the market, they must invest more and more in human capital. In this sense, lean education is a very viable alternative for reaching the goals and objectives of organizations.

#### **Towards Reducing Queues: Muri, Mura, Muda** *John Bicheno, United Kingdom* (Thursday / November 15)

Taiichi Ohno of Toyota is reported to have said, 'All we are trying to do is to reduce the time from order to cash.' Kingman's equation offers a unifying concept around the hard (quantitative) elements that contribute towards this reduction in lead time through the Toyota concepts of Muda, Muri, and Mura. The equation, based on queuing theory, incorporates four elements: arrival variation, process variation, utilisation, and process time. Utilization has two elements, arrival rate and process rate. This means that there are five interacting elements to the queue or cycle time of a process. Variation can be aligned with Mura, utilisation with Muri, and each element contains waste or Muda. This review paper explores the elements of Kingman's equation and their interactions, the relative effectiveness of Six Sigma, TPM, and various Lean tools. In particular, the paper explores some overlooked aspects of demand and variation, that lead to Lean initiatives not meeting expectations. The ultimate aim of the paper is to contribute towards a unified understanding of Muri, Mura, and Muda: their interactions, priorities, and appropriate use.

#### **A New Approach to Developing Lean Understanding in Higher Education** *Ralph Kriechbaum, Germany* (Thursday / November 15)

In 1996 the authors of "Lean Thinking" James P. Womack and Daniel T. Jones described five principles on how to approach the changes necessary in an organizational context in order to achieve the level of operations they had described in their first book "The Machine That Changed the World"

published in 1991. The focus was to share with the readers how the companies had achieved the level of what was called “Lean” thereafter.

The research described in this conference paper is an innovative approach that sheds light on a new approach to verify the effectiveness of a new way of learning to develop added value processes with reduced and eliminated forms of muda. This new form of teaching developing lean processes differs from the sequence of principles described in the book called “Lean Thinking”. The research was conducted to better understand the challenges educators face in their approach developing an understanding of what the American authors called “Lean” among their students in a university context. In the past teaching had followed the sequence of “Lean Thinking” principles taken from the same named book in the specific order: Value, Value Stream, Flow, Pull and Perfection. Leading students through these five principles had demanded specific sessions of input between the different principles. Without clear guidance from the educator it was impossible for students to understand the necessary steps from one principle to the next. Starting with a traditional batch-and-queue approach of value creation for customers, it had been very demanding for educators to help the students understand the necessary steps to be taken in order to move to a what Womack and Jones called a “flow” approach to value creation.

In the new approach developed in order to open the opportunity to change the role of the educator, the sequence of the five principles has been altered to create an environment in which the students can better develop lean thinking on their own. It requires less additional input from the educator between experiencing the different principles. Thus the educator may give the learners an opportunity to develop an understanding out of their own thinking rather than based on specific input given through principles described in a book written by American authors. The learners get the chance to experience the outcome of their own thinking capabilities. They now may develop a level of pride on the outcome of their own thinking that has been made possible through the new approach to developing an understanding of what the American Authors called “Lean”.

## **Monitoring and controlling real-time production using waste identification diagram *Rogério Santos Menezes, Brazil***

(Thursday / November 15)

The global industry is facing a new technological revolution where the production lines are assisted by computational models that present the information of the machines and equipment in an intuitive and real time way. This electronic supervision contributes to and facilitates decision-making by factory floor managers so that products have cost reduction by eliminating waste. This paper presents an automatic production monitoring system using waste identification diagrams, the Waste Identification Diagram (WID), in a cardboard box making machine. The project evaluates Overall Equipment Effectiveness (OEE) indicators of machine availability, quality and speed before and after the improvements implemented. Programmed and unscheduled losses were compared and those relating to work-in-process, setup, transport, distance, speed and quality were compared. The experiment promotes a positive evaluation of the WID methodology in the identification and elimination of wastes and in the improvement of indicators of equipment failures and failures, reduction of production rate and production of defective items.

## 3.2 Industry 4.0

Room: Ponte de Lima  
18 presentation+4 discussion

### **Industry 4.0 as a way to enhance Lean Manufacturing and Six Sigma**

*Farid Mendonça Júnior, Brazil*

(Thursday / November 15)

The Lean Manufacturing principles are a systematic approach to identify and eliminate waste through continuous improvement. The principle applies tools and methods to systematically eliminate elements that do not add value to the process. On the other hand, the Six Sigma methodology should be used when the variables are unknown, in order to obtain a reduction in variability of the processes to reduce the occurrence of problems or defects. The combined use of these two methods is known as Lean Six Sigma. With the advance of Information and Communication Technologies (ITC), in the context of Industry 4.0, machines will be making ever the more data available, using Machine Learning to map the individual and group behavior. With this behavior exposed and mapped, it will unleash the Lean Six Sigma methodology, as there will be less unknown variables. This article intends to make a counterpoint between the current visions of Lean Six Sigma with the digital components of the Industry 4.0. The methodology will consist of researching secondary data through revision of literature, scientific articles and books specialized in the field of Lean Manufacturing, Six Sigma and Industry 4.0. It is an exploratory research, based on reference and qualitative research.

### **Industry 4.0-based improvement of the Lean game by using the innovative decision support system** *Nikola Gjeldum, Croatia*

(Thursday / November 15)

The Lean Learning Factory is used for the education of industry employees and students in the environment similar to the real factory shop floor. The education process has to be adapted to the increasing variability and changeability due to demands for personalized products in practice. By applying a concept of integrative procedure for management of production and service improvement process on the didactic lean game, it is decided which concept will be developed that will assist trainers during a simulation run. The simulation manual data gathering process and the simulation run results presentation require a large effort of the educator. This disadvantage is even more emphasized if slightly different or personalized products is to be assembled in one moment during the simulation run. The main aim of this research is the application of the developed decision support system within a defined procedure for the selection of the optimal improvement variant. It is based on the multi-criteria decision-making with the help of the HUMANT algorithm and Web application user-friendly interface for defining decision-makers preferences. The system is presented and tested. The decision has been presented. It is decided to use an application of Industry 4.0 concept related equipment, RFID readers and tags for real-time data gathering and automated analyzing and preparation of the gathered data for presentation.

### **Industry 4.0: Knowledge and capabilities needed for workers, middle-managers and top managers** *Carina Pimentel, Portugal*

(Thursday / November 15)



Throughout the several industrial revolutions, the evolution of technology and of the production operations was huge and evident. Following this evolution, it was imperative an adaptation from all the participants in the value chain, from the closest levels off the shopfloor to the top managers, both in terms of knowledge and competencies needed to carry out each position and work.

Currently we are facing a new industrial revolution, the well-known era of Digitalization, the Revolution Industry 4.0. We are facing a revolution where all processes and equipment's will communicate with each other autonomously, new manufacturing and support technologies will emerge, where paper will be replaced by IT-flows and man's influence on manufacturing processes will change radically.

An important question that arises is related to the new need for adaptation by the workforce. Is the existing knowledge enough to deal with such Revolution Industry 4.0? Are the competencies required of employees currently suitable? What new knowledge and capabilities should be required to future professionals?

There is no doubt that adaptations will have to happen. Therefore, this research is focused in the study of the new needs of knowledge and capabilities that come with the Revolution Industry 4.0 in the several hierarchical levels, from the workers in the shopfloor, passing by middle and top managers, through the application of a case study.

## **Learning Lean in High-Variety/Low-Volume: Lessons Learned from the EuroLean project and the learning model in the Lean4.0 project *Menno Herkes, The Netherlands***

(Thursday / November 15)

Looking at learning Lean and understanding and solving problems, it seems that between Industry and Academia is a wide gap. The Lean philosophy of flow and continuous improvement is developed in the Low-Variety/High-Volume context of car manufacturing. Most Lean tools are especially applicable in highly repetitive environments. The recently finished EuroLean+ project focused on Lean principles and tools that can be applied in High-Variety/Low-Volume environments. This resulted in a learning platform for operations managers and scholars in operations management. The platform consists of a dynamically extendable collection of best practices and a number of key instruction video's and other educational content on Lean tools that can be used in High-Variety/Low-Volume companies. We will present results from the Erasmus project Eurolean+, it also provides a preview of the just started Erasmus project Lean European Action Learning Network 4.0 (Lean 4.0). The Eurolean+ project was a collaboration of 4 academia: NTNU (Norway), the HAN University of Applied Sciences (the Netherlands), the Hochschule Osnabruck (Germany) and the University of Gent (Belgium), and several industrial partners.

In Lean 4.0, the same academia and a network of industry partners will use the outcomes of EuroLean as a starting point and focus on the question: How to organize a network learning community between industry and academia for the development of the operations function in a High-Variety/Low-Volume environment?. We will focus on the linkage between Lean methods and Industry 4.0 technologies in companies, as the use of (Smart) information technologies will play an important role in future companies.

Our basic premise is that Industry 4.0 solutions will have an important impact on the development of the Lean philosophy and methods (Khanchanapong, et al., 2014; Kolberg & Zühlke, 2015; Gilchrist, 2016). Currently, however, there is no satisfactory framework combining these two areas (Kolberg & Zühlke, 2015). We will develop such a framework in the project Lean 4.0, using the learning platform of EuroLean+ and develop it further to provide a framework for exchange of knowledge. In Lean 4.0 we will also provide a model (a double learning cycle) to bridge the knowledge & application gap between academia and industry. This will improve the cycle of identifying the right issues, developing knowledge, putting the knowledge into practice and learn, and evaluating the developed knowledge. The use of information technology plays a pivoting role.

In the presentation, we will explain the development and results of Eurolean+ (framework as well as learning content). We will also discuss the Network-Action-Learning- model that will be developed and tested in Lean 4.0.

#### References

- Gilchrist, A. (2016). Introducing industry 4.0. In A. Gilchrist, Industry 4.0 (pp. 195-215). Berkeley, CA: Apress,.
- Khanchanapong, T., Prajogo, D., Sohal, A., Cooper, B., Yeung, A., & Cheng, T. (2014). The unique and complementary effects of manufacturing technologies. *Int. J. Production Economics*, 191–203.
- Kolberg, D., & Zühlke, D. (2015). Lean Automation enabled by Industry 4.0 Technologies. *IFAC-PapersOnLine*, 48(Issue 3), 1870-1875.

### 3.3 Lean Applications

Room: Braga  
18 presentation+4 discussion

#### **Lean practices to improve the learning process and production document control: a case study *Marcelo Pereira, Brazil***

(Thursday / November 15)

The advent of lean practices has driven changes in organizations, especially by seeking systematic practices to identify and improve processes, helping organizations to consolidate a culture focused on knowledge management, training, capacity building, and discipline, aiming at the achievement of organizational results and to the members of the different teams of the company. The case study developed in this work intends to share the practical results of the adoption of automated document control systems within the productive processes, as a component associated with lean practices adopted by the company studied, which is based in the industrial center of Manaus. The work developed was aimed at disseminating lean practices to better control the process, as well as introducing a culture focused on the adoption of good management practices, from the development of automated work instructions to productive process, allowing the teams' self-development, facilitating the training stage of the respective teams that act in the process. As an additional contribution to the organization, it allowed easy access to information, agility to the document management system, ease of updating versions and elimination of physical documents in the production line, giving contributions to the organization's results in the field of quality management, production and teams.

#### **Operations Management and Lean Production – an overview based on publications in journals *Rui Lima, Portugal***

(Thursday / November 15)

In the past decades the interest in Lean Production has increased in the field of Operations Management (OM) and Industrial Engineering. This work characterizes OM from the perspective of Lean, based on papers published in indexed journals in the last four decades. The study combines bibliometric analysis of three set of papers selected from the Scopus database, using search terms related to OM, Lean production and the intersection of these two sets. Additionally, the sets of papers are analysed from different perspectives and methods: analysis of keywords, analysis of content, and qualitative interpretation from outcomes of text mining and Principal Component Analysis. The analysis confirm the myriad of contexts and subjects of OM from the perspective of Lean Production. US, UK and Brazil have been leading the production in the intersection between OM and Lean Production. According to the dimensions of the OMBOK, the top related dimensions found have been 'Planning and Control', 'Strategy', and 'Processes'. From the perspective of Lean Production, the top subjects related have been 'Performance indicators', 'Tools', 'Organizational culture' and 'Continuous improvement'. Text mining and Principal Component analyses confirmed the qualitative results and indicate focuses related to frameworks to deploy Lean in OM environments, the systemic impacts of Lean in organizations and supply chains, and fields of analysis as civil construction and healthcare.

## **Application of Kaizen philosophy to increase productivity: a case study in an electronics industry *Dércio Reis, Brazil***

(Thursday / November 15)

The production line studied is part of the operation of a company, located in Polo Industrial de Manaus, being the second largest Contract Manufacturing in the world in the manufacture of equipment for large telecommunications and computer companies. In pursuit of productive efficiency and cost reduction, companies outsource stages, or even their entire production process. The providers of these services must keep their costs in line with what was predicted when they quote the project, so that they can meet customer demand without harming their financial results. The quotation of the production line of the product under study was elaborated considering the metric of Units Produced per Person per Hour (UPPH) equal to 5.33, that is, the production of 80 pieces per hour using 15 direct employees in the line. However, the line was operating with 2.5 UPPH, producing 53 pieces per hour and using 21 employees. Effective measures were needed to solve this problem. The goal of the project was to identify barriers, reduce the number of line workers by 21% and increase capacity by 29%. The study lasted four weeks and was performed in two stages. In the first stage the operations were filmed and data collection and analysis took place. In the second phase the action plan was drawn up and the improvement actions implemented. During the process, the chronoanalysis of all line operations were performed in order to measure the average cycle time of each operation. After determining the cycle times, the Tack Time of the line was calculated considering a rate of 80 pieces per hour. We used the tools of the lean manufacturing: Brainstorm, Ishikawa Diagram, Pareto Diagram and the Action Plan to correct the problems identified. Once established targets were met, the results obtained allowed the elimination of the divergence between labour costs and expected costs and eliminated delays in deliveries caused by low productivity.

## **Improving healthcare quality in an oncology public day hospital *Julio Garcia Sabate, Spain***

(Thursday / November 15)

The implementation of improvements based on lean manufacturing in hospitals (lean healthcare) could be considered as a relatively mature field, both at the level of implementation and at the level of publications. However, in Spain, most of the publications on the implementation of lean tools in hospitals are located mostly in warehouses or auxiliary services to the hospital. In addition, there are few publications on the implementation of lean tools in public public management hospitals. The article shows the intervention that the signers of the paper made in a public hospital, which was looking for improvements in the management of hospital patients. The authors acted as promoters of the lean by articulating the intervention in the form of very practical courses with doctors and nurses of the different services of the hospital. The paper shows the improvements made in the day hospital, in the section dedicated to the treatment of cancer patients in the chemotherapy phase. The paper aims to show the results of the improvements and the application of the map of the value chain for the diagnosis and creation of the future map, and the identification of the improvements that can be implemented, and those that are considered impossible by the configuration and size of the hospital. In addition, the structure of the courses that facilitated the involvement of the staff (in some cases) and the way of working with the hospital staff that finally led to the implementation of improvements in the day hospital will be shown in the paper.

### 3.4 Lean Games

Room: D.Afonso Henriques  
18 presentation+4 discussion

#### **An Educational Game for Mixed Model Assembly Line Design Using Lean Concepts** *Can Yukselen, Turkey*

(Thursday / November 15)

An educational game is developed for assembly line design using lean concepts. The game aims to show the participants that using lean techniques improves the line efficiency. LEGO® parts are used as educational material to simulate the assembly process of a selected product.

The game has four phases: In Phase 1, the participants assemble the entire product individually to get used to doing assembly operations; in Phase 2, working as a team, they design an assembly line with workstations that ideally have equal workload, while in Phase 3, they are introduced to lean concepts (yamazumi, takt time, pull, built in quality, team leader concept) and then they are allowed to redesign the line. Finally in Phase 4, participants create an mixed model assembly line (MMAL), introduce MMAL balancing concepts and enhance Just in Time (JIT) production system in order to use SPS (set part system) material replenishment system.

At the end of the session Key Performance Indicators of Assembly Lines designed in phases 2,3 and 4 are compared to see the effectiveness of lean concepts on line efficiency. This game has been played by several teams from different manufacturing sectors. KPI (key performance indicators) analysis of the results shows that the performance of the simulated assembly lines has improved after applying the lean techniques and material replenishment system.

#### **The contribution of simulation games in learning Lean Education in students of production engineering** *André Aquere, Brazil*

(Thursday / November 15)

This research study aims to study how the simulation games in Lean Education can contribute to the learning of students of Production Engineering. For this, two educational games are applied, GP3 and LSSP\_PCP3; in a high public education institution. The results show that the use of simulation systems makes more dynamic each of one classes more dynamic classes, providing an environment that stimulates a problem analysis and and the decision making process, which can contribute to the increase of students' learning.

#### **Use of gamification as a tool for developing competences - a proposal of application for analysis and prevention of failures** *Simone Sarges, Brazil*

(Thursday / November 15)

This article proposes the development of an analysis and failures prevention system that makes use of gamification as a strategy for employee engagement. This approach allows the involvement of users with some aspects, such as the narrative of the game, continuous reflection and competition, which is directly linked to the recognition in the industrial organization, that occurs in the form of awards, materials or not, contributing to the personal motivation regarding the fulfillment of the goals pre-established by the company's sectors.

Therefore, a study was carried out through bibliographical research that aims to form a mapping process illustration of the system use and its instructional methods to employees.

## **Would you like some Wine? Introducing Variants to the Beer Game**

Christoph Roser, *Germany*

(Thursday / November 15)

The beer game is a well-known game to demonstrate the bullwhip effect in supply chains. However, this game mechanics offers so much more potential for teaching the effects in supply chains. We extended the beer game to include additional variants. In the spirit of the game (pun intended), these additional variants are wine and schnapps. The original beer game has two rounds, the first to show the bullwhip effect, and a second one to demonstrate how pull production can reduce this effect. In a third round, we introduce wine and schnapps. While the total will be demand is unchanged, the distribution across three variants will wreak havoc with the previously working pull system. In a fourth round the pull system is adjusted, and the participants learn about the increase in inventory needed if the same demand is split across variants. In a fifth round, levelling is introduced. While levelling is a well-known theory, its application is much more difficult. Even though the levelled system matches the expected demand perfectly, random fluctuations will push the system to and usually beyond its limits. The participant's effort to maintain the pull system despite contrary information from the supply chain will worsen the bullwhip effect once the system breaks the levelled approach. In a last and final sixth round the students learn that even a levelled system requires flexibility, and has to be adapted if the demand leaves the range of the levelled system. Hence, throughout the game the participants learn and experience the negative effect of product variants on the inventory, and are introduced to the difficulties of levelling.