Zero Defects in Learning Factories: Excellence in education of manufacturing engineering

Darmstadt | September 8\textsuperscript{nd}, 2015
Research to Improve Future Production:
Welcome to the PTW
TU Darmstadt and the PTW: An Engine for Innovation

26,000 Students
303 Professors (f/m)
13 Departments
5 Areas of study
110 Majors

3,500 Students
27 Faculties
700 Employees
70 Doctorates in 2013

1,300 Listeners per Year
12 Courses/Lectures
87 Employees
50 Running Research Projects and Industrial Projects
Our Vision

Research
We aim for excellent and application oriented research in all our fields.

Teaching
We teach practice oriented subjects through innovative learning methods.

Personal Development
We develop our staff to become future production specialists and executives.
PTW Research Groups

- Machining technology
- Additive Manufacturing and Dental Technology

Production Technology

Main Fields of Application:
- Mechanical Engineering
- Automotive
- Aerospace
- Dental Technology

Production Organization

- Center for industrial Productivity (Process Learning Factory)
- Management of industrial Production
- Sustainable Production
Initial situation for a new learning approach

Survey among 50 staff managers and directors:

• What are alumni of Technische Universität Darmstadt good at?
• Where is a need for improvements?

Results

• 70% of the students are going to work within the departments of production, development or quality assurance
• As future employees in production, the alumni lack of:
  – Knowledge about processes and Lean methods
  – Skills in the establishment and adaption of production systems
  – Perception of ideal workflows in manufacturing and enthusiasm for continuous improvement
Learning by experience on the shopfloor builds lasting knowledge and skills

We keep in mind only a part of the things we perceive:

- 10% of what we read
- 20% of what we hear
- 30% of what we see
- 50% of what we hear & see
- 70% of what we say
- 90% of what we do
8 years of Lean Best Practice at TU Darmstadt:
Process Learning Factory CiP (Center for industrial Productivity)

**Realistic Environment**
- 500 m² space
- 2 machining lines with 9 machine tools
- 2 assembly lines
- Cleaning and QA
- Shopfloor-Management
- Learning-cells

**Real Products**
- Pneumatic cylinder (entire value stream incl. production planning process)
- Gear motor (high-variant assembly)

**Educational Offers**
- Curriculum with 15 Workshops in 27 days:
  - Lean Basics  (2+2+2)
  - Lean Material Flow  (2+2+2)
  - Lean Machining  (2+2+1)
  - Lean Quality  (2+2+2)
  - Lean Thinking  (1+2+1)
The hardware in the learning factory represents a midsize factory in series production.
The CiP curriculum addresses employees who are involved in the implementation of Lean methods.

### Phase 1: Lean understanding
#### Lean Basics
- **Basics and diagnosis**: The need for Lean, 7 types of waste, Value stream mapping, OEE
- **Value stream design**: Pull principle, Flow production, In-takt production, Value stream design
- **Quality techniques**: Lean quality assurance, Poka Yoke, Problem solving, Jidoka

### Phase 2: Lean core elements
#### Lean Material Flow
- **Just-in-Time**: Pull systems, Kanban, supermarket
- **Production control**: Heijunka, Levelling

#### Lean Machining
- **Quick change-over (SMED)**: Change-over time optimisation
- **Maintenance**: Strategies, TPM
- **Cellular Manufacturing**: Selection of Machining Org.

#### Lean Quality
- **Measuring system analysis**: Capability of measuring systems
- **Machine capability**: Machine acceptance test
- **Process capability and SPC**: SPC, control charts

### Phase 3: Lean culture
#### Lean Thinking
- **Leadership for continuous improvement processes**: Improvement and leadership routines, Coaching principles
- **Value added excellence in indirect processes**: Lean Office with 5S, Job structure analysis, Value stream analysis and design
- **Methods- and transfer- competence for Lean trainers**: Sensitisation for Lean, Moderation techniques, Workshop development

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* 1-day-Workshop
** 2-day-Workshop

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**Ability to develop operational excellence in the individual environment**

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**Transformation of CiP to a Lean best practice enterprise**
Example of a lean training
Single minute exchange of die (SMED)

**Day 1**
- Theory
- Simulation game

**Theory**
- Theoretical foundation

**Simulation game**
- Understanding improvement potential

**Day 2**
- Practical implementation

**Practical implementation**
- Knowledge about practical issues

60% practical content

Analysis of changeover process:
- Before standstill
- During standstill
- After standstill

Internal or external steps?
- Internal to external steps

Reduce internal steps
- Optimize external steps

Standardize process

- Analysis of changeover process
- Internal or external steps?
- Internal to external steps
- Reduce internal steps
- Optimize external steps
- Standardize process
## Research Topics of the CiP-Team

<table>
<thead>
<tr>
<th>Competency Development for Lean Production</th>
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<tbody>
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<td>• Methods for institutionalization of continuous improvement processes in production environments</td>
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<td>• Competency development for employees in continuous improvement processes</td>
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<td>• Productivity improvements via implementing low-cost-automation in machining</td>
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<td>• Simulation-based analysis and design of lean material and information flows</td>
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<td>• Supporting lean production systems through information technology</td>
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<td>• Design and optimization of in-house value streams according to „Just-In-Time“ principles</td>
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<td>• Conception and implementation of flexible production and intralogistic systems</td>
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Research Focus
Lean Quality
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Our Competencies
- Quality techniques for lean production in light of the zero defect approach
- Integration of quality management systems and lean production systems

Our Offers for the Industry
- Design and implementation of quality management systems considering lean methods
- Consulting and application support for lean quality techniques
- Coaching in the systematic problem solving process

Partners of the Process Learning Factory CiP

Institute of Production Management, Technology and Machine Tools | Prof. Dr.-Ing. E. Abele / Prof. Dr.-Ing. J. Metternich | 231027Se1 | 12
Research Focus

Competency Development for Lean Production

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Our Competencies

- Design, operation and improvement of Learning Factories
- System for continuous improvement
- Shopfloor Management Systems

Our Offers for the Industry

- Design of customized training modules to the required competencies of your personnel
- Development and stabilization of target-oriented continuous improvement processes
- Supporting the development and implementation of your Learning Factory
- Design and implementation of shop floor management systems

Partners of the Process Learning Factory CiP
Research Focus
Flexible Machining
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Our Competencies
- Holistic approach for flexible machining in Germany, especially by Cellular Manufacturing
- Productivity improvements via implementing low-cost-automation in machining

Our Offers for the Industry
- Support for the introduction of Lean-methods and flow-production in machining (“Lean Machining”)
- Consulting and support for the introduction of Cellular Manufacturing concepts
- Analysis and advisory services for the improvement of changeover and maintenance processes
- Best-practice know-how for low-cost-automation

Partners of the Process Learning Factory CiP

Institute of Production Management, Technology and Machine Tools | Prof. Dr.-Ing. E. Abele / Prof. Dr.-Ing. J. Metternich | 231027Se1 | 14
Gradual development of Learning/Teaching Factories

**since 2007:**
Local Learning Factories, isolated

**since 2011:**
European Initiative on Learning Factories

**2014:**
CIRP CWG on Learning Factories

**2017:**
STC-O Keynote-Paper on Learning Factories

Globalization & Networks
CiP in Numbers (2007-2014)

15 Research Projects

more than 6,500 student visitors via lectures

c.a. 700 visitors per year

more than 2,200 industrial representatives trained

ca. 95 students in 19 ADPs

ca. 120 student theses (BT, StA, MT, DA)

ca. 150 students in 10 tutorials

on average 12 participants per Workshop
Process Learning Factory CiP at TU Darmstadt: Our next steps

- Initial situation
- Inauguration
- Expansion Administration
- Assembly Level 4 “LCA”
- Expansion Internal Logistics

REALITY (Content and Complexity)


One Vision - Many Questions

Building Concept
Start of Trainings
1st Expansion Machining
2nd Expansion Machining
Expansion Industrie 4.0
Thank you very much for your attention!

Please don't hesitate to contact us in case of further questions.

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