Learning factories:
Excellence in education of manufacturing engineering

Process Learning Factory CiP

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Institute of Production Management, Technology and Machine Tools
Technische Universität Darmstadt

www.prozesslernfabrik.de
Welcome to our Institute PTW

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

Production Organization

Sustainable Production

Management of industrial Production

Center for industrial Productivity (Process Learning Factory)
Initial situation for a new 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
First steps: Questions considered from idea to realisation

- Range of topics?
- Didactic methods?

- Managers and Professionals from industry?
- Bachelor and Master students?

- Products?
- Used Technologies?

- Partners?
- Provision of finance?

Initial questions (2005)

Content

Target groups

Hardware

Realisation
Process learning factory CiP at Technische Universität Darmstadt: Milestones in recent years

- Initial situation
- Inauguration
- Award winner
- Expansion Machining
- Expansion Intra-logistics

One vision - Many questions

Building concept

Start of Education

Expansion Indirect processes

Trans-European Dissemination

2005 2006 2007 2008 2009 2010 2011
CiP – the product range is chosen to cover different production characteristics

**Low Variety Production: Pneumatic Cylinder**

- Realization of complete value stream including machining, assembly and indirect processes (order fulfillment)
  - Pneumatic cylinder

**Low Volume, high variety: Gearbox Motor**

- About 4,000 different variants are possible
  - Electric Motor

**Chaku Chaku Machining: Key Fob (as give away)**

- Flexible adaption of machining centers to volume and product
  - Key Fob
The hardware in the learning factory represents a midsize factory in series production.
Properties and probable application ranges of learning factories

### Probable application ranges

- **Education**
  - Universities
  - Vocational schools
  - Enterprises

- **Advanced Training**
  - Groups
  - Small and medium sized enterprises
  - Job-seekers

- **Knowledge platform**
  - Innovations
  - Testing environment
  - Application

- **Network**
  - Learning factories
  - Industry
  - High schools

### Learning factory

- **Properties**
  - Methodology
  - Technics
  - Organisation

- **Didactic**
  - Real products
  - Machines
  - Assembly

- **Experimental Area**
  - Slides
  - Didactic cells
  - Demonstrations

- **Visualization**
  - Researcher
  - Trainer
  - Factory staff

- **Workforce**
Integration of the process learning factory in the education of mechanical engineering students

Master thesis

Tutorial / Advanced Design Projects (ADP)

Lectures: Management of industrial production, Machine Tools and robots, Automation

Bachelor thesis

Lecture: Technology of manufacturing processes

Student workforce, Research assistant (HiWi)
“Learning-Cells” on the shop floor provide a short theoretical wrap-up of each method

„Learning-Cell“:
- 3 to 6 content tables
- Hardware exhibition supports the transfer to practical application

EXAMPLE SMED / QUICK-CHANGE-OVER

**Step 1** MOTIVATION
Description problem in manufacturing and its consequence

**Step 2** FUNCTIONALITY
Visualization of functionality and elements

**Step 3** IMPLEMENTATION
Description of each implementation step

**Step 4** EFFECTS
Demonstration of workflow and process improvement
The CiP curriculum addresses employees who are involved in the implementation of Lean methods.

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<th>Phase 2: Lean core elements</th>
<th>Phase 3: Lean culture</th>
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<td><strong>Lean Basics</strong></td>
<td><strong>Lean Material Flow</strong></td>
<td><strong>Lean Thinking</strong></td>
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<td>Basics and diagnosis**</td>
<td>Just-in-Time**</td>
<td>Leadership for continuous improvement processes*</td>
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<tr>
<td>• The need for Lean</td>
<td>• Pull systems, Kanban, supermarket</td>
<td>• Improvement and leadership routines</td>
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<td>• 7 types of waste</td>
<td>• Production control**</td>
<td>• Coaching principles</td>
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<td>• Value stream mapping</td>
<td>• Heijunka, Levelling</td>
<td>Value added excellence in indirect processes**</td>
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<td>• OEE</td>
<td>Flexible manpower systems**</td>
<td>• Lean Office with 5S</td>
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<td>Value stream design**</td>
<td>• Yamazumi, flexible line design</td>
<td>• Job structure analysis</td>
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<tr>
<td>• Pull principle</td>
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<td>• Value stream analysis and design</td>
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<td>• Flow production</td>
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<td>Methods- and transfer- competence for Lean trainers*</td>
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<td>• In-takt production</td>
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<td>• Sensitisation for Lean</td>
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<td>• Value stream design</td>
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<td>• Moderation techniques</td>
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<td>Quality techniques**</td>
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<td>• Workshop development</td>
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<td>• Lean quality assurance</td>
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<td>• Poka Yoke</td>
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<td>• Problem solving</td>
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<td>• Jidoka</td>
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* 1-day-Workshop
** 2-day-Workshop

Transformation of CiP to a Lean best practice enterprise

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Previous cooperation partners in research and education

Research and vocational education with partner companies

Management Training

Vocational education with regional SME
In the past 5 years a range of managers and professionals have been educated at process learning factory CiP.
## Research Topics of the CiP-Team

### Competence Development for Continuous Improvement Processes
- Methods for institutionalization of continuous improvement processes in production environments
- Competency development for employees in continuous improvement processes

### Flexible Machining
- Holistic approach for flexible machining in Germany, especially by Cellular Manufacturing
- Productivity improvements via implementing low-cost-automation in machining

### Lean Production and Information Technology
- Simulation-based analysis and design of lean material and information flows
- Supporting lean production systems through information technology

### Flexible Production and Intralogistic Systems
- Design and optimization of in-house value streams according to “Just-In-Time” principles
- Conception and implementation of flexible production and intralogistic systems
2011: Foundation of the „European Initiative on Learning Factories“ with the lead of TUD/PTW

Universities in Europe that work with CiP (extract)

- Escola Superior de Tecnologia de Setubal
- Ecole Centrale de Lyon
- Politecnico di Milano
- TU Wien
- University Split
- Hungarian Academy of Science
- Stockholm Institute of Education
Our vision for the year 2020:
Model company at Technische Universität Darmstadt

Intention of the model company

- Enlargement of current education offer for students and industry employees
- Research in comprehensive processes
- Integration and cooperation of several departments in a common object
- Motivation for multidisciplinary research activities
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<tr>
<th>Name</th>
<th>Title</th>
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