Competence-based Process Planning

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Knowledge-intensive Production

- High percentage and diversity of manual work tasks
- Significant qualification requirements
- High amount of customized variants
- Low number of units

Necessity of a flexible production system and organization

Competencies of the workers are a key competitive factor for the production system
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The socio-technical System

Technical System

Production Tasks and Ressources

Requirements

Strategic production targets
(Costs, delivery realibility, Quality, Variability)

Social System

Skilled working personnel

Competencies

Need for quantification of the interdependencies

Integrative process planning enables exploiting potentials of socio-technical System
Survey: Monetary Potentials

- Improved workplace and machine utilization
- Long term improvement of produced products
- Better calculation
- Higher productivity of the production staff
- Increased motivation of the production staff
- Improved quality of work
- Entering new markets with new technologies
- Requirements-oriented personnel development
- Better production transparency
- Improved flexibility for short-term planning
- Knowledge transfer by "training on the job"
- Discharge of the production planner

160.000 €/a potential savings by an average turnover of 6 mio €/a of the 43 companies
Quantification of competencies

(1) Skill-Management-Matrix
   - Categorizing the business area, product and process
   - Including technical, personal and social skills
   - Using standardized competence values (1-5)

(2) Math. description of learning effects „on-the-job“
    incl. variance using expert-knowledge

(3) Quantification of the relationship between competence and process-efficiency

(4) Algorithm-based personnel-assignment (Matching) regarding planner´s preferences
Production Strategy

Degree of competence development orientation [%]

Decision range for an appropriate planning strategy for a defined time period

Strategic competence orientation

Short-term cost orientation

Degree of short-term cost orientation [%]

- a) competence-developing planning strategy
- b) short-term cost-oriented planning strategy
- c) Exemplary positioning of the production system
Concept overview

Frame
- Requirements to the products and processes (work plans, work instructions, etc.)
- Framework conditions of the production based on number of orders, availability of workers
- Competencies of the production workers (professional, self and social skills)

Classification of product and process requirements

Matching

Competencies and learning effects of the workers

Strategy and decision making

Process Planning
- Decision range for an appropriate planning strategy
- Degree of short-term cost orientation [%]
- Degree of strategic competence orientation [%]

Production and efficiency result
1. Order Management
2. Process Management
3. Employee Management
4. Competence Management
5. Competence-based Planning
6. Results Analysis
Software prototype

1. Product
2. Process times (min, potential min, potential max)
3. Qualification criteria according to the DQR for the job competencies
4. Potential (normalized)
5. Requirements: Assembly, machine
Case-study

- **Company A** producing complex investment goods
  - cellular manufacturing  sequenced flow- production
  - 37 employees, high diversity of needed qualifications
  - Aim: 20% more Output with the same number of production workers
Competence-Analysis

Combined product- and process-specific competence description is basis for qualification
Proposed learning curves

Learning curves considering learning and teaching capabilities have been formulated

- a) Shift of one competence-level
- b) Shift of two competence-levels
- c) Shift of three competence-levels
Cost-benefit ratio

- Definition of 4 workers to be qualified „on-the-job“ by team work within 5 weeks based on the Skill-Management-Matrix
- Learning and teaching capabilities and the resulting time and costs have been quantified (process-efficiency factors)

Aim:
- Degree of flexibility: 100%
- Benefit: 20% higher Output
- Costs: 150,000 €

Benefit: +3 % Growth in flexibility
- Costs: 15,000 €

Integrated production- and personnel-planning with focus on competence growth
Summary and Outlook

• Competencies are one main competitive factor in knowledge-intensive production systems

• Current approaches focus on technical or social aspects with unsufficient integration and quantification of the subsystems

• A new method and software-prototype have been developed allowing for an
  – integration of „on-the-job“ competence-development
  – by a combined production- and personnel planning and the
  – calculation of the resulting cost-benefit-ratio

• The method has been evaluated in a first case-study for flow-production for specialized vehicles

• IT-support for competence development and adaption of production organization will be implemented in future projects
Thank you for your attention!

Questions?

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Backup
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average monetary saving potential/year

improved workplace and machine utilization
long term / strategic improvement of the produced products
better calculation
higher productivity of the production staff
increased motivation of the production staff
improved quality of work
entering new markets with new products and technologies
requirements-oriented personnel development
better production transparency
improved flexibility for short-term human resource planning
training / knowledge transfer through "training on the job"
discharge of the production planner

percentage of indications

1-1.000€  1.001-5.000€  5.001-25.000€  25.001-50.000€  >50.000€  average value
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Complexity of the production system / Requirements to competencies

Single-process

Process chains

Number of observed dependencies and parameters

Input
Process
Output
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Competence Analysis

Requirements Matrix

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<th>Requirements</th>
<th>Process 1</th>
<th>Process 2</th>
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<tr>
<td>B</td>
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Competence Matrix

<table>
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<th>Worker 2</th>
<th>...</th>
<th>Worker n</th>
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<td>Y</td>
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Requirements: e.g. Product Knowledge, Process Experience, Technical Skills

Competencies: e.g. Process experience, Formal Qualification

Process Modelling and Optimization

- Process modeling of the virtual chain
- Optimization parameters
- Target function (costs, time, quality, flexibility...)
- Pareto-Optimization and experienced based a-posteriori choice of best parameter-set

Planning of coupled Process Chains

- Long-term production planning (integrated technology and competence-oriented)
- Systematic improvement of competencies „on the job“ through KPIs (cost-benefit-ratio)
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1. Basic settings
2. Process Chain Planning
3. Competence Management
4. Optimization Settings
5. Results Analysis