"Development of Competences in Product Development in Engineering Education"

o. Prof. Dr.-Ing. Dr. h. c. Albert Albers / Ol Norbert Burkardt

IPEK – Institut für Produktentwicklung

Indirectly Feasible Assessment Criterias

1. Professional Competence
   - fundamentals in various disciplines
   - internalization of the most important basics

2. Methodological Competence
   - design methodology
   - problem solving
   - various methods & tools
   - QFD, DOE, CAQ, CAD, CAM

3. Social Competence
   - working techniques of working
   - communication and team ability
   - visualization & presentation skills
   - leadership

4. Elaboration
   - Transformation, ideas, presentation
   - costs & decision making

5. Creativity
   - problem sensitivity
   - creativity techniques
   - courage for new solutions
   - ...
Karlsruhe Institute of Technology
One institution. Two missions.

Staff
8,000

Professors
350

12 km - 20 min

Students
23,500

Million Euros Budget
650
IPEK - Institute of Product Engineering
IPEK ▪ Institute of Product Engineering Karlsruhe

Facts

- 2 professors
- 7 research groups
  - 3 senior engineers
  - 54 scientists
  - 20 technical staff
- education
  - since 1996 50 Ph.D.
  - 14 lectures
  - over 300 student assistants
  - ~3000 coached students
- equipment
  - automotive test labs
  - high performance computing
  - test vehicles
  - mech. & elec. workshops
IPEK Research Approach

**systems**
- drives
  - e.g. vehicle powertrains
- mechatronical systems
  - e.g. humanoid robot
- micro systems
  - e.g. micro planetary gear
- power tools
  - e.g. direct fastening tool

**methods**
- validation methods
- Contact & Channel-Model
- development methods
  - e.g. knowledge management
- optimization methods
  - e.g. topology optimization

**process models**
- holistic development processes
  - e.g. integrated product engineering model iPeM
- optimization processes
IPEK Research Approach
Research Fields

- drive systems
- optimization
- lightweight design
- condition monitoring
- design methods and management
- friction systems
- NVH / driveability
- mechatronic systems
- appliance and power tool design
Armar III in Action

Recognition and 6D pose estimation of colored and textured objects
Fiber Reinforced Structures in humanoid Robots (ARMAR IV)

- **Benefits:**
  - Energy consumption
  - Safety
  - Precision
  - Dynamic Operating Conditions

Body designed as a Hybrid Structure

Multifunctional Light-Weight Wrist-Joint
Validation
Driveability und Comfort assessment
Importance of „Competence“ in Education

- Competencies are **skills of individuals** [According to Weiner (2004)]
  - to solve certain **problems**
  - to **use** related motivational, volitional and social skills
  - to enable successful and responsible **problem solving** in **various situations**

- **Deficiencies** in Academic Education
  - Which are the **predominant deficiencies** of applicants?

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>55.1%</td>
<td>47.0%</td>
<td>38.4%</td>
<td>13.1%</td>
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</tbody>
</table>
Assessment of Competencies

Indirectly Feasible Assessment Criterias

5. Creativity
- problem-sensitivity
- creativity techniques
- courage for new solutions
- ...

4. Elaboration
- ability in transferring ideas
- presentation orientation
- cost awareness
- decision making

Indirectly Feasible Assessment Criterias

1. Professional Competence
- fundamentals in various disciplines
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- ...

2. Methodological Competence
- design methodology
- problem solving methodology
- Various methods such as QFD, DoE, CAD, CAQ
- ...

3. Social Competence
- individual techniques of working
- communication and team ability
- visualization & presentation skills
- leadership
- ...

Directly Feasible Assessment Criterias

Hindered Assessment Criterias
Influencing Factors on Creativity

Experience  Creativity  Phantasy

Knowledge
High Expectations in Education

- ... The government has to treat its universities neither as secondary schools nor as special schools...
  [Wilhelm von Humboldt (1767-1835)]

- ... Researching education and educational research form the universities...
  [Albert Albers]

Our demand: Research and development of methods and processes for product engineering including their evaluation using real systems and prototypes and their integration into excellent education and teaching.
KaLeP: Karlsruhe Education Model for Product Engineering

Karlsruhe Education Model for Product Development (KaLeP)

<table>
<thead>
<tr>
<th>Courses</th>
<th>Environment</th>
<th>Key Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture Tutorial</td>
<td>Realistic industrial environment</td>
<td>Integration into design</td>
</tr>
<tr>
<td>Project</td>
<td></td>
<td>project work</td>
</tr>
</tbody>
</table>

- **Courses**
  - Lecture
  - Tutorial
  - Project

- **Environment**
  - Realistic industrial environment
    - Team 1
    - Team 2
    - Team 3
    - Team 4
    - Team 5
    - Team 6
    - Team 7
    - Team Coordination
    - Industrial Cooperation Partner
    - Prof. Albers

- **Key Competencies**
  - Prof. Competence
  - Creativity
  - Methodol. Competence
  - Elaboration
  - Social Competence
# KaLeP: Karlsruhe Education Model for Product Engineering

<table>
<thead>
<tr>
<th>Course Focus</th>
<th>Systems</th>
<th>Methods</th>
<th>Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>Machine Design</td>
<td>Methods of Product Development</td>
<td>Integrated Product Development</td>
</tr>
<tr>
<td>Settings</td>
<td>Lecture</td>
<td>Tutorial</td>
<td>Lecture</td>
</tr>
<tr>
<td></td>
<td>Tutorial</td>
<td></td>
<td>Tutorial</td>
</tr>
<tr>
<td></td>
<td>Project</td>
<td></td>
<td>Project</td>
</tr>
<tr>
<td>Competence</td>
<td>High</td>
<td>Medium</td>
<td>Very High</td>
</tr>
<tr>
<td>Acquisition</td>
<td>Team Work</td>
<td>Design Methods</td>
<td>Team Development.</td>
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<tr>
<td></td>
<td>Self Organization</td>
<td>Creativity Techniques</td>
<td>Team Leading</td>
</tr>
<tr>
<td></td>
<td>Communication</td>
<td>Idea Transfer</td>
<td>Project Management</td>
</tr>
<tr>
<td></td>
<td>Idea Transfer</td>
<td></td>
<td>Presentation</td>
</tr>
<tr>
<td>Course Content</td>
<td>Project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Students</td>
<td>800</td>
<td>400</td>
<td>42</td>
</tr>
<tr>
<td>Curriculum</td>
<td>Bachelor</td>
<td>Bachelor</td>
<td>Master</td>
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</tbody>
</table>

Prof. Albert Albers – KaLeP: Karlsruher Lehrmodell für Produktentwicklung – Ein Ansatz zur Kompetenzerfassung in der Ingenieurausbildung
KaLeP: Karlsruhe Education Model for Product Engineering, Machine Design 1-4

- **Lecture**
  - Content: theory
  - Theoretical basics
  - Style: ex-cathedra
  - Place: lecture hall
  - Students: 800

- **Tutorial**
  - Content: theory
  - Particular cases
  - Style: ex-cathedra
  - Place: lecture hall
  - Students: 800

- **Project**
  - Content: project tasks
  - Practical comprehension
  - Style: team work & coaching
  - Place: team work spaces
  - Students: 5 (x160)
  - Tools: CAD, PDM, wiki
Machine Design: Project Work

- Lectures covering the basics of Mechanical Design with >800 students (Systems Engineering, Bearings, Gears, Clutches, etc.)
- Tutorials and workshops to gain practical experience
- Accompanying 4 months of project work, typical fields of mechanical engineering


**St-o-A Review**
- Cross-team cooperation
- First meeting of student group

**Concept**
- Team work
  - Wiki
  - CAD, PDM

**Full Product**
- Team work
  - Wiki
  - CAD, PDM

**Presentation**
- Feedback Discussion

Prof. Albert Albers – KaLeP: Karlsruher Lehrmodell für Produktentwicklung – Ein Ansatz zur Kompetenzerfassung in der Ingenieurausbildung
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4. Elaboration
- creativity in transferring ideas
- problem orientation
- cost of costs
- decision making

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- problem-sensitivity
- creativity techniques
- courage for new solutions
- ...

Indirectly Feasible Assessment Criteria

Directly Feasible Assessment Criteria

Hindered Assessment Criteria
Focused Assessment of Communication- and Teamwork-Competencies

- Essential promotion of social competencies
  - Problem: **Enormous range** of social competence
  - Challenges: **Imparting and assessment** of social competencies in education

- Communication- and teamwork-competencies as essential elements of social competence
  - **Essential pre-condition** for employment in engineering
  - Teamwork as **essential element** for integrated product development
  - Holistic approach to product development: **Humans in the center**
Focused Assessment of Communication- and Teamwork-Competencies

- **Cooperation project:** Inst.fürTechnikdidaktik KIT Karlsruhe, ITB Bremen, LMU Munich
- Identification and definition of **indicators** for professional teamwork
  - Professional **communication and conversation** in human interactions
  - Identification and definition of **tasks and roles** of a successful team
  - Application of **teamwork-methods** (MS Project, Wiki) for coordinated actions
  - Identification, definition and assessment of **individual and team achievements** for holistic approaches and results
- Indicators **successful implemented** in elements of **KaLeP:** Karlsruhe Education Model for Product Engineering
Promotion of Teamwork-Competencies

- Machine design: design project
  - High complexity of task
  - Designing a racing motor scooter
- Application of teamwork-methods
  - MS Project and Wiki
  - Essential pre-condition for success
  - Teamwork as essential element
High Complexity of Design Project
Assessment of Teamwork-Competencies

- Evaluation of teamwork-methods
  - Evaluation and assessment of *type and level of use* in design project
  - Mandatory *documentation and verification* of correct use
  - Documentation is *subject of assessment*
  - Special *weighting evaluation key* in use for assessment
  - **Comparison** with feasible assessment of professional competencies

- Assessment of communication- and teamwork-competencies
- Assessment of social competencies
GEARE - Global Engineering Alliance for Research and Education

- KIT (IPEK)
  Karlsruhe, Germany
- Purdue University,
  West Lafayette, IN, USA
- SJTU Shanghai Jiaotong University,
  Shanghai, China

- Exchange program for undergraduate students (internship and study abroad)
- Exchange program for graduate students (thesis research in international teams)
- Long distance project-work
Exchange program for undergraduate students:
Exemplary Timetable 2009/2010

<table>
<thead>
<tr>
<th>Period</th>
<th>Location</th>
<th>Country</th>
<th>Activity</th>
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<tbody>
<tr>
<td>Spring 2009</td>
<td>Karlsruhe</td>
<td>Germany</td>
<td>Study</td>
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<td>20.04. - 25.07.09</td>
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<td>USA</td>
<td>Industrial Internship</td>
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<td>Fall 2009</td>
<td>USA: Study</td>
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<td>Purdue</td>
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<td>01.09. - 19.12.09</td>
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<td>China: Study</td>
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<td>Industrial Internship</td>
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<td></td>
<td>01.09.09 - 30.01.10</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30.01. - 30.04.10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Design Task mkl IV Workshop - Result
(Sponsored by „EUROPA Park“)
Designed at KIT (4. Semester)
Design Task mkl IV Workshop - Result
Prototyping at Purdue (5.Semester)
Example mkl examination SS 2012 (time 3 hours)

Task:
Design of a Drilling Machine
(Box Column Drill)
Students Result

![Diagram of a mechanical device]

1.0

2.0

Note: Detailed technical drawing with annotations and dimensions.
Students Result
IP Lectures – Structure Project Work

Company

Projectmanager

Projectmanagement

N.N.  N.N.  N.N.

Company

N.N.

N.N.

N.N.

Technologie

Innovation

Team 1  Team 2  Team 3  Team 4  Team 5
IP Powertrain 2015 Project
Teamdevelopment
Integrated Product Development
Project Example

**Task** Project „GreenKeeper“ IP 03/04

Development of an **innovative product** for the company STIHL, which extends the product portfolio in the **target market** „Lawn & Garden“ in a promising way.
Integrated Product Development
Project Example

Konkreter Projektverlauf

<table>
<thead>
<tr>
<th>Task</th>
<th>TTM-Project</th>
<th>Market Launch</th>
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<tbody>
<tr>
<td>Kick-Off</td>
<td>Carrier Support System HT</td>
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<td>Profiel</td>
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<tr>
<td>Concept</td>
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<tr>
<td>Embodiment</td>
<td>Series development at STIHL</td>
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</table>

------------------------ 4 Months --------------------------

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-------- 18 Months ------
IPEK - International Education

- University of Purdue, USA
- DEFIS – Paris / Metz, France
- EDC University of Cambridge, UK
- SJT und Tongji University Shanghai, China
- FDIBA – TU Sofia, Bulgaria
- University of Budapest, Hungary
- University of Nis, Serbia
- Partners of Tempus IV 2012 (Nis, Belgrad, Sarajevo, Skopje, Sofia, Novi Sad, Kragujevac et.al....)
Outlook

- Identification and definition of **indicators for creative competencies**
- Integration into **concepts** for assessment of creative competencies
- **Evaluation and verification** of concepts using KaLeP education and training groups:
  - **Transparency and traceability** of assessment results
  - Constructive Alignment
  - Scholarship of teaching and learning
  - BMBF **research projects**
IPEK teaching approach

Learning Methods by „Experience and Suffering“

- „Anyone is Creative; In Most Instances Methods are Missing.“
  Edward de Bono

- Learning Methods You Must Look for Applications Under Realistic Conditions

Parole: Never Give Up!