Transdisciplinarity and the Definition of Competencies and Standards

Prof. Dr. Ing. Walter E. Theuerkauf
Agenda of the presentation

• Introduction
• Global Situation of Technology Education
• Holistic view on Technology
• Transdisciplinary Description of technology
  • Model of a general Process
  • Theory of closed and open loop Control
  • Theory of Problem Solving
  • Theory of psychological regulation of actions
  • Theory of technological thinking and acting
• Definition of competencies and Standards
• New Learning arrangements
  • Learning Theories - Constructivismus
• Summary
Situation of Learning Technology in School

Combination of Technology with other disciplines
- Mechatronic
- Bionic
- Biotechnology
- Nanotechnology

International terms of Technology Education
- Technology Literacy
- Science and Technology
- Mathematic, Science and Technology (MST)
- Design and Technology (D&T)
- Design and Engineering (D&E)

Situation in Germany – Different states = Different opinions
- “Sachunterricht” (Social, scientific and technical Dimensions)
- Technology as discipline
- Science and Technology
- “Arbeitslehre” (Economy, Home Economics, Technology = Work orientated
- Mathematic, Science, Informatics und Technology
Situation of Learning Technology in School

Background in Pedagogic:

- Humanistic conception has eliminated the industrial school concept.
- Hand Skill Movement in Finland, Sweden and Denmark (Slöyd)
- "Without Hand Skill the academic education do not generate practical abilities" (Cygnäus)
Mechatronic is not a subject, science or technology it is instead to be regarded as a philosophy.

Mechatronic is a fundamental way of looking at and doing things and by its very nature requires a unified approach to its delivery." (Tonkinson, Horn 1995)
A comprehensive engineering means to regard all processes and reflect the understanding of the influence of technology for human being worldwide.
Theory of the circulation - Water Cycle, Material Cycle, Blood Cycle e.g.

- Water Cycle
  - Evaporation
  - Condensation
  - Rain precipitation
  - Flow

In höheren Luftschichten Wasser verdunstet durch Sonneneinstrahlung

Über Bäche und Flüsse gelangt das Wasser wieder ins Meer

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Purification plant for water – Technology scheme

Process integrates mechanical, chemical and physical procedures.
Open and closed loop control

Biotechnology – Transdisciplinary Discipline

Products = Processes

Application fields

Engineering

Cross Section Technology

Life Science Disciplines

Basic Discipline

Medical, Nutrition, Agriculture, Environment

Chemical, Physical, Manufacturing Technology

Biotechnology/ Biogenetic

Biochemistry Microbiology, Virology e.g.

Biology

Quelle: Abicht et. al., Unterricht Arbeit & Technik

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Model of a general process.

Source: Graube, Theuerkauf 2002

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Process to produce a bread in a bakery

Technical dimension

Social dimension

Durchschnittlicher Bruttostundenverdienst in Handwerksberufen in Deutschland 2003-2006

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Theory of closed and open loop Control

Flow of Information

Environment

Energy

Aktorik

Basic Operation

Sensorik

Prozessor

Feedback

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Transdisciplinary communication

Structure of an enterprise

Management
Designing
Controlling
Manufacturing

Horizontal Flow of Information

Vertical Flow of Information

Digital Cross Linking

Significance of information for communication on all levels

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Technical thinking and acting

Product Life Cycle Management

Innovative thinking and developing new solutions,
Calculating and designing a construction,
Realization and fulfill manufacturing requirements,
Logical and distributing processes
Evaluative and experimental procedures
Use, maintenance and repair
Careful use of our resources and ecological point of view.
Theory of the Procedure of Problem solving

1. Problem
   - Analyzing the problem
   - Structuring the problem
   - Defining the problem

2. Search for existing solutions
   - Find innovative solutions
   - Systemizing solutions

3. Analyzing the solution
   - Assessment of the solution
   - Fixing the solution

4. Solution

5. Search for the solution

6. Selection

7. Search for the target

8. Analyze of the situation

Creativity

Assessment / Decision

Source: Lindemann

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Theory of psychological regulation of actions

Target

Conditions

Comparison

Anticipation

Feedback

Change

Obstacle

Test

Exit

Operate

Source: Hacker 2005

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## Competencies for Technology Education

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Description of necessary contents/ abilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>► Analyze technical processes and system.</td>
<td>Systematic classification and description of technical processes and systems on the field of mass-, heat-, and information transfer; description of the way they form technological structures</td>
</tr>
<tr>
<td>► Apply technology.</td>
<td>Structural understanding of how to apply technology; basic technical skills, both theoretically and practically</td>
</tr>
<tr>
<td>► Communicate technical facts.</td>
<td>Basic knowledge of technical terms and technical language; basic knowledge of the documentation of technical facts</td>
</tr>
<tr>
<td>► Evaluate technical processes and systems.</td>
<td>Evaluate technology by taking into account how technology, men, nature, and society interact with each other</td>
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</table>
## Standards of Technology. Extract of 12 Standards

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
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</table>
| 1   | **Product development:**  
• explain, apply, and give reasons for the technological structuring of product development |
| 2   | **Basis methods of approaching technological problems:**  
• description of technological problems  
• development and description of possible solutions  
• knowledge and application of the necessary mathematical methods of calculation  
• comparative evaluation of possible solutions  
• realization of solutions |
| 3   | **Practical basic skills:**  
• explain and practice the appropriate, safe, and environmentally sound handling of selected technical materials, tools, appliances, and machines |
| 4   | .......... |
Legitimation for Subjects for teaching technology

Disturbed Balance in the world by the
- acceleration of industrialization
- rapid growth of the population
- worldwide malnutrition
- exploitation of reserves of raw materials
- devastation of the living space

Basic Needs of the human being
- Work and production
- Energy as the source of our live
- Living space
- Communication and mobility
- Food and health of the human being
- Household and his implications

Technical change
Key Innovations

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Communication between engineering and business administration

Communication square

Business Administration
Sequenz of Process

Technical Sequence
of Process

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Connection between economy, business administration and Technology

Import

Export

Foreign Countries.

Investment

Loans

Enterprise

Capital in banks

Household

State Germany

Taxes

Taxes

Flow of Money and Goods

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Constructivismus demands holistic views

Constructivismus means to impart real life. Therefore it is necessary to regard the criteria of transdisciplinarity (Ulrich, Probst 1988) as follows:

- Prozessorientation means to reveal complex and net worked structure of processes
- Description of processes by theoretical models which show the connection of the operations (Copy of a process)
- Cross linkage of facts within the processes with digital information (databases)
- Concatenation of natural and artificial processes.
- Confrontation with actual and key problems.
Learning arrangements – Models represent Reality

Manufacturing Model Plant

Virtual Factory (Cosimir)

Source: Festo Didaktic

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Learning arrangements

Internet lab
Exchange and multiple use of facilities

Learning Community
Cooperation between public and vocational schools

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Orientation at Key-Technologies in Companies and Households

High automated assembly line

Intelligent building

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Summary

Real Life mean a transdisciplinary view

Transdisciplinarity demands:
• Process orientation in technology education,
• Technology takes in real life the role of cross discipline,
• Standards represent technological thinking and acting = Technology
• New Learning methods (Case Studies, external cooperation's, e.g.)
• Leaning arrangement outside of School - Companies, Universities, e.g.
• Technology has to be imparted as a compulsory component in programs for teacher training.
• Cooperation with other disciplines an other institutions.
Hybrid model plant. Manufacturing and processing operations

Technology can only survive if there is a solution to handle transdisciplinarity.

Thank you for your patience.

Quelle Festo Didactic

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Produkt Lebenszyklus

- Produkt-Entwicklung
- Produkt-Entstehung
- Fertigung
- Montage
- Vertrieb
- Betrieb
- Recycling

fertigungs-, montage-, prüf., normgerecht
kostengerecht, formgebungsgerecht
beanspruchungs-, ausdehnungs-, korrosions-, risikogerecht
recyclinggerecht

Quelle: Eigner

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Annual Conference 2008 Salt Lake City

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[Diagram with processes and timelines]
Konstruktionszeichnung mit Entwurf für die Einhausung des bionischen Manipulators

Quelle: TETRA