Teaching Methods in Engineering Education

Didactic of Engineering Education
Socialization in professional and social life

Requirements on employees in structures of production and service

Determine the content

„Berufliche Handlungskompetenz“

Out of it be derived

"Employability"
"Flexibility"
"Learning"

Didactic Intentions

Methodical Procedure

„Majority“ „Mündigkeit“

• philosophical positions
• educational psychological regularities
• sociological insights
• ...

„Act-Theory“
Didactic-methodical design of engineering education

**external side**
forms of organisation

- (1) of vocational lessons/lectures
- (2) of vocational learning
- (3) of vocational teaching

**internal side**
internal structuring

- (1) didactic functions
  - (2) methodical procedure
The Term: Teaching Method

“System of rules, which defines classes of possible operational systems, which lead from certain starting conditions to a definite objective.”

(Klaus, G; Buhr, M: Philosophisches Wörterbuch Bd.2. Leipzig 1996, S.717)

“Method, therefore, is a logical structured step or sequence of operations of actions to achieve a definite objective.... Method is defined by the logic of the subject and the structure of the subject of its object and its contents respectively.”

(Klingberg, L.: Einführung in die allgemeine Didaktik. 1974, S.279f)

“Teaching methods are these forms and procedures through and with which teachers and students acquire their surrounding natural and social reality under institutionalized conditions.”

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<th>Examples</th>
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<td>Objective aspect (aimed at achievement characteristics and behavioral characteristics of personality)</td>
<td>Methods for the development of skills, attitudes and beliefs</td>
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<td><strong>Epistemological aspect</strong></td>
<td>Reductive and deductive methods, historic-genetic approach</td>
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<td>Aspect of the didactic function within the process of imparting and acquisition</td>
<td>Methods of introduction, consolidation, practice, control</td>
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<td>Aspect of the interaction of pedagogical guidance by the teacher and self-activity by the learner</td>
<td>Methods of lecturing, demonstration, teaching conversation, independent work of learners</td>
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<td>Aspect of the use of specific teaching aids</td>
<td>Methods for the work with lecture books, programmed instruction aids</td>
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By **teaching method** we describe a system of act orientations by the teacher to initiate learning acts with the aim of shaping personality traits, which are aimed at achieving competence of action. (in a defined area of action)
Example for inductive method

Thermal insulation

example 1: thermal insulation in Germany

22°C 10°C

stonework

insulating material

example 1: thermal insulation in Bangkok

22°C 35°C

Vapor barriers have to be put on the warm side of the insulating material.
Example for inductive method

Subject: serial connection of resistances

\[ R_1 \quad R_2 \]

measuring of resistances
(measuring of U-voltage and I-current)

\[ R_{\text{tot}} = \frac{U_{\text{ges.}}}{I} \]

<table>
<thead>
<tr>
<th>R_1</th>
<th>R_2</th>
<th>R_{\text{tot}}</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>20</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>30</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>100</td>
<td>10</td>
<td>110</td>
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</tbody>
</table>

(Designations in Ohm)

**generalisation**

\[ R_1 + R_2 = R_{\text{tot}} \]
Analysis of several facts which are supposed to have a common regularity

Emphasizing similar features in all facts. Between the features of a fact are essential connections

Formulating the realization, that in all examined facts each feature exists because of the other one.

Transferring this realization on all facts of the same type under the same conditions that is generalizing the relations between the features through induction.
Example for deductive method

Thermal insulation

22°C — 10°C

stonework

insulating material

vapor barrier

Why the Vapor barriers have to be put on the warm side of the insulating material?
Example for deductive method

Subject: serial connection of resistances

pre-conditions:
laws after Kirchhoff
law after Ohm

\[ U_{\text{tot.}} = U_1 + U_2 \]
\[ I_{\text{tot.}} = I_1 = I_2 \]

\[ R_{\text{tot.}} = \frac{U_{\text{tot.}}}{I_{\text{tot.}}} = \frac{U}{I} = \frac{U_1 + U_2}{I} \]

\[ R_{\text{tot.}} = \frac{U_1}{I} + \frac{U_2}{I} \]

\[ R_{\text{tot.}} = R_1 + R_2 \]

\[ R_1 + R_2 = R_{\text{tot.}} \]
Deductive Teaching Method (general - particular)

Problem or task description

Establishing general statements or rules of which at least one has to refer to the relevant fact

Step-by-step connection of the statements towards problem or task solution

Formulating the final concluding sentence, in comparison with the posed aim

If necessary, experimental corroboration of worked out finding

Rose, H.; Thomas, W.: Unterrichtsmethodik Elektrotechnik
Berlin 1986
Example:

Structure of the **bacterial** cell

Starting from the bacterial cell as a whole, the teacher split the cell under the aspects of **structure and function** in their parts:

Components: the nucleus-equivalent, plasmids, cytoplasm, cytoplasmic membrane, cell envelope
Example:
Programming a CNC machine

- Manufacturing steps for producing a component
- Characteristics of the individual production steps
- Dependencies between the production steps
- Sequence of manufacturing steps

Transfer the structure into a CNC program
Deductive (2) path of cognition

Relation of logical consequence:

example: 1) Petrol in my car is used up
          2) The engine in my car stalls.

\[
\begin{array}{ccc}
1) & 2) \\
W & W & W \\
W & F & F \\
F & W & W \\
F & F & W \\
\end{array}
\]

\[
\begin{array}{ccc}
1) & 2) \\
W & W & F \\
W & F & F \\
W & W & W \\
\end{array}
\]
**Logical equivalence**

A) A triangle is equilateral (3 equal sides)

B) A triangle has equal angles.

**Logical antilogies**

All students are hard-working

No student is hard-working

Some students are hard-working

Some students are not hard-working

\[ (1) \quad (2) \quad (3) \quad (4) \]
Beispiel 1:

A1: In young sourdoughs, the dough is still not evenly interspersed with strong gas developers. (e.g. yeast)

AND

A2: Use of dough that is not evenly interspersed with strong gas developers leads to uneven pore structure in the pastry.

LC: The use of young sourdoughs in bakery production leads to irregular pore structure in the pastry.
Beispiel 2:

A1: The use of young sourdoughs in bakery production leads to irregular pore structure in the pastry.

A2: Young sourdoughs is used for bread making.

LC: The bread has an irregular pore structure.
Deductive (II) Teaching method

**Deduction:**

initial statements (Premise) → thought-process → concluding statement (conclusion)

Using logical reasoning

The deductive proceeding in class is characterized by the logically consistent deduction of the realization from true initial statements.
Reductive Teaching method

Reduction:

- initial statements (Premise)
  - thought-process
  - Using non-logical reasoning (work with hypotheses)
  - final statement(s)

The reductive proceeding in class is characterized by the development and confirmation of hypotheses.
Example for regressiv-reductive method

- **Initial point:** fusion Chrysler - Fiat
  - example is characteristic for actual economic development

  **What are the reasons for these economic concentration processes?**

- Discussion about the implications for the company

  - **Marketing** → fortification of marketing potency, prevention of competition, independent price formation,
  - **Production** → expedient division of labour, coordination of research, rationalization of capital equipment
  - **Capital** → self-financing through profit-shifting, financial independence
  - **Material** → discount, self-furnisher
  - **Personnel** → exchange of experts

- Implication for the company if it doesn’t expand:
  - danger of competitive capacity
processes of economic concentration are necessary for companies to save their international competitive capacity (hypothesis)

formation of big corporates, syndicates and cartels
Example for regressiv-reductive method

- Inductor has magnetic field only, if electric current flows through it. $\rightarrow$ directed flow of charge carriers
- Bar magnet has its characteristics on the basis of molecular magnets.

$\rightarrow$ What is the reason for magnetism in molecular magnets?
Example for regressiv-reductive method

- Basic parts of molecular magnets are iron atoms.
- Iron atoms have moving electrons in their atom mantle.
- Through direction of this movement of electrons is a directed flow of charge carriers possible.
- *(Molecular current hypothesis after Ampere)*

→ common essence of inductor and bar magnet
The regressive-reductive method

Analysis of a given fact, which is in its appearance unknown to the learner or whose effect has to be traced back to a yet unknown cause.

Defining the goal of realization

Emphasizing such characteristics which are supposed to be of importance to the establishment of a realization.

Assigning the fact to already known and explained appearances, causal relations, rules

Stating a thesis about the nature, cause, reason of the fact

Explaining the fact by means of the hypothesis.

Rose, H.; Thomas, W.: Unterrichtsmethodik Elektrotechnik
Berlin 1986
Carbonating of concrete

Initial advisement:

- The hydration of cement in concrete builds calziumhydroxid \( \text{Ca(OH)}_2 \)
- This \( \text{Ca(OH)}_2 \) is the reason for a high pH-value in concrete (12,6)
- If the pH-value about 9 it isn’t possible that corrosion proceeds → It isn’t possible that core iron rusts in concrete.

But: Marginal core iron in concrete rusts! Why?
- Corrosion is only possible if pH-value lower than 9

**hypothesis:**

- Through environmental influences the pH-value on the surface of concrete decreases

**confirmation of hypothesis:**

If the hypothesis is true, than pH-value on the surface of new concrete is significant greater than the pH-value of older concrete which was caught environmental influences.

**test → pH-indicator**

- results:
  - new concrete 12,6
  - old concrete 8,3

Hypothesis is confirmed.
The hydration of cement in concrete builds calcium hydroxide 
\[ \text{Ca(OH)}_2 \]
Calcium hydroxide has a pH-value of 12,6.

→ new concrete has a pH-value of 12,6

Carbon dioxide (CO\(_2\)) in air react with water to carbonic acid (H\(_2\)CO\(_3\)).  
\[ \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3 \]

Calcium hydroxide react with carbonic acid to calcium carbonate  
\[ \text{Ca(OH)}_2 + \text{H}_2\text{CO}_3 \rightarrow \text{CaCO}_3 + 2\text{H}_2\text{O} \]

Calcium carbonate has a pH-Value of 8,3

→ Old concrete has on the surface a pH-value of 8,3

Rust protection is only ensure if the pH-value about 9.

→ It’s possible that core iron near by surface in concrete rusts.
Molecular current hypothesis after Ampere is the initial point.

- Through direction of movement of electrons in the iron atoms is a directed flow of charge carriers generated. This directed flow of iron atoms is the reason for magnetism in molecular magnets.

Confirmation of hypothesis:
If the hypothesis is true then must a disorganisation of the direction of movement of electrons in the iron atoms cause decrease or forfeiture of magnetic field.

How is it possible to discreate the direction of movement of electrons in the iron atoms?

- to knock the bar magnet on a table
- to anneal the bar magnet

Knocking of the bar magnet causes decrease of magnetic field.
Annealing of the bar magnet causes forfeiture of magnetic field.

→ Hypothesis is confirmed
Progressive-reductive method

The starting conditions are:
A hypothesis about the nature, cause, reason of a fact

Analysis of the hypothesis

Drawing conclusions from the hypothesis, for example through experiment or observation in reality

In case there is a correspondence between conclusions and reality then the hypothesis can be considered as probably true, otherwise it is wrong

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Berlin 1986
### Teaching methods under the aspect of path of cognition

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<tr>
<th>Analytic</th>
<th>Whole - Part</th>
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<tr>
<td>Synthetic</td>
<td>Part - Whole</td>
</tr>
<tr>
<td>Deductive 1</td>
<td>General - Particular</td>
</tr>
<tr>
<td>Inductive</td>
<td>Particular - General</td>
</tr>
<tr>
<td>Deductive 2</td>
<td>Attaining true statements by truthful-logical conclusions</td>
</tr>
<tr>
<td>Reductive</td>
<td>Attaining true statements by non truthful-logical conclusions</td>
</tr>
<tr>
<td>Genetic</td>
<td>Imperfect - Perfect</td>
</tr>
<tr>
<td>Historic</td>
<td>Logical - Historical</td>
</tr>
<tr>
<td>Causal</td>
<td>Cause - Impact</td>
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Criteria of choice of teaching methods

- characteristics of the matter of acquisition
- pedagogical intentions
- pre-conditions of learners
- temporal and spatial conditions
Thank you for your attention