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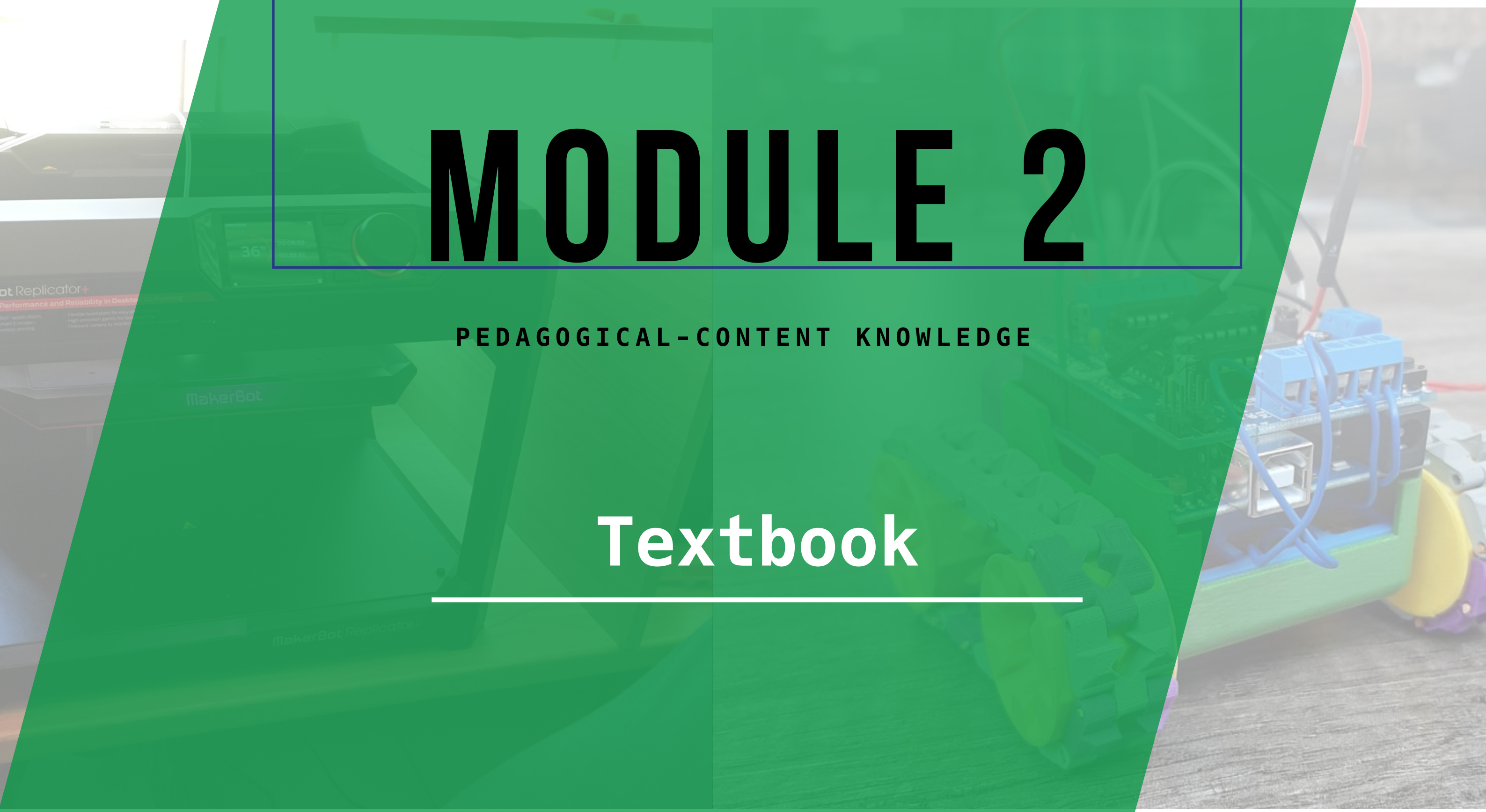

MODULE 2

PEDAGOGICAL-CONTENT KNOWLEDGE

Textbook

MODULAR TRAINING & EDUCATION

Education is Future

IN MECHANICAL
& ELECTRICAL ENGINEERING

TRAINME

EDITING

1st Edition

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This study book has been developed within the bilateral programme TRAINME in order to promote in-service lecturers in the fields of mechanical and electrical engineering at South African TVET colleges. The programmee has been designed by the Inter-Company Training Center in Easter Bavaria (ÜBZO) and University of Stuttgart on behalf of the German Federal Ministry of Education and Research and DLR in cooperation with the South African Department of Higher Education (DHET).

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ABOUT THIS BOOK

This textbook is part of the TRAINME programme Module 2 for TVET Lecturers in Mechanical and Electrical engineering. The textbook pursues an approach to 21st century learning by critically reflecting on the main findings of instructional design models & concepts, methods of instruction and learning task design. It supports your understanding of the relationship between learning and teaching by questioning:

1. Was it good instruction in the fields of Mechanical and Electrical Engineering?
2. How do I implement the curricular requirements in a learning-effective manner?
3. How do I create a competency-based lesson?
4. How do I design a learning situation with a motivating action situation and use subject-didactic teaching / learning paths?
5. How do I moderate teacher-student conversations professionally and effectively?
6. How do I design motivating tasks ?

The accompanying workbooks support you to apply theory from this textbook to practice.

EXPLANATION OF ICONS

Further Reading

Watch a Video

Cross Reference

When you click on the icons or when you scan the QR-Code you will be led to particular files, websites or videos.

Content

Unit 1: Introduction

Unit 2: Instructional Design Models, Concepts & Principals

Unit 3: Methods of Instruction

Chapter 1

Basics of Pedagogical-Content-Knowledge for TVET

1.1 INTRODUCTION

Pedagogical content knowledge (PCK) or Didactic is a special combination of (deep) knowledge of the structure of a specific subject/topic AND knowledge about subject-specific pedagogy or „didactics“ (in European terminology). According to Shulman, PCK is an academic construct that represents requirements, acquisition, and application of educators competences (Shulman, 1986).

It is an idea rooted in the belief that teaching requires considerably more than delivering subject content knowledge to students, and that student learning is considerably more than absorbing information for later accurate regurgitation (Loughran et al., 2012). PCK is the knowledge that teachers develop over time, and through experience, about how to teach particular content in particular ways in order to lead to enhanced student understanding. However, PCK is not a single entity that is the same for all teachers of a given subject area; it is a particular expertise with individual idiosyncrasies and important differences that are influenced by (at least) the teaching context, content, and experience (Loughran & Mulhall, 2012).

In the TVET context with its strong theory-practice, complex task-structures with various responsibilities and partly conflicting interests, PCK is more challenging than in the pre- and secondary educational system (Lipsmeier, 1980).

Didactics

The word didactics comes from the Greek word “didάskein” (dida´skein), which means teaching. The scientific term didactics (sometimes also spelled “Didaktik” as in German) stems from the German tradition of theorizing classroom learning and teaching. Didactics serves as a major theory in teacher education and syllabus development, especially in the German-speaking and Scandinavian countries. With a slightly different meaning, it is also employed in the Dutch (algemene didactiek) and Africaans literature. General didactics re-presents the overarching theory of both decision making on and processes of teaching and learning in societal institutions (especially in schools and universities devoted to general and domain-specific education) (Arnold, KH., 2012).

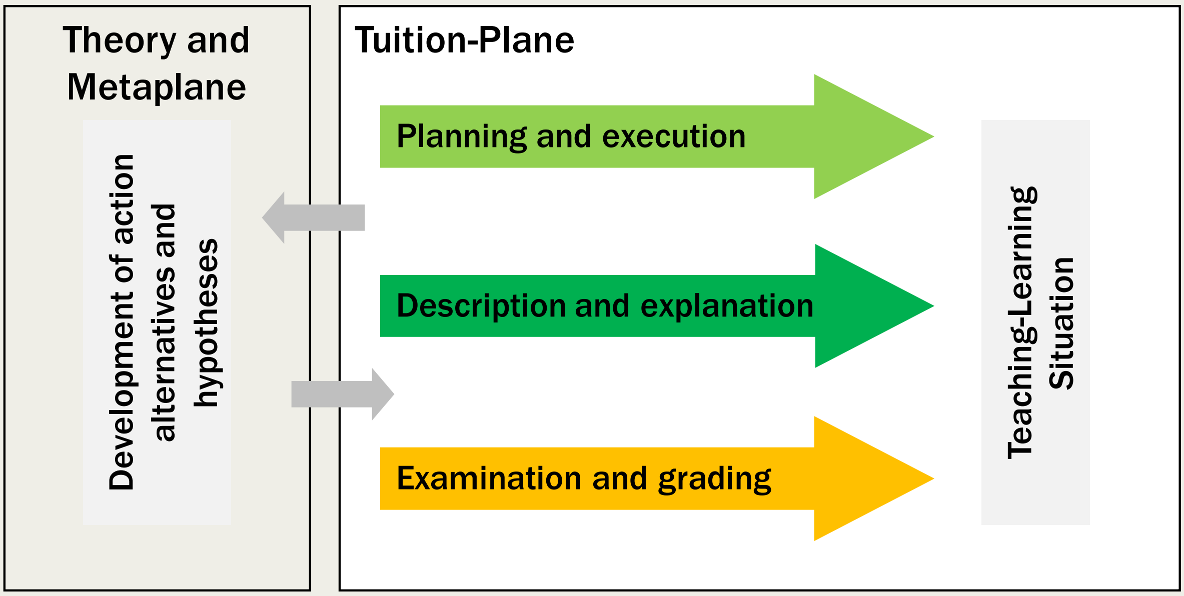


Figure 1| Objectives and Functions of PCK (Source: Own construction based on based on Euler, 1997, pp. 100–102; Tenberg, 2006, p. 12)

Pedagogical-Content-Knowledge of Teachers at TVET Colleges

Example of the Fields of System and Information Technology for Electronics Technicians

The rapid technological advances in information and communication technology are changing in the world of work, but also our communication behaviour both in our work and private life changes to a large extent.
Therefore, the German *Standards for Didactics* (Ministry of Culture, Youth and Sport, 2018) describes aspiring pedagogical-content knowledge in the fields of Systems and Information Technology for Electronics Technicians at TVET colleges.
For didactics of system and information technology, the adoption to the rapidly changing technologies requires to concentrate on the fundamental functional principles, clear modeling, and techniques that have a generally applicable, exemplary character, enable transfer and can represent the basis for future innovative developments.

Following areas are part of the pedagogical-content knowledge (or didactics) of System and Information Technology:

- Basics and basic circuits of the analog and digital electronics,
- Configuration and programming of microcomputer and microcontroller systems,
- Basics of network technology,
- Functionality and configuration of network components,
- Conception, construction and provision of Communication networks,
- Basics and basic circuits of the analog and digital transmission technology.

Lesson Preparation & Reflection

The teacher teaches the students how the systems and information technology work. In doing so, both the life and the working environment of the students are taken into account in a special way. The Teacher

- creates concrete learning situations, illustrates technical laws,
- maps technical processes through simulations,
- uses comprehensible models for mapping complex systems,
- uses didactic reduction to show fundamental connections.

Practical relevance and orientation for action are promoted through device-related teaching [...]

Teaching & Managing

Teachers design learning processes based on universal teaching principles.
Teachers illustrate learning content and learning objectives using experiments and simulations. The Teacher

- pays attention to the greatest possible practicality,
- takes into account the state of the art,
- uses motivating, technical problems,
- involves the students.

Assessment

In system and information technology, several solutions often compete. The Teacher is aware of the exemplary nature of their teaching model and therefore attaches importance to a comparable and transparent performance assessment [...]

Education

The teacher is aware of her role model function. It takes ethical aspects into account when implementing subject-specific content. Teachers have an impact on students' behaviour to be careful about the facilities and equipment.

1.2 STEPS OF LEARNING IN ACTION-BASED EDUCATIONAL SETTINGS

How does learning occur in a competency-based lesson?
The learners get into the learning process with competencies and hopefully leave with more and more developed competencies. The learning process follows a sequence of five steps.

Step 1: Definition of a Problem
The first step is to discover and develop the problem (question, topic, task, relevance, ...). On this and the next step, the affective and cognitive system of the learner is brought into imbalance by a „disturbance ". The learning incentive is thus generated to bring the affective and cognitive system back into balance (e.g., by assimilation or equilibration). The individually adjusted overabundance as a form of the disturbance brings the learner into the imbalance.

Step 2: Development of Concepts
In a second step, individual ideas are developed, negotiated, and brought forward for discussion. This also includes the introduction of previous experience, prior knowledge, opinions, attitudes, etc. On one side, this is already a learning process and on the other, it is the basis for subsequent learning. The level of experience and knowledge is made conscious and public.

Step 3: Editing Learning Material or Evaluation of Information
Without new information. Data, experiences, external impulses will not increase in learning in the intended sense. Therefore, the learners receive appropriate information about learning materials from the teacher, which the learners process and evaluate individually or in suitable social forms. In this third learning step, learning products of material nature (table, mind map, text, sketch, picture, diagram ...) or also of an immaterial (spiritual) nature in the form of knowledge are created. This is where learning growth takes place. The learning growth, the learning-added value, the knowledge growth, the competence expansion is - figuratively speaking - still in an amorphous, unstable, and fluid state and must „coagulate" in the subsequent phase, stabilize and solidify.

Step 4: Discussion of the Results or Products

During the processing of the learning materials, the evaluation of the information, and the creation of the learning product, new ideas are formed. Old ones are expanded or refined and made more precise. In the fourth step, these individual new ideas are articulated, verbalized, reshuffled, and compared and negotiated with those of other learners. In this step, the learning group will agree on common insights in the sense of a common core. By discussing the learning product in the group, the knowledge and learning gains coagulate into a concentrate.

Step 5: Definition of Knowledge Development

In the fifth step, the learning gain is defined by comparing it to the ideas developed in the second step. The learning gain is tested as a competence in the active use of knowledge. The learners must apply what they have learned to new tasks, possibly in a new context. In this way, it is tested whether the competence gain can stand up to successful handling. Additionally, this step creates learning awareness by becoming clear and aware of the learning growth.

Step 6: Improvement, Connection, Transfer

The new knowledge learned in a particular context, and possibly applied in another context, is decontextualized and anchored in an expanded and expanded knowledge network. Since the storage in the memory takes a different path from the physiological point of view than the retrieval, the use of what has been learned is practiced, and dealing with the acquired knowledge is habituated.

Parts of this chapter are translated literally or rephrased from the following source: Leisen, J. (2010). Lernprozesse mithilfe von Lernaufgaben strukturieren.

Chapter 1

Instructional Design Models & Concepts

1.1 Introduction

Models of instructional design are conceptual frameworks that provide well-developed ways of teaching and learning. Instructional models assist teachers in helping students learn how to learn. Teaching models indicate the types of learning and outcomes that could be anticipated if they are used. Researchers believe that using a variety of models is a characteristic of excellent teaching. Instructional design models (or models of didactics) are usually developed with a twofold intention:

- It provides dimensions to describe didactical activities and thereby serves as an instrument for the structural analysis of the decisions made as a basis for the reflection on the given conditions.
- It provides a scheme to plan educational activities in a structured way, moving from the conditions to the decision fields.

Therefore, planning methodical arrangements of teaching and learning and / or educational material that will guide learners to achieve their learning objectives easily starts with instructional design.

There are several models developed and discussed in the discourse on didactics: communicative didactics, didactics for learning and teaching, action-oriented didactics, didactics based on neuroscience, dialectical didactics, didactics with focus on learners and teachers (and not only on content), etc.

1.2 ”Bildung“ -Centred Approach to Didactics (Klafki)

Klafki‘s Didactic Analysis is a well known approach in general didactic. Klafki has been the dominant figure in general didactics in the Federal Republic of Germany, however, his work is increasing in other countries (Meyer & Rakhkochkine, 2018). According to Klafki, didactic analysis is the core of preparation of instruction (Klafki, 1995). Klafki’s model offers Didactic Analysis as an approach to decide on the content of education on the one hand, and on the substance of content on the other hand (Sedelmaier, Landes, 2015). A question that arises for the teacher is:

Which contents and subjects do young people have to deal with in order to achieve a self-determined and rational life in humanity?

Klafki proposes to use a guideline that contains five guiding questions to address this confrontation:

”I. What wider or general sense or reality do these contents exemplify and open up to the learner? What basic phenomenon or fundamental principle, what law, criterion, problem, method, technique, or attitude can be grasped by dealing with these contents as ‚examples?
[...]

II. What significance does the content in question, or the experience, knowledge, ability or skill to be acquired through this topic already possess in the minds of the children in my class? What significance should it have from a pedagogical point of view?
[...]

III. What constitutes the topic’s significance for the children’s future?
[...]

IV. How is the content structured (which has been placed in a specifically pedagogical perspective by questions I, II and III)?

[...]

V. What are the special cases, phenomena, situations, experiments, persons, elements of aesthetic experience, and so forth, in terms of which the structure of the content in question can become interesting, stimulating, approachable, conceivable, or vivid for children of the stage of development of this class.“

Klafki (1995): Interest Matters: The Importance of Promoting Interest in Education

(Klafki, 1995).

On that account, Klafki's didactical analysis presents the „worthwhile" contents that a teacher must select as requiring justification. The justification is sought on the basis of factors **present significance**, **future significance**, **exemplary significance**. In addition, the **structure of content** and **accessibility** must be applied to and weighed as criteria for the selected content. The competencies of the learner are explicitly developed through an active, mutual confrontation of an individual with reality (Klafki 2007, 27-35). The teacher's role is key decisive here in terms of content selection and its methodological presentation. The question of what content should a student be confronted with, which can never be answered unequivocally, poses a challenge to didactics.

Example of Didactical Analysis Using the Conventional Milling Maschine

1. A milling is generally an elementary machining method for both metallic and non-metallic materials, which enables time-saving, effective and „high-precision" machining, e.g. for the production of fits.
2. These basic manual skills are a prerequisite in the metal industry for understanding and operating a CNC machine.
3. Different materials require different tools, feed rates, speeds, etc. Milling machine can give an idea of the limitation of surface treatment and the use of coolants on different materials. For instance, when a fine surface treatment is desired, a grinding machine is required. The quality also depends on the feed rate, the speed and the choice of tool.
4. The structure of the topic fits in a number of practical material processing topics. For example, knowledge of the tools used, the formulas for calculating the cutting speed and the feed rate in connection with the material to be machined.
5. Accessibility: By demonstrating the operations of a CNC machine and possibly pre-processing steel with conventional tools such as a saw or a file, the meaning and special features of the machine are made impressively clear to the students.

1.3 DIDACTICS FOR LEARNING AND TEACHING (BERLIN MODEL)

Six basic questions for an analysis of a lesson

- What is my intention of doing something?
- What do I convey to students' horizon?
- How do I do that?
- By what means do I realize this?
- To whom do I impart this?
- In what situation do I impart this?

The didactics for learning and teaching (Berlin Model) can be used as a method to plan, analyse and reflect teaching processes. At the centre stands the structural analysis of lessons. According to the model, activities are characterised by four fields which define the range of necessary or possible didactical decisions: Intentions, content, methods, and media; all fields are interdependent in intricate ways. Furthermore, didactical activities are constrained by two general conditions – anthropological-psychological and socio-cultural conditions. They characterize the individuals participating in the activity and the socio-cultural situation in which these individuals are embedded, ranging from the small groups to society as a whole. Finally, each didactic activity has consequences for the participating individuals (anthropological-psychological consequences, e.g. enhancing one's competence) as well as for the group or the society (socio-cultural consequences, e.g. changes in attitudes or values).

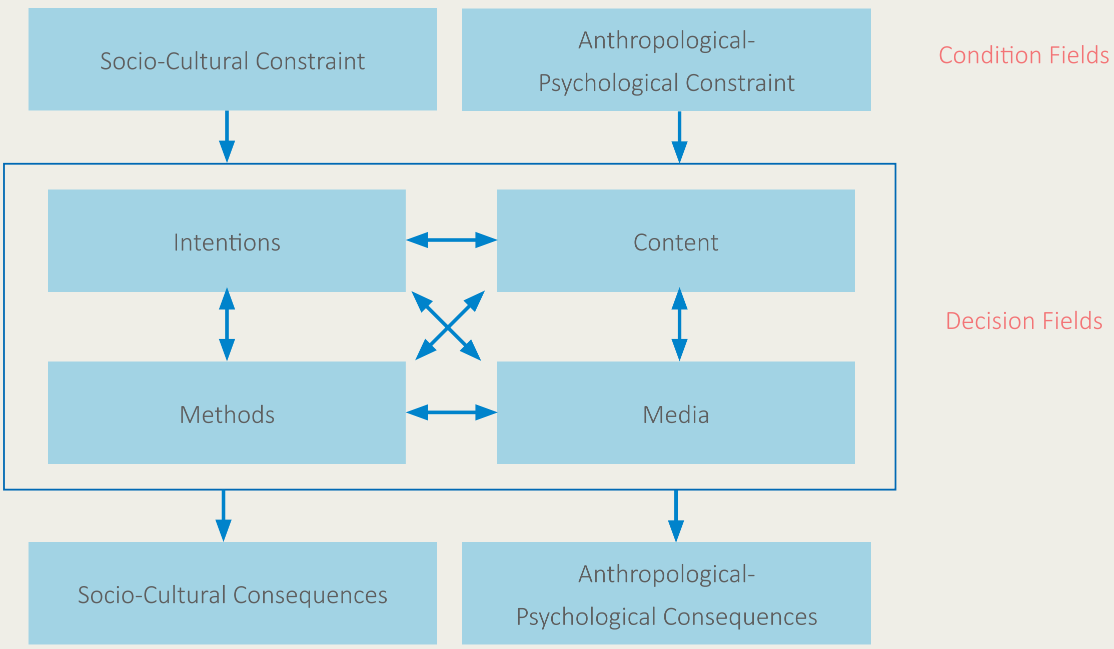


Figure 2 | The Berlin Model (Source: Own construction based on Peterßen, 2001, p. 54)

1.4 ACTION-ORIENTED LEARNING

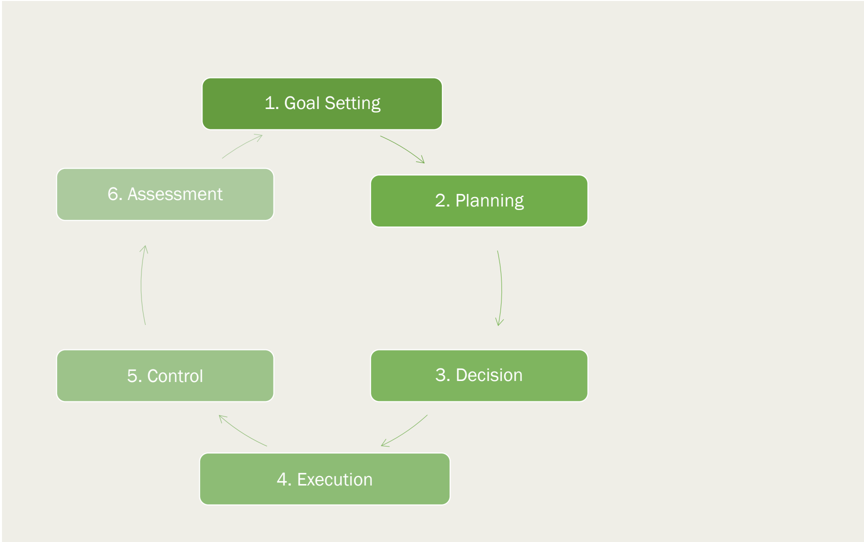


Figure 3 | Lesson Based on Actions (the six factors should be used to build up the lesson) (Source: Own construction based on Nickolaus, 2012)

In Module I, you have already learnt about the acquired abilities and - so to speak 21st century - skills, and the relevance for competence-based learning into the various levels of training and further education. However, the science of education, and the didactics in TVET in particular, have offered us only rough clues about how to employ which method in order to develop competence Empirical research, shows us that action-oriented concepts are suited to facilitate the learning of skills to cope with constant change, and social skills (Lindemann, 2002; Nickolaus, 2012). The foundation of action-oriented learning is the planning and implementation of the task as well as the subsequent control and evaluation. The acquisition of action knowledge takes place by means of active problem solving in complete actions, where in addition to technical, also overarching methodological, social and personal competences will be acquired (Lindemann, 2002; Nickolaus, 2012). Besides the development of competences, some effects of action-oriented learning are increased motivation, better possibilities of inner differentiation (Nikkolaus 2012, p. 83), and better development of the individual professional skills .

Lindemann (2002): The principle of Action-Oriented Learning

"The point of professional training is to confront apprentices in vocational training and/ or as well pupils of professionally oriented educational careers of secondary schools with practice related tasks that have to be solved. The background is always a specific profession-related and, above all, complex situation; subsequently instructions are commissioned that have to be worked out. From a didactical point of view, these tasks of apprenticeship and work are the creative instruments of instructors and teachers (Lindemann, 2002)."

1.5 CONCEPT OF GOAL ORIENTATION (TAXONOMIES OF LEARNING)

In the 1950s, Benjamin Bloom and a group of collaborating psychologists created a framework for levels of understanding that classifies the different skills and objectives the educators set for their students. Each educational achievement depends on the level below. It's often depicted in the form of a pyramid—similar to Maslow's hierarchy of needs.

Over the years Bloom's taxonomy has been revised, and alternative taxonomies have been created. One important contribution of Anderson and Krathwohl was the addition of actionable verbs for each level.

Krathwohl (2001): A Taxonomy for Learning and Assessing

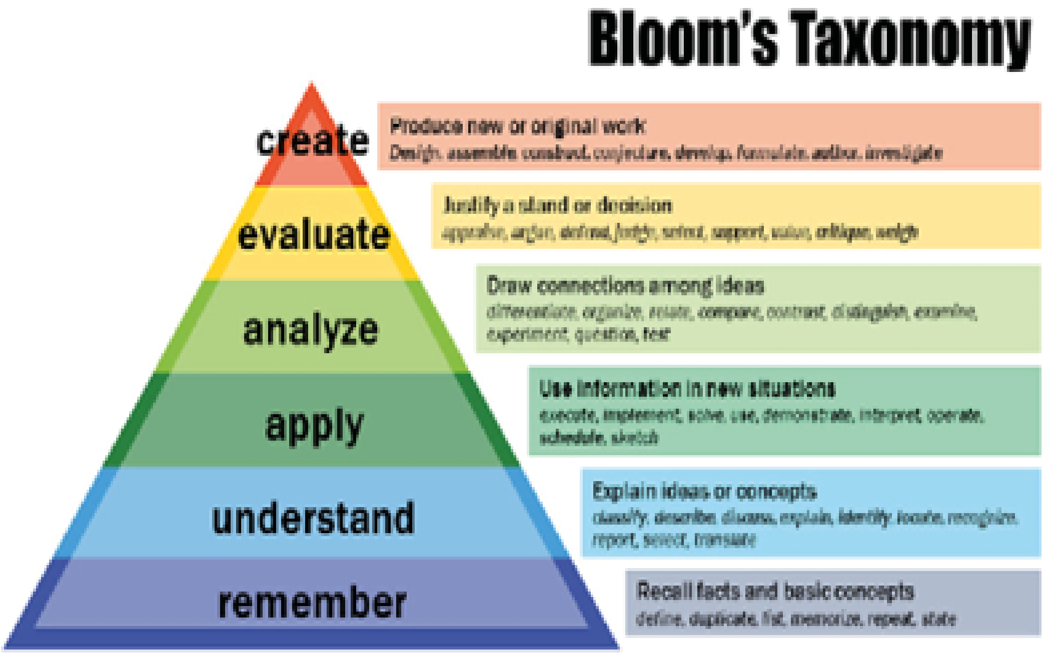
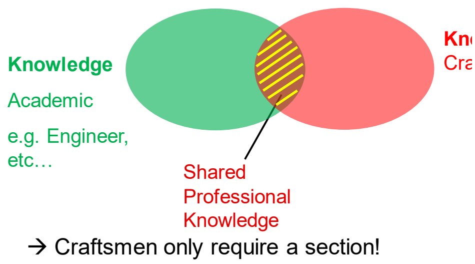


Figure 4| Blooms Taxonomy (Source: „Bloom's Taxonomy" by Vandy CFT is licensed under CC BY 2.0)

More about Anderson and Krathwohls taxonomies, see Workbook- Lesson Plan

1.6 METHOD OF SIMPLIFICATIONS & IDEALIZATIONS (DIDACTIC REDUCTION)



The conversion of complex facts and phenomena into students' conceptual understanding is a core requirement for teachers in the preparation and implementation of learning opportunities. In the area of technology, initial scientific statements are too abstract (qualitative problem) and too complex (quantitative problem). A skilled worker only needs to know a subset from the initial statement. Therefore, content and topics must be simplified and reduced to its essentials.

How can complex content and topics be simplified and reduced to its essentials?

The Didactic Reduction is a method that helps to reduce the complex and abstract statements, and presents them in a student-friendly manner!

Didactic reduction consists of two series:

- Horizontal and
- vertical didactic reduction,
- or the combination of the two directions.

Subject analysis
- Complex elements of a lesson

Didactic structuring
- Components to understand subject matter

Restriction analysis
- Expected learning difficulties

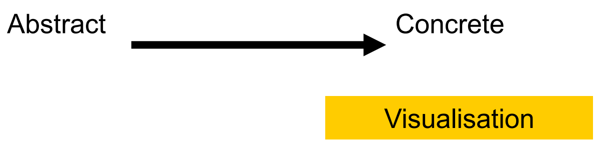
Horizontal Didactic Reduction
- Visualisation

Vertical Didactic Reduction
- Which components can be neglected?
- What restrictions on validity scope can be attributed?

Figure 5 | Decision-Steps for Didactic Reduction

1.6.1 HORIZONTAL DIDACTIC REDUCTION

- The conclusion is coordinated with a concrete statement
- Eligibility perimeter is retained



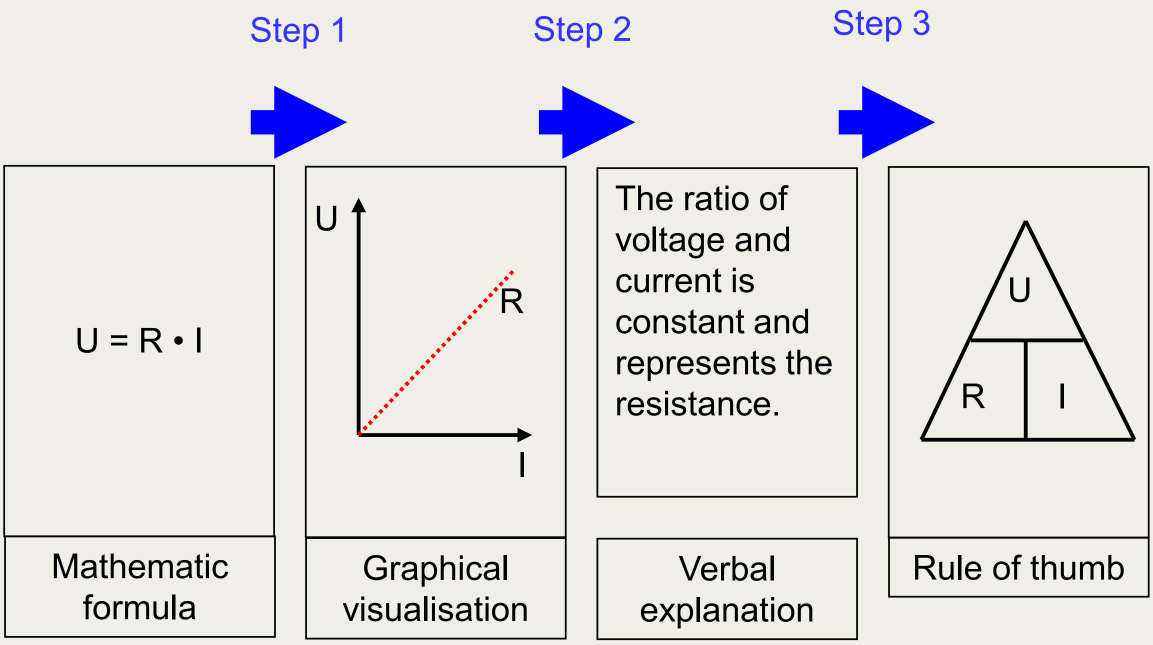
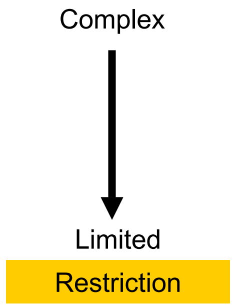


Figure 6| Horizontal Didactic Reduction (Source: Own construction based on Grüner 1978, S. 76 – 96)

1.6.2 VERTICAL DIDACTIC REDUCTION

- An excerpt is formed from the initial statement
- Validity scope is reduced



Eligibility	Expression
Scientific Statement	$\oint_A \vec{B}\cdot d\vec{A}=0$ $\oint_s \vec{E}\cdot d\vec{s} = -\int_A \frac{d\vec{B}}{dt}\cdot d\vec{A}$ $v(t)=\lim_{\Delta t\to 0}\frac{\Delta x}{\Delta t}$
Electrically charged particle in magnetic field • Electrical part is temporarily constant • Magnetic field is temporarily constant • Velocity is constant	$\vec{B} = const.$ $e = 1{,}602\cdot 10^{-19}\,C$ $\vec{E} = const.$ $\vec{F}_L = q\cdot(\vec{B}\times\vec{v})$ $\vec{v} = \frac{l}{t}$
• Particles are perpendicular to the magnetic field • Vector component is negligible • Permeability is negligible	$F_L = q\cdot B\cdot v$

1. Step

2. Step

Figure 7| Vertical Didactic Reduction (Source: Own construction based on Grüner 1978, S. 76 – 96)

NOTES

Chapter 1

Methods & Concepts of Instruction

1.1 INTRODUCTION

The structure of a lesson is based on these two questions:

1. Is the teaching designed in such a way some effects of action-oriented learning are?
2. Does teaching allow each individual to acquire the subject matter individually and actively?

The effectiveness of all education systems depends largely on the quality instruction (including cognitive activation, classroom management and social support; see Textbook Module 1) and learning in the classroom, workshops, laboratories and other places where education takes place. If effective teaching and learning happens, teachers need to use a variety of methods and techniques at their disposal. Methods of instruction are forms and procedures by which teachers and students acquire and communicate the natural and societal realities around them in a class setting (Jank & Meyer 2011, S. 54). In the advanced sense, classroom methods is a general term for attempts to mediate between the individual-subjective requirements and interests of the student, and the objective standards under guidance of pedagogic intentionality, whereas the standards often manifest themselves both in subject-specific sciences and in standards set by society. Methods refer to the 'how' of the class; i.e. the way to communicate knowledge and skills, and how to teach proper learning. In another scope: The method should guide the student to a fruitful encounter with certain contents and to assist them when attaining and process them.

There is a wide diversity in teaching methods and techniques, no one method can be regarded as the best for every teaching situation

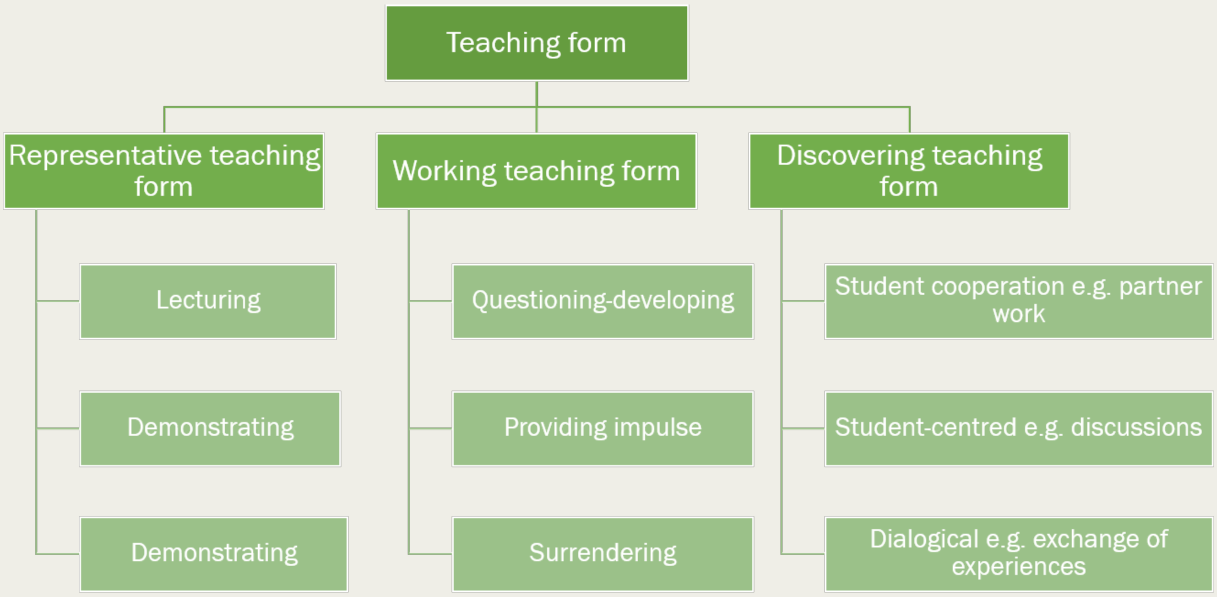


Figure 8| Divisions of Instruction Methods (Source: Own Construction based on Ott 2000, S. 128)

Teaching Methods for Inspiring the Students of the Future

1.2 GENERAL METHODICAL DECISION LEVELS

„Methodology is considered to be a sub-area of a didactics and considers objectives and pathway issues" (Bonz 2006, p. 328). On the one hand, methodology is used to develop a plan for the implementation of the curriculum; on the other hand, to find a way to achieve competence development goals. The justification of methodological decisions is based on methodological, structural and decision-making levels as so-called didactic levels of action, since factual aspects must be fully justified.
Bonz emphasizes that first decisions about the overall concept have to be made before micro-methods for individual learning phases and steps can be determined (see Fig. 9; Bonz 2006, p. 329 and Pahl 2013, p. 51). These are:

- Action forms
- Social forms
- Articulation
- Teaching actions
- Media

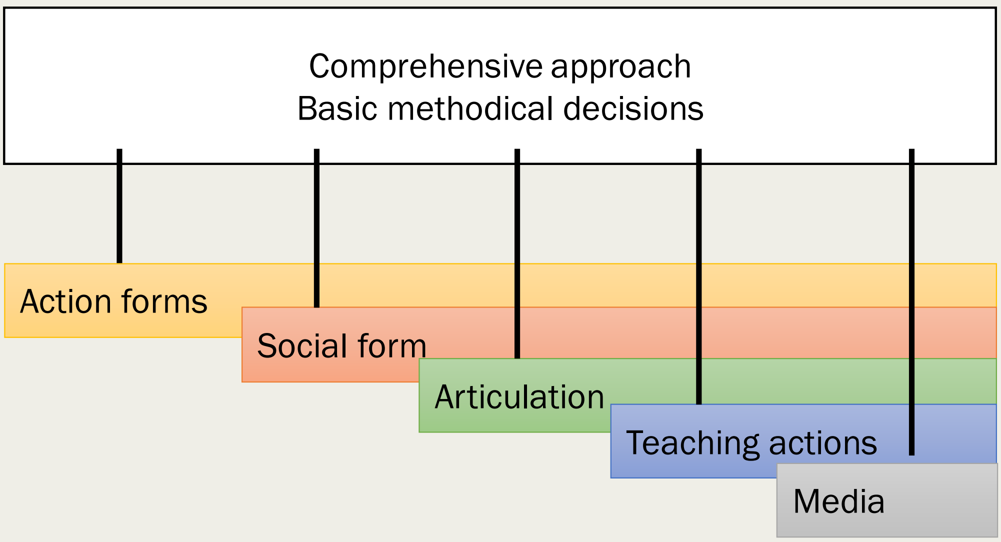


Figure 9| Methodical Dtructure and Decision Levels (Source: Own Construction based on Bonz 2009; Bonz & Schanz 2009)

The decision to apply one method or another depends on a number of factors, including the teacher, the learner and the environment. The decision of a method depends on an intelligent didactic analysis of the educational purpose (learning goals, objectives etc.), the learners in the class, the curriculum content and the type of subject matter being taught. However, in TVET, most instruction is work-oriented and the participation of learners in instruction in any technical and vocational trades must be active and direct. Therefore, learners must be exposed to action-based teaching approaches.

ACTION FORMS

Indicate in what way teachers influence students in order to encourage and to advance the students.

SOCIAL FORMS

Are characterised by external social organisation of the teaching-learning-processes and the subsequently connected interaction possibilities (Bonz 2009, S. 29).

- It determines the interaction possibilities and the positions of the teachers and students.
- The choice of the social form occurs on the plane of the holisitic conception and the form of action.

ARTICULATION

Is the descriptor for the segmentation of the teaching-learning processes in steps, phases, or parts (Bonz 2009, S. 33).

- Orients itself on an ideal flow of the learning processes.
- Order should correspond with the phases of learning and provide adequate learning aides
- The methodical division into learning phases is referred to as formal steps.

TEACHING ACTIONS

Are methodical action in order to realise teaching and tuition (Bonz 2009, S. 36).

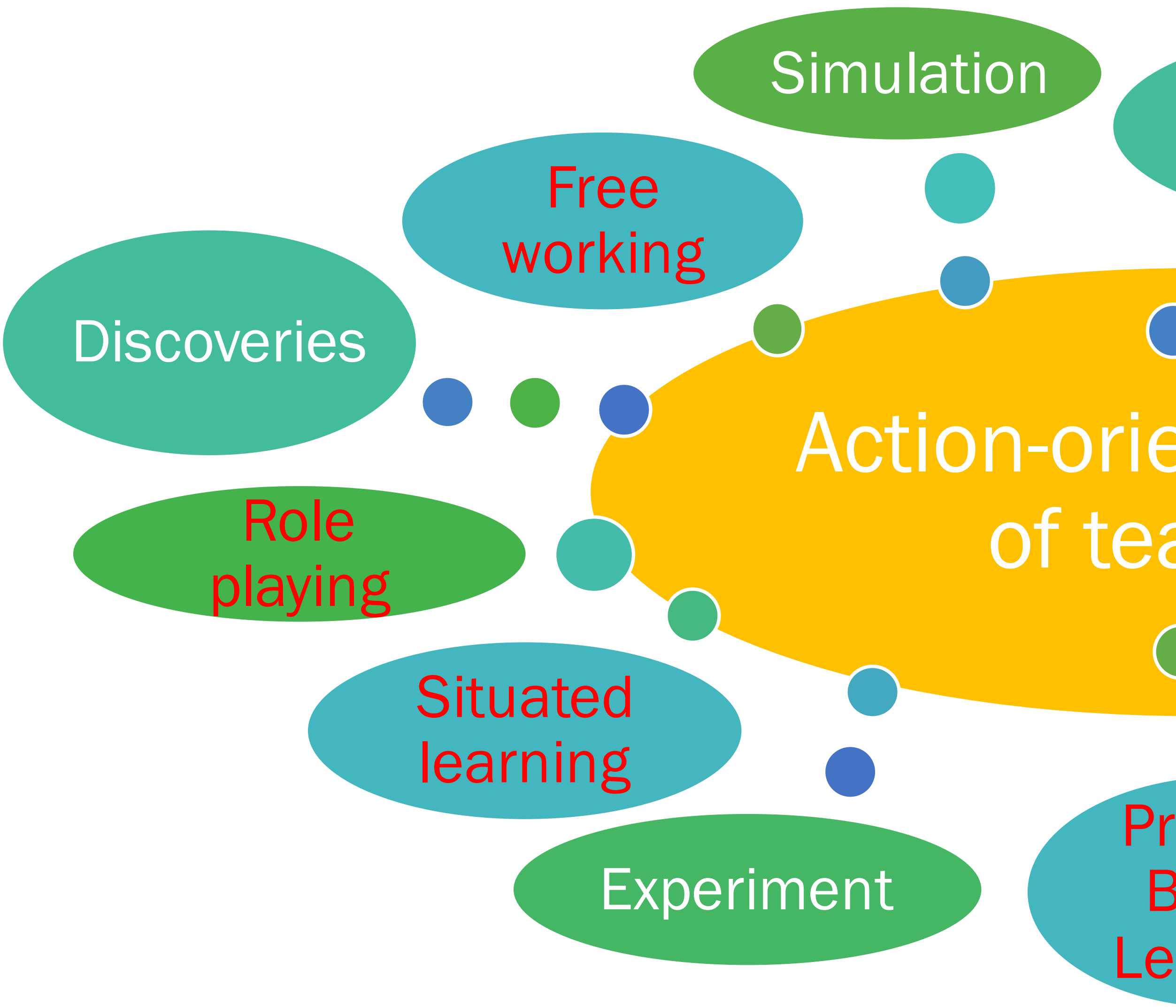
MEDIA

Media are communication tools to support and improve teaching and tuition (Bonz 2009, S. 40).

1.3 ACTION-BASED INSTRUCTION

Action-based instruction puts the learner at the centre of the learning process. An action-based approach is related to other approaches, such as project-based, problem-based teaching and learning etc. (see Figure 9). All these forms of instruction are designed to get students actively (and cooperatively) involved during the class period. The following pages introduce some selected action-based instruction methods.

Action-based instruction can include aspects of diagnostics and differentiated instruction of course; which is even desirable.



Bünning (2007): Approaches to Action Learning in Technical and Vocational Education and Training (TVET)

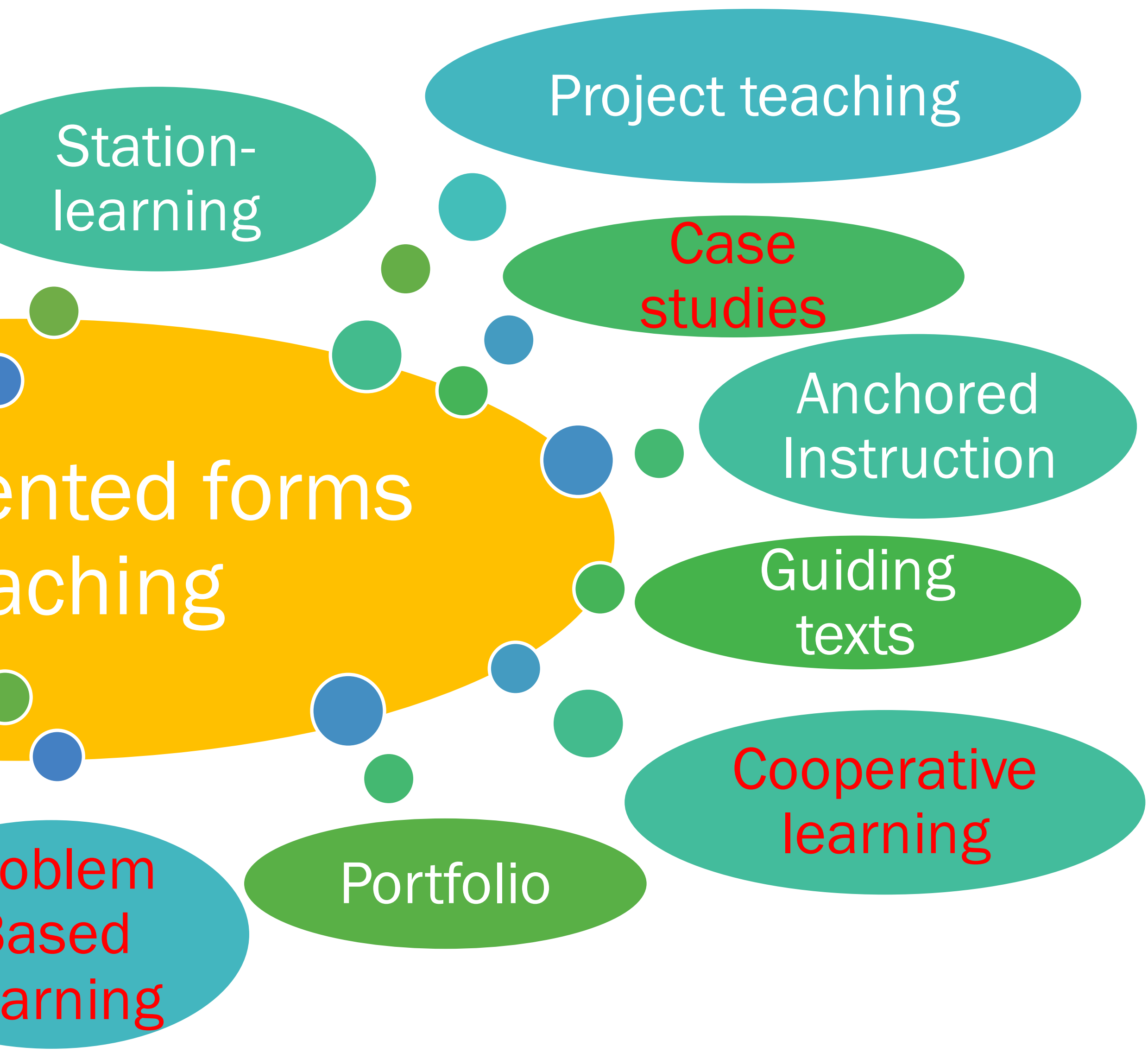


Figure 10| Action-Oriented Methods (Source: Own construction based on Reich, K.)

1.3.1 PROBLEM-BASED LEARNING

Problem-based Learning is a form of teaching and learning in which knowledge acquisition happens through the concrete and largely independent discussion in a small group („from each other and with each other“) with an authentic (real or fictitious) problem from practice. Defining the problem is not explicitly named, but finding a definition is part of learning. The case study is processed in small groups and under the guidance of a teacher in predetermined work steps (see Reusser, 2005, p. 159, 173). In contrast to the similar designed „case-based learning“ (see Christensen/Hansen, 1987) the POL is not alone the work on cases, but also promotes the active-constructive performance of the learners (see Reinmann/Mandl, 2006, p. 639). In the literature, various approaches are referred to problem-oriented learning (see Barrows, 1985, p. 62 ff.; Schmidt, 1983; Marks/Thömen, 2002). A common practice is the method of „Seven Steps“:

Definition of the Problem

1. Discuss the case and make sure everyone understands the problem
2. Identify the questions that need to be answered to shed light on the case (Problem definition)

Knowledge Aquisition

3. Brainstorm what the group already knows and identify potential solutions
4. Analyse and structure the results of the brainstorming session
5. Formulate learning objectives for the knowledge that is still lacking

Deep Problem Analysis

6. Do independent study, individually or in smaller groups: read articles or books, follow practicals or attend lectures to gain the required knowledge
7. Present and discuss the findings

(Becker et al., 2010)

21st Century Skills (Soft Skills)

- Problem Solving
- Critical Thinking
- Communication
- Collaboration
- Creativity
- Innovation

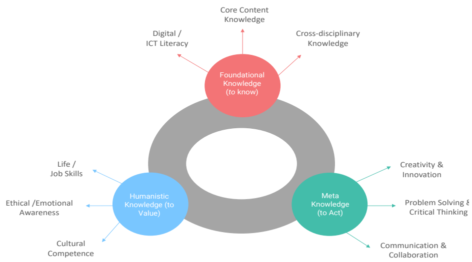


Figure 12| „21st Century Skills“ (Source: Own construction based on Kereluik et al., 2013)

Bos, Lee (2013): Problem-Based Instruction and Web 2.0: Meeting the Needs of the 21 st Century Learner

Top Desired Skills for Tech Workers

- Problem Solving
- Decision-Making
- Communication
- Oral & Written
- Collaboration: Teams
- Business Analysis
- Project Leadership
- Ethics & Tolerance
- Functional Area Knowledge

Figure 11| „Talleyrand Marine Terminal“ by JAX-PORT is licensed under CC BY-NC 2.0

1.3.1 PROJECT-BASED LEARNING

Pecore (N.N.): From Kilpatrick's Project Method TO Project-Based Learning

Project learning or also called project method is to give the student the possibility to organise themselves more independently and to actively contribute to the learning process. The concept represents internationally elaborated and empirically proved methods for teaching-learning processes in educational settings that approach to, development of desired skills (e.g. see p. 27). Based on constructivist principles of learning, Project Learning focusses on complex and realistic problems, and thereby, on combining the acquisition of knowledge and the development of general (self-organising and self-responsibility) and domain-specific problem-solving strategies as well as learning methods. The special form of this instruction enables the student to not only contribute constructively to the lesson, but also to participate in the planning of the lesson beforehand. A great advantage also involves the product- and practice-orientated work. It helps the student to make progress in transforming knowledge into practice. At fixed points, the groups talk about their progress and discuss problems with the teacher.

The project method can have the following course:

1. The method begins with finding and receiving an obvious set problem concerning the participants.
2. In a second step the problem is located and stated more precisely.
    - A general instruction goal in form of a problem is given
    - Instruction relevance of the action is partly given in form of a problem, a plan, and an experiment
3. The third phase is characterised by drawing up action and solution bases
    - By making a plan to solve the problems the aim is stated more precisely
4. The simulation phase is to help to test the worked out solution possibilities intellectually and to check them for the implementation of the plan.
5. In the end, the experimental check is the implementation of the worked out project plan.
    - Carrying out the plan as a problem solution or implementing the product, if required balanced realisation under the principle of job-sharing.
6. Implementation and usage of the results

(Frey, K.l 1991, in Bünning, 2007)

1.3.2 THE EXPERIMENT: EVOKING STUDENTS' PRECONCEPTIONS

An experiment is a systematic and controlled attempt to verify a question or hypothesis. Functions of scientific experiments are the further development of the scientific knowledge, the analysis of technical relationships, the optimization of constructions and dimensions. Experiments in classroom contexts are not only a methodological reduction of scientific experiments. Classroom experiments pursue learning in context of affective, cognitive and psychomotor objectives. If you follow the division of lessons into the three phases opening, development and closure (see guideline Lesson Plan), you can use an experiment:

- as a **motivating element** in a new topic and as a trigger for a cognitive conflict in the reference field of changing pre-concepts
- for **Knowledge acquistion** for scientific inductive (e.g. experimental derivation of Ohm's Law) or technical components, and their basic mode of action (e.B. experiments on the gearbox)
- to **deepen and consolidate expertise**

Project Based Learning: Why, How, and Examples

Student Experiments	Demonstration Experiments (performed by a teacher)
• Promoting self-activity in the implementation of their skills, and insights • On the content area as well as on natural and technical science work • Can be carried out on an equal basis and in a piece of work	• Performing the experiment is dangerous • Optimal illustration of the experiment setup seems necessary • Test arrangement is only available individually • Important parts in the foreground, unimportant in the background • Individual students can be involved in the design, execution and evaluation of experiments

Figure 13| Distinction between Organisation: Student vs. Demonstration Experiments

Recap

PRECONCEPTIONS

Relevant literature provides adequate evidence that, in general, conceptual change has better learning outcomes when compared to traditional approaches of teaching (Duit, Treagust & Widodo, 2008).

Preconceptions (or students' ideas, biases) are various everyday theories that manifest from one's own experience when an individual observes a given phenomenon of any kind and tries to decipher them. In this way, the individual creates personal contexts that correlate to what they have already learned and are often at odds with scientific explanation. Thus, preconceptions can be considered also as prejudices or biases in forming scientific concepts (Méheut M., 2012). Existing ideas of e.g. physical effects among students have a significant influence on the process of information processing in new subject matter so that these are considered to be the most significant cause of topic-related learning difficulties. Students' perceptions are the main source of internal learning difficulties: Learners process lesson content based on physically inadequate ways of thinking (Schecker & Duit 2018, p. 5).

The preconceptions are found in the constructivist perspective. Thus, in order to correct these „wrong" ideas, tasks are needed in which thinking is prioritized rather than focusing on numbers. A correctly executed calculation with physical values can simulate an understanding of content, although it is not given. Students should think about the physical principles before calculation. For example, frequently occurring everyday ideas can serve as a reason for discussion in class in order to work through the misleading ideas.

As learned, misconceptions and preconceptions may arise as barriers in learning; replacing them with scientific ones is possible only through conceptual change. However, the misconception is highly resistant to change (Clement, 1982).

CONCEPTUAL CHANGE

(Posner, Strike, Hewson & Gertzog, 1982)

The Conceptual Change aims to further develop the student's ideas in order to be able to distinguish them consciously from physical concepts. A Conceptual Change is not to be understood as a concept exchange (impossible), but as concept development and concept awareness. It presupposes some success conditions, which must be fulfilled, that an evolution of an everyday concept can take place:

- Dissatisfaction with existing concept exists at the subjective level
- The new concept has been understood to a certain extent
- The new concept appears intuitively plausible
- The new concept appears to be transferable and helpful to new situations and phenomena

The conditions are at the same time to be understood as guidelines for lesson planning.

Tomara et al. (2017): Instructional strategies to promote conceptual change about force and motion: A review of the literature

<u>Metacognition and Conceptual Change</u>

Metacognitive abilities are the knowledge of one's own cognitive abilities and procedures for acquiring knowledge as well as their application. This includes learning strategies and knowledge of how memory functions. It has been proven that Conceptual Change can be positively influenced by certain preconditions of thinking. If people assume that natural science consists of linked and proven theories as individual facts, this influences Conceptual Change in a positive way. Learners are more open to trying to get to the bottom of their own concepts (Hopf & Wilhelm, 2018, p. 35)

<u>Instructions that combine various forms of constructivist principles of teaching and learning:</u>

- Experimental Learning
- Deductive Explanation Tasks (DETs)
- Embodied Demonstration and Animation
- Aid of Computer Technology

.

1.3.3 COOPERATIVE LEARNING & ACTIVATION OF PRIOR KNOWLEDGE

Learning is largely influenced by what the student already knows [or imagines] (Ausubel 1968 in: Schecker & Duit 2018, p. 3).

Cooperative Learning encompasses action-based instruction method like group work, project based learning, reciprocal teaching etc. (more in Module 1, p. 109).
Effective learning requires teaching in such a way that students are given the opportunity to share the new content with the existing cognitive structures (cognitive activation). If the already developed mental network of the students is not activated, then they have no way of re-creating, integrating and retaining the content. Therefore, it is important to start a learning process to activate knowledge of the students. Mental bridges to previous knowledge support the students to be aware of the new topic. The activation of the prior knowledge can happen with the help of the three-step.

Three Steps Interview Strategy is a strategy which gives learners opportunities to repeatedly use their knowledge of a subject. The Three steps Interview Strategy is a physically active process to activate students prior knowledge of a topic through conversation.

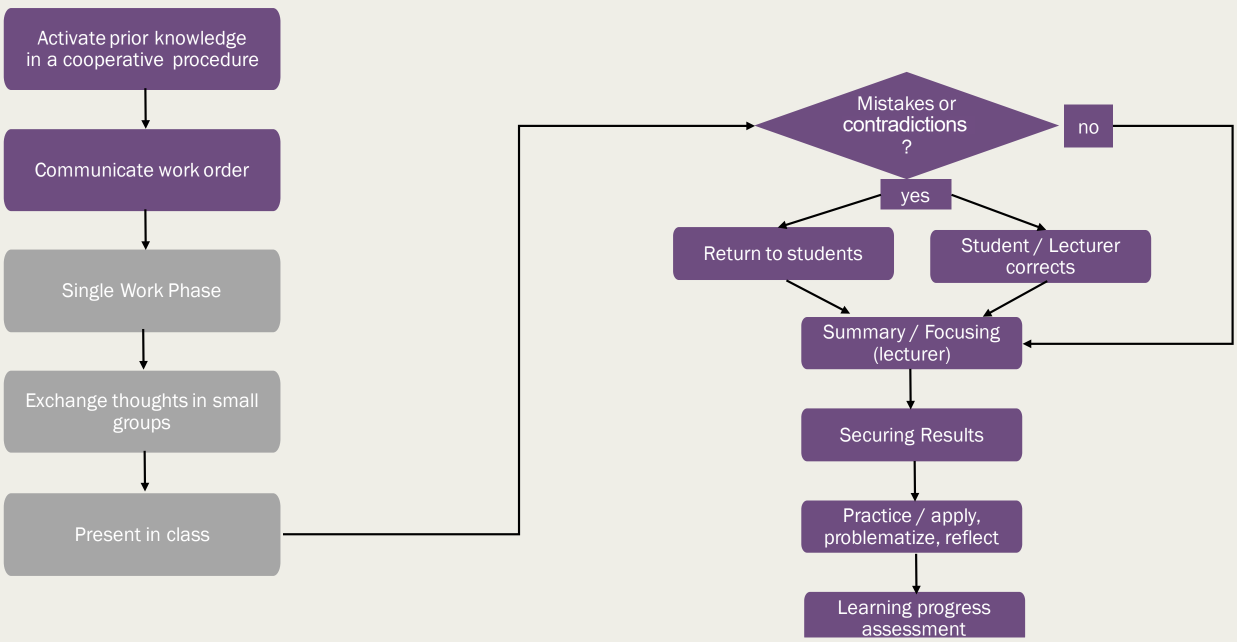
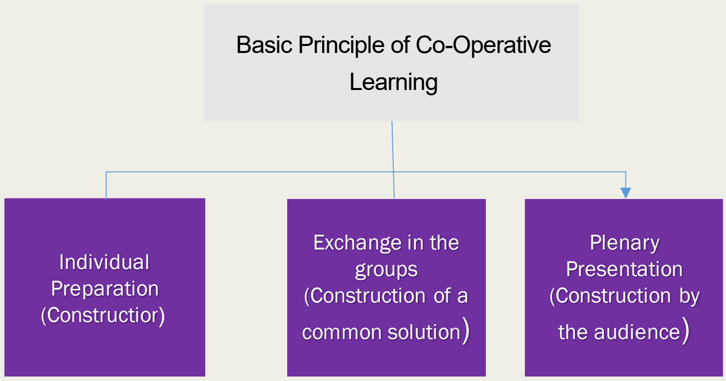


Figure 14| Activation of Prior Knowledge (Source: Brüning & Saum, 2011)



1) ACTIVATE PRIOR KNOWLEDGE

The first step of thinking or rather individual development serves to activate prior knowledge and establish teaching's starting point. Likewise, one's thinking should help to create links between learning and prior knowledge. Thus the new learning content should be mentally integrated into the existing knowledge. Example: Each student first considers alone what they know about series and parallel connection, writes this down and exchanges with their partners after 5 minutes. It is important that one considers themselves so as to build bridges of memory to previous knowledge or bring about an awareness of the topic.

2) EXCHANGE IN (SMALL) GROUPS (CONSTRUCTION OF A COMMON SOLUTION)

The core of this phase is interaction. Only then are the individual thoughts expressed, further developed or changed in the process. Besides, all learners are cognitively active and integrated into the learning process. Contradictions stimulate discussion and clarification, which consequently aid the learning process.

3) PRESENTATION, DISCUSSION, REVISION (PLENARY PRESENTATION)

This phase contains the same elements as phase 2, but additionally, the teacher participates in supporting conflicts or giving feedback to the individual groups in order to repeat the three-step process and foster independent clarification of the contradiction by the learners.

1.3.4 ANCHORED INSTRUCTION

Group at Vanderbilt (1990): Anchored Instruction and Relationship to Situated Cognition

„Anchored Instruction" is a constructivist approach developed in the USA. The term "anchored instruction" refers to the basic principle of anchoring the targeted knowledge and skills in concrete problem-solving context situations. Anchored Instruction is closely related to situated, problem- and project-oriented forms of learning that try to build up knowledge and skills by using complex, authentic problems (CTGV, 1997, p. 47).

1.3.5 SIMULATION

Application possibilities

- Allows for learning in a fictional reality, which is created through the simulation model
- Decisions have more priority (In relation to the overall action)
- Promote inter-connected thinking
- Is conducted in order to prepare for the complexity of the various situations

Requirements

- Social competence ⟶ Interaction with the group
- Require a lot of participation from all involved

Preparation

- Prepared workplan for every student, i.e. a work team with solutions
- Allowed tools such as Literature, Internet, Computers, experimentation material, ...
- Case study
    - Current problem/issue briefly summaries
    - Working chart with explanations with regards to the simulation procedures
- Role cards/role allocation
    - Specific roles with information in order to understand the role that will be portrayed (e.g.: Industrial council, Company management, shareholders, employees, customers, citizen initiatives, ministry, etc...).
- Action card, impulse cards

1.3.6 STATION LEARNING

Aims
- Independent gathering of knowledge
- Independent acquisition of texts
- Independently assessing learning successes
- Practicing cooperation capacities and teamwork
- Strengthening the student's sense of responsibility
- Recognizing the connections between sub-areas

Application possibilities
- Independent acquisition of new learning content
- Deepening already acquired knowledge/a certain learning field (learning target: 'becoming acquainted with')
- Practicing (Learning target 'mastering')
- End of a learning sequence in order to provide students with the possibility to close any gaps
- In the scope of interdisciplinary teaching

Preparation
- Formulate the working assignments of each station clearly
  - The pre-formulated learning aims must be translated into the working assignments – Text assignments, Handcraft instructions, Experimental designs, Research instructions etc…
- Stations must be designed in an aesthetically pleasing and multi-sensory way
  - Which materials are needed, which are available?
  - Where does the student find what information? Who can they ask if unsure? How will they be assisted?
  - Working materials such as control slip, working journal, document files, labelling for learning stations, rules, etc…
- Aside from 'mandatory stations" also try to install „rest and relaxation stations"
- Establish and signpost each learning station, spread out tasks, put up maps, make working spaces available, …

1.5 FLIPPED CLASSROOM

The concept originally comes from the USA. „To flip“ means something like „turn around“ - and that is exactly what happens with Flipped Classroom (or Inverted Classroom): the organization of the lessons is reversed. The students learn the (new) content not in the classroom but **individually and independently** at home with the help of a script that serves as a guide to develop knowledge and skills by themselves, and above all with the help of so-called screencasts, i.e. short videos. In the classroom, appropriate tasks are then used to practice, deepen and transfer the skills. The teacher acts as a consultant. Instead of conveying content to the students in class and then giving them the appropriate exercises as homework, the focus of the lesson is more on applying what the students have learned independently at home.

The advantages are: Students can proceed at their own pace at home and then work on the application of knowledge independently or in a group. If necessary, the teacher assists the students as a coach and keeps an eye on the individual learning progresses. Of course, the new media cannot replace the teacher. But the role is shifting from imparting knowledge to being a consultant, who guides the students through personal contact and individual support to learn independently. With flipped classroom, the teacher promotes the students‘ independence, make better use of the lesson time and of course brings a lot of variety to your lessons.

Lee et al. (2015): Evaluation of a Flipped Classroom in Mechanics of Materials

The Traditional Lecture and the Flipped Classroom Model in Schematic Comparison according to Bloom's Taxonomy

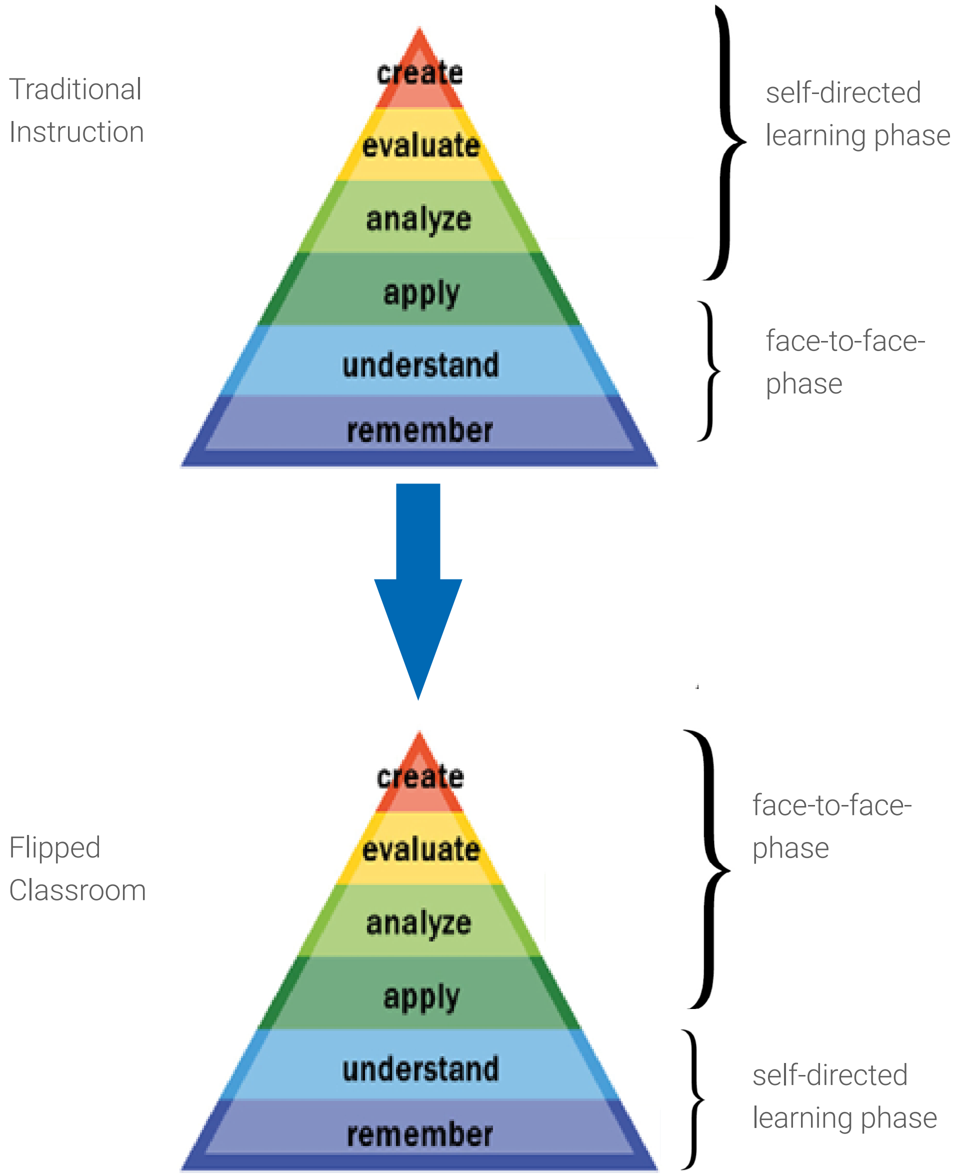
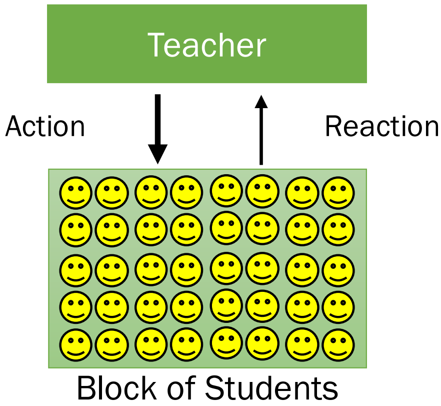


Figure 15 | The Traditional Lecture and the Flipped Classroom Model (Source: Own Construction based on Tolks et al., 2016, p. 23)

Flipped Classroom Model: Why, How, and Overview

1.4 TRADITIONAL INSTRUCTION

Traditional forms of instruction (or teacher-centred / instruction) are characterised by linear target-oriented comprehensive approach or explanatory lecturing. Traditional instruction is a forms of teacher action and stands for various form of presentation (the lecture by the teacher - information, instruction, asking-developing, transferring skills, performing experiments, explaining machines, expounding coherences). Learning processes happen as a reaction of students to the action of the teacher (Bonz & Schanz 2009, S. 101, Bonz 2009, S. 68 – 76).



Advantages:

- Time-saving determination of learning goals
- Efficient lesson planning (Bonz 2009, S. 75)
- Effectiveness in the transfer of knowledge
- Target-oriented steering of the course of the lesson (ibid.)

Difficulties/Criticism:

- Assessment of the students
- Teachers are not informed whether learning contents have been absorbed and processed by the students
- Individual differences are neglected
- Learning goals such as independence or development of social competences cannot be acquired to a sufficient level
- Disciplinary difficulties / resistance to authoritarian teachers

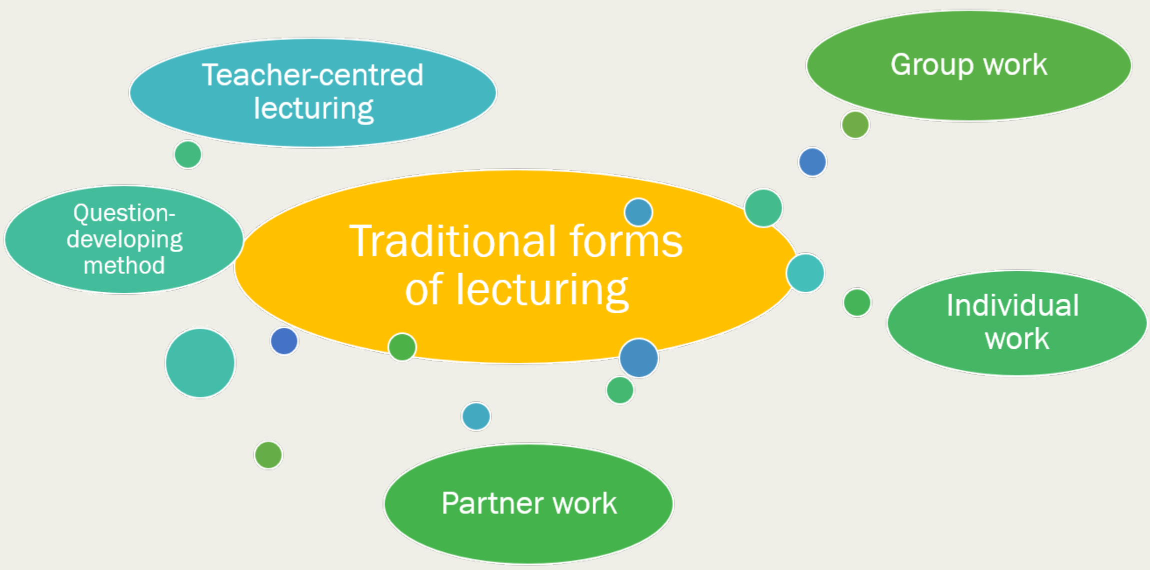


Figure 16| Traditional Forms of Instruction (Source: Own construction based on www.methodenpool.uni-koeln.de)

Teachers are not informed whether learning contents have been absorbed and processed by the students.
Thus variation through lecturing aides:
Question-> traditional-> Question-development lecturing/classroom conversation
Impulse-> Impulse lecturing-> Developing and acquiring a topic
Presenting media such as presentation media

1.4.1 GROUP WORK

Focused both on participants and tasks, group work can be an ideal way of including a social element in learning specific topics.

- Possible applications
  - Deepening of a sub-area
  - Development of new content
  - Dividing a learning area into several learning contents
- Is constituted of three differently organised phases
  - Initiation phase -> Takes place in the classroom conversation
  - Group work -> central learning and working phase
  - Concluding phase -> Presentation of group work, concluding discussion

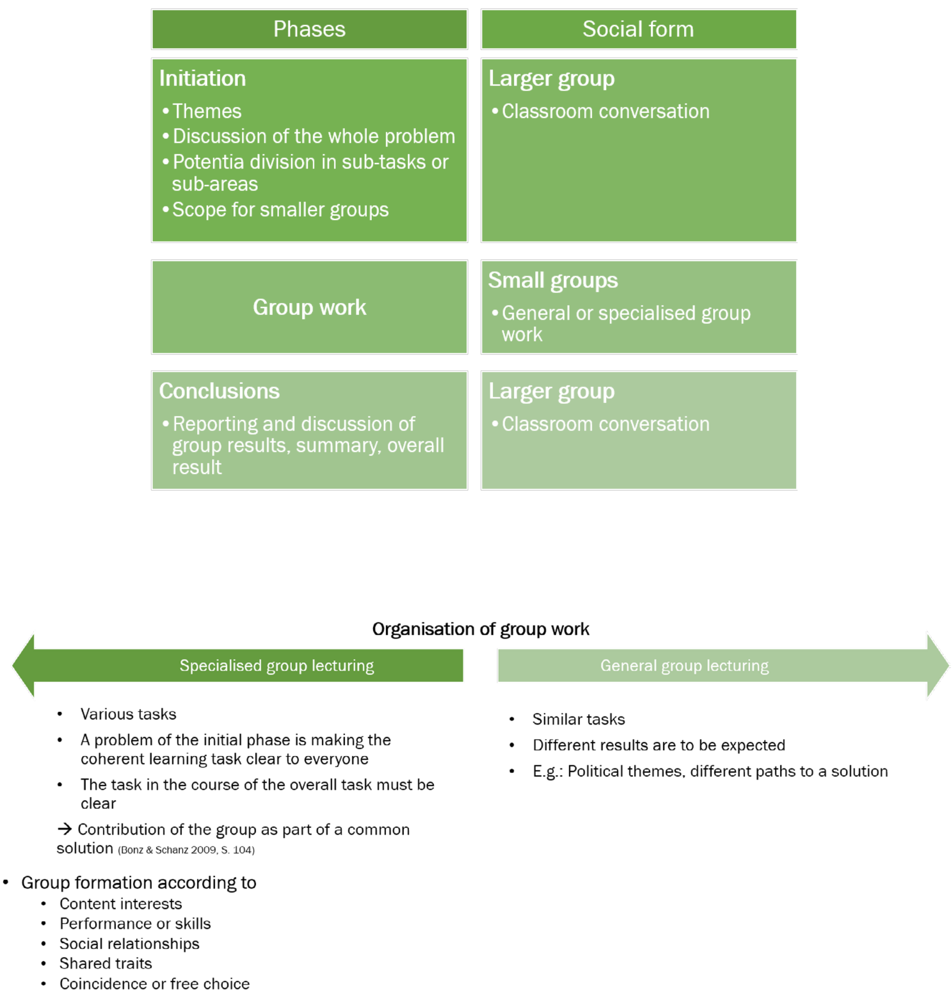


Figure 17| Organisation of group work (based on Bonz & Schanz 2009, S. 104, Bonz 2009, S. 96 – 103, Hugenschmidt & Technau 2011, S. 75f, Wittwer 2005, S. 95)

NOTES

Chapter 2

Instructional Media & Technologies

2.1 INTRODUCTION

Instructional media encompasses all the materials and physical means a teacher might use to implement instruction and provide opportunities for students to develop an understanding of a topic or content. This may include traditional materials such as chalkboards, handouts, charts, slides, overheads, real objects, and film, as well new media such as computers, Internet and Virtual Reality. The instructional materials are aligned with all other elements in the course, including the learning objectives, assessments, and activities.

Remember: Based on the framework of interest, studies have shown that teachers can enhance students' situational interest by using media and manipulating the components of learning material (see interestingness)

Read more in Textbook- Module 1,
Chapter Pedaogical-Psychological Basics

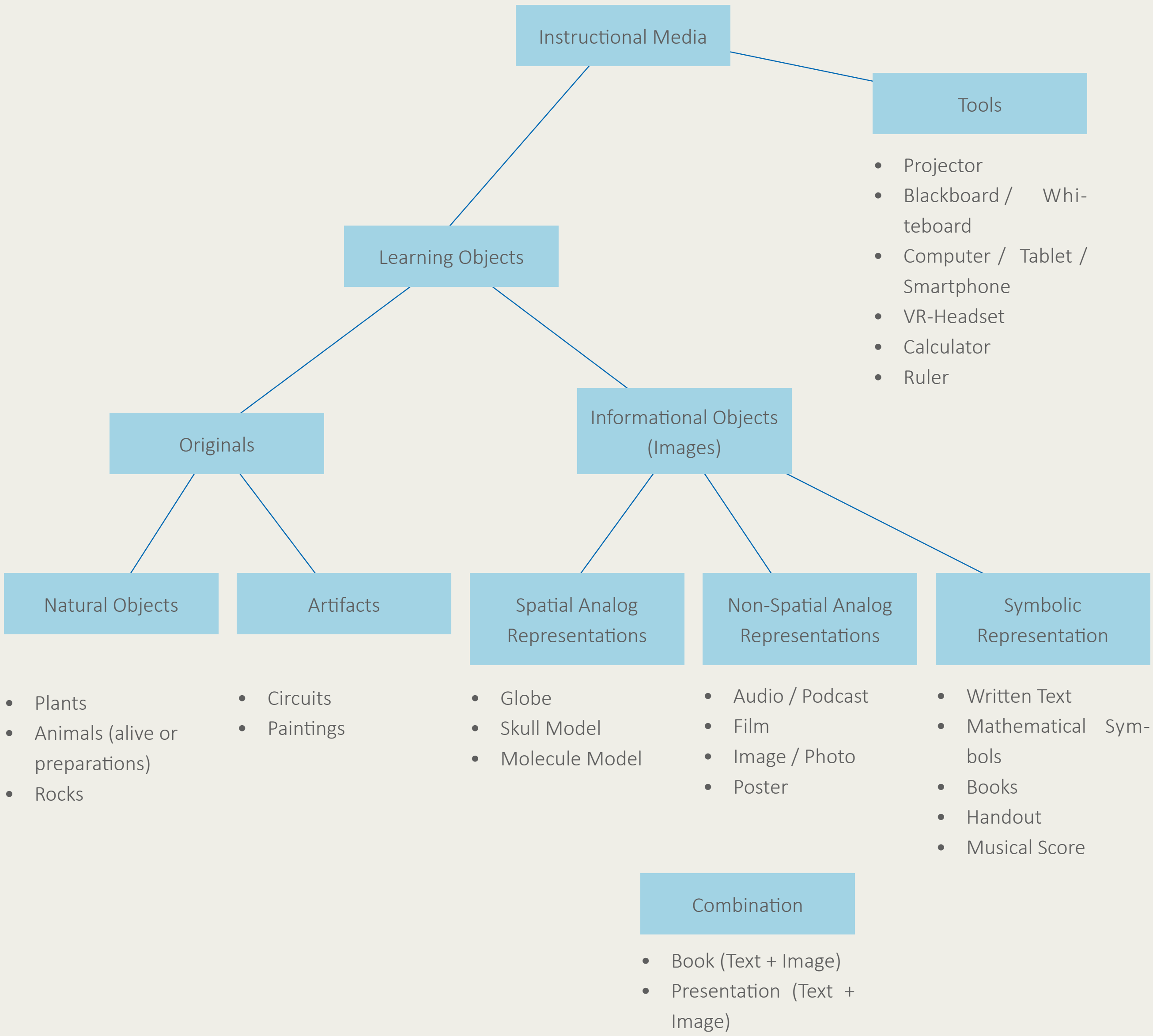


Figure 19 | Overview Instructional Media (Source: Own Construction)

2.2 DESIGN OF LEARNING TASKS

Learning tasks play an important role in instructional settings. They may be characterized as an interface between the learners and the information offered in the learning environment. The orientation towards *good* learning tasks means that students engage intensively with an object, topic, subject matter etc., in the sense of planned action and cognitive activation. The possibilities to acquire and expand knowledge and interests, are other aspects of *good* tasks (see Grygier & Hartinger, 2012, p. 8-11). Ideally, the learners receive feedback on how well they performed on a learning, task and guidance on how to acquire the relevant information. While there is general agreement on the significant role of learning tasks, there is as yet little knowledge on how to design them appropriately (Richter, 2012).

2.2.1 FEATURES OF LEARNING TASKS

AREA	FEATURE	AREA	FEATURE
Authenticity	- Skills assessment - Real-World Relation	Complexity	- Structuring - Form of representation
Cognitive Activation	- Work on preconcepts - Type of knowledge - Cognitive process	Differentiation	- Openness - Promotion - Differentiation of learning

Figure 24| Features of Learning (Source: Own Construction based on Reinfried, S., 2016)

Criteria of Good Learning Tasks

- build on the experiences and prior knowledge of the learners, are important them, authentic, have a reference to reality.
- promote and encourage thinking,action and the development of skills and abilities.
- are clearly formulated in terms of content and objectives.
- connect to the familiar, open up new and lead to relevant concepts, scientific theories and laws.
- are involved in meaningful and emotional contexts, make you curious, awaken interest and promote a questioning attitude.
- promote creativity, the development and implementation of ideas, the unbound thinking about „things of the world".
- are designed in such a way that the achievement of different requirements and thus a natural differentiation among learners is possible.
- challenge the learners without overburden (fitting), and enable different access methods, learning stragtegies and solutions.

(Reinfried, S., 2016 based on J. Grell, M. Grell, Unterrichtsrezepte, Beltz, Weinheim, 1983, S. 232 ff. und M. Admina „Mit Lernaufgaben grundlegende Kompetenzen fördern" in P. Labudde (Hrsg.) Fachdidaktik Naturwissenschaften 1.–9. Schuljahr, Haupt/ UTB 2. Auflg. 2013, S. 117 ff)

2.2.1 FORM OF LEARNING TASKS

CLOSED-ENDED FORMS

Students can see possible answers.

Examples:

- Which material has highest thermal conductivity? (Cross on!)
[ ] tile
[ ] wood
[ ] copper
- Which of the following statements is/are correct? (Cross on!)
[ ] Air resistance only applies to parachutes.
[ ] Air resistance isn't felt on the ground.
[ ] Drag slows you down.

- Which of the terms belong together in pairs (please connect with strokes): ...

- Multiple-Choice
- Associations

Advantages:

- Clear recording of the response, therefore
- objective evaluation
- time-economic implementation and evaluation, thereby
- it is possible to identify a greater number of data

SEMI-CLOSED FORMS

Tasks identified by keywords, symbols, a short graphic representation or the like to be completed:

Examples:

- Write down all types of gears that come to mind!

- Insert the missing words: The greater the mass, the greater the ____________ of gravity.

- Associations
- Fill-in-the-Blanks

Advantages:

- possibility for individual and free reply
- answers compressed to the essentials
- combination of different areas of competence

Disadvantages:

- difficult objective evaluation
- time consuming for students to work on
- risk of influencing the response performance through suggestive effects

OPEN-ENDED FORMS

Tasks that are more extensive, even require formulated answers and diverse solutions are possible:

Examples:

- Design an object ...
- Programme a circuit ...
- Write an essay about ...

- Explain why intrinsic semi-conductor ...
- What do you think ...

- Design, Creation
- Formulation of solutions and justifications

Advantages:
- enabling more individual and free solutions
- capture more creative and complex services
- less time consuming development

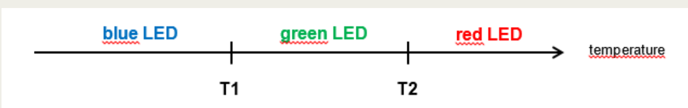
Disadvantages
- difficult definition of correction criteria, thereby
- limited objective evaluation
- long processing time for students and time-consuming correction by teachers

Learning tasks should confront students with such tasks or situations which trigger a development of competences. This includes: a systematic structure of the necessary action-regulating knowledge.
For TVET, this means the use of more „open" tasks with reference to practice and real-world problems is necessary.

If learning tasks „trigger" a development of competence and skills, then learning tasks are didactic tools of „self-directed learning" (Müller, 2011).

Learning tasks should be like a treasure map in the hand of the students to develop new knowledge and skills.

2.2.1 COMPETENCE-BASED LEARNING TASKS

GUIDELINE FOR FORMULATING A LEARNING TASK EXAMPLE FROM AN ELECTRICAL LESSON	
Learning Field / Topic	Install, adjust and test electronic controls and regulations Here: Replacement and installation of an air conditioner
Lesson objective	• how to use a temperature sensor (TMP36) • using the "map"- command • output of the values (serial monitor, serial plotter) • averaging of values • application of "if – else" commands (interlaced and not interlaced)
Scenario	As an electronics technician for operating technology, you are responsible for maintenance and new installation of electrical systems at your company's maintenance department. When a split type air conditioner was not working, you are commissioned to maintain the air conditioner.
Entry Instruction	In individual work ... / In groups ... 1. **Do a research and list resasons why an A/C is not working.** 2. What is the function of a temperature sensor installed on the evaporator of indoor unit? 3. Locate different sensors within the air conditioning unit. 4. **Read the description of the sensor and connection diagram (handout). Mark the relevant technical requirements and list them by their level of difficulty!**
Follow-up instructions	5. Complete the incomplete program „01x_Temperature_measurement" so that it uses the temperature sensor to measure the current temperature 5 times, form an average of these values and output them via the serial monitor or the serial plotter on the screen. 6. Use the "if-else" function to switch a green or a red LED on or off if the temperature is correct (green LED) or too high (red LED). 7. Continue to use the "if-else" function (interlaced) to control a third LED (blue). The blue LED should light up when the temperature falls below a certain value, the red LED should be activated if the temperature exceeds a higher value. The intermediate temperature range should be indicated by the green LED lighting up.  8. A too low (blue LED) and a too high temperature (red LED) should be indicated by a short beep (0.5 s) via a loudspeaker.

Closing instruction	Present your results to your class.
Required equipment	ppt., blackboard, Arduino / breadboard / cables / temperature sensor TMP36 / external power supply, resistors, LEDs (green, red, blue), piezo speaker

Figure 26| Guideline for Formulating a Competence-Based Learning Task (Example Helmut Windschiegl; adapted)

Always create realistic and sustainable learning activities

Use verbs when formulating learning goals or objectives

NOTES

Arnold, R. (1990): Berufspädagogik: Lehren und Lernen in der beruflichen Bildung; ein Studienbuch. Aarau: Verl. für Berufsbildung Sauerländer.

Bonz, B. (1996): Methoden in der schulischen Berufsbildung. In: Bonz, Bernhard (Hrsg.): Didaktik der Berufsbildung; Bd. 17. Stuttgart: Holland+Josenhans

Bonz, B. (2009): Methodik. Lern-Arrangements in der Berufsbildung. 2. neubearb. Aufl. Baltmannsweiler Schneider Verlag Hohengehren.

Bonz, B. & Schanz, H. (Hrsg.) (2009): Didaktik und Methodik der Berufsbildung. Baltmannsweiler: Schneider Verlag Hohengehren GmbH (Berufsbildung konkret; Bd. 10).

Euler, D. (1997): Didaktik einer sozio-informationstechnischen Bildiung. Köln: Botermann & Botermann.

Grüner, G. (1978): Bausteine zur Berufsschuldidaktik. Trier: Spee-Verlag.

Fend, H. (1981). Theorie der Schule. München: Urban & Schwarzenberg.

Helmke, A. (2015). Unterrichtsqualität und Lehrerprofessionalität: Diagnose, Evaluation und Verbesserung des Unterrichts. Seelze: Klett-Kallmeyer.

Hugenschmidt, B. & Technau, A. (2011): Methoden schnell zur Hand. 66 schüler- und handlungsorientierte Unterrichtsmethoden. 2. Aufl. Seelze: Kallmeyer in Verbindung mit Klett.Bonz, Bernhard & Schanz, Heinrich (Hrsg.) (2009): Didaktik und Methodik der Berufsbildung. Baltmannsweiler: Schneider Verlag Hohengehren

Klafki, W. (1995). Didactic analysis as the core of preparation of instruction (Didaktische Analyse als Kern der Unterrichtsvorbereitung), Journal of Curriculum Studies, 27 (1), p. 13-30.

Klafki, W. (2007). Neue Studien zur Bildungstheorie und Didaktik: Zeitgemäße Allgemeinbildung und kritisch-konstruktive Didaktik. Beltz

Klafki, W. (1995). Neue Studien zur Bildungstheorie und Didaktik.Zeitgemäße Allgemeinbildung und kritisch-konstruktive Didaktik.

Leisen, J. (2010). Lernprozesse mithilfe von Lernaufgaben strukturieren. Informationen und Beispiele zu Lernaufgaben im kompetenzorientierten Unterricht. Unterricht Physik, 117 (118), p. 9-13.

Lipsmeier, A. (1980). Qualifikationsanforderungen des Beschäftigungssystems und Reform der Berufsausbildung. In: B. Bonz & A. Lipsmeier (Hrsg.): Allgemeine Technikdidaktik - Bedingungen und Ansätze des Technikunterrichts. Stuttgart, p. 49 - 60.

Loughran, J. et al. (2012). Understanding and Developing Science Teachers' Pedagogical Content Knowledge. Sense Publishers 2012.

Meyer, H. & Jank, W. 1991. Praxisbuch Meyer: Didaktische Modelle. Cornelsen Lehrbuch

Meyer, H. & Terhart, E. (2007): Guter Unterricht – nur ein Angebot?. Interview mit dem Unterrichtsforscher Andreas Helmke. In: Becker, Gerold, Feindt, Anreas, Meyer, Hilbert, Rothland, Martin, Stäudel, Lutz & Terhart, Ewald (Hrsg.): Guter Unterricht. Maßstäbe & Merkmale – Wege & Werkzeuge. Friedrich Jahresheft 2007, p. 62 – 65.

Ministry of Culture, Youth and Sport (2018): Fachdidaktikstandards.

Müller, H.-J. (2017): Lernaufgaben in der prozessorientierten betrieblichen Berufsausbildung. In: Dietl/Schmidt/Weiß/Wittwer (Hg.): Ausbilderhandbuch, 193, p.1-22.

Nickolaus, R. (2012): Didaktik – Modelle und Konzepte der beruflichen Bildung. Orientierungsleistungen für die Praxis. 3. Korr. U. erw. Aufl. Baltmannsweiler: Schneider Verlag Hohengehren.

Jank, W., & Meyer, H. (2011): Didaktische Modelle. 10. Aufl., Berlin: Cornelson.

Ott, B. (2000): Grundlagen des beruflichen Lernens und Lehrens. 2. Aufl., Berlin: Cornelsen.

Peterßen, W. (2001). Lehrbuch Allgemeine Didaktik. München: Oldenbourg.

Reich, K. (Hg.): Methodenpool. In: url: http://methodenpool.uni-koeln.de

Reinfeld, S. (2016): Kompetenzorientierte Lernaufgaben – mehr als alter Wein in neuen Schläuchen? In: Ga&S, 223 (38), p. 4-14.

Richter S. (2012) Learning Tasks. In: Seel N.M. (eds) Encyclopedia of the Sciences of Learning. Springer, Boston, MA. https://doi.org/10.1007/978-1-4419-1428-6_342

Sedelmaier, Y., Landes, D. (2015). A Competence-Oriented Approach to Subject-Matter Didactics for Software Engineering. In: International Journal of Engineering Pedagogy (iJEP) 5 (3), p. 34–44.

Tenberg, R. (2006): Didaktik lernfeldstrukturierten Unterrichts. Theorie und Praxis beruflichen Lernens und Lehrens. Bad Heilbrunn: Klinkhardt.

Tolks, Daniel et al (2016): "An Introduction to the Inverted/Flipped Classroom Model in Education and Advanced Training in Medicine and in the Healthcare Professions." GMS journal for medical education vol. 33 (3), p. 1-23.

Wittwer, W. (Hrsg.) (2005): Methoden der Ausbildung. Didaktische Werkzeuge für Ausbilder. 3. Aufl. Konstanz: Verlag Dr.-Ing. Paul Christiani GmbH & Co. KG. GmbH (Berufsbildung konkret; Bd. 10).

Terhart, E. (1983): Unterrichtsmethode als Problem. Weinheim: Beltz.

Terhart, E. (1989): Lehr-Lern-Methoden: Eine Einführung in Probleme der methodischen Organisation von Lehren und Lernen. Weinheim: Juventa.

Wittwer, W. (Hrsg.) (2005): Methoden der Ausbildung. Didaktische Werkzeuge für Ausbilder. 3. Aufl. Konstanz: Verlag Dr.-Ing. Paul Christiani GmbH & Co. KG. GmbH (Berufsbildung konkret; Bd. 10).

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