

Four Decades of Research in Science Education – from Curriculum Development to Quality Improvement

6.1 The role of constructivism in science education: yesterday, today, and tomorrow¹

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In the eighties of the 20th century, constructivism became an important model of teaching and learning in general and in particular in science education. Since more than 20 years, constructivism is the main model to describe, analyse and interpret processes in the science classroom and informal learning settings. What makes this model so attractive? Where is it used? What are its advantages and disadvantages?

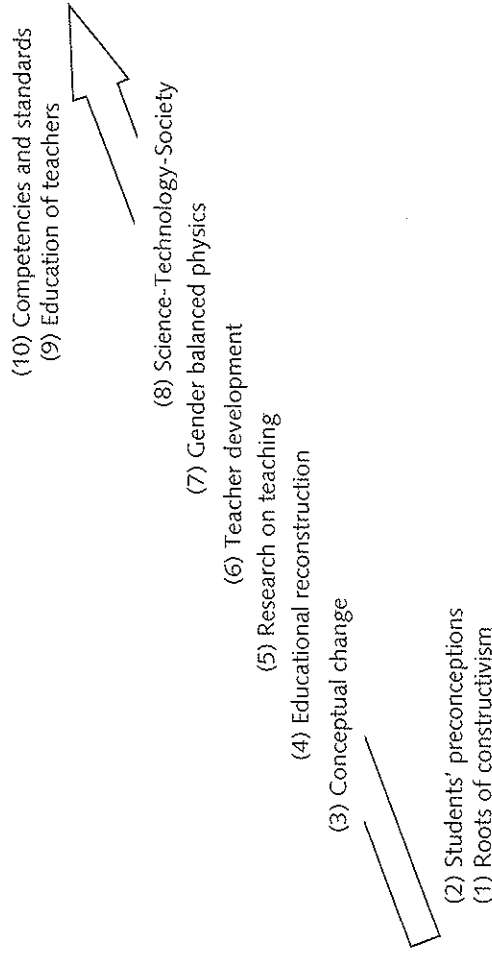


Figure 1: The role of constructivism in science education: yesterday, today, and tomorrow.

After a short definition of constructivism (chapter 0) I will look backwards in presenting some of the roots of constructivism (1) and its relation to the research on students' preconceptions (2) that has been done in the seventies and eighties of the last century. After this retrospection I will discuss the role of constructivism in some of the main fields of current

¹ When I distinguish between yesterday's, today's and tomorrow's role of constructivism one should keep in mind that there are smooth transitions and that the development of the constructivist view was and still is a continuous process.



for scientists with colleges and the scientific community. The importance of the exchange cannot be overestimated. This is why a new concept has been developed, the so-called co-construction of knowledge (Ritchie, 1994). Shulman (1992, p. 27) concludes for the ideal classroom: "There is always room for another opinion. Indeed, another opinion is mandatory. Knowledge is socially constructed because it is always emerging anew from the dialogues and disagreements of its inventors. Similarly, the ideal classroom must be a setting where opposing views collide, where every thesis is subjected to critical scrutiny and communally sanctioned doubt."

The principles described here in the individual and in the social dimension are beyond controversy. In different theories of constructivism they differ only by the value attributed to them. In radical constructivism the first principle dominates all others, in social constructivism the second one (Duit & Treagust, 1998; Labudde, 2000b; Widodo, 2004). The following last two dimensions are not part of all definitions of constructivism, but they play at least as consequences of the first two constructivist principles an important role for the teaching and learning of science (and other subjects).

3. The dimension of the contents, i.e. the question which contents are suitable for the learners: If learning is an active process of constructing new knowledge based on existing knowledge, as mentioned before, then the contents to be learned must be within the horizon of the learner. Alternatively, as others have claimed (for an overview see Labudde, 2000b, p. 66-92), the contents of science instruction must be related to the world of the learner, i.e. to his or her life and experiences. This is an old postulate in science education, proposed in many research projects, e.g.: "Feeling a need to make sense of one's experiences constitutes the core of learning, and we propose that situating learning in the lived experiences of students is essential for generating this need." (Roychoudhury, Tippins, & Nichols, 1995, p. 900)

"Design principles [in science instruction]: Locate interesting contexts. The topic of investigation is an authentic question or problem that has some consequences to the lives of children." (Duschl & Gitomer, 1996, p. 3) Referring to students' life and experiences has become one of the most important principles in science education.

4. The dimension of the teaching methods, i.e. the role of the teacher as an expert, adviser, and classroom manager: How can the learning process of the individual (see above a) and the co-construction of new knowledge (b) be supported by the teacher? By ex-cathedra teaching and classroom-discussions this is to some extent possible, in particular if the teacher is successful in evoking students' preconceptions and in initiating discussions between the learners about different preconceptions and about differences between preconceptions and the concepts of the scientific community. But for promoting learning as an active process and for stimulating the co-construction of knowledge other teaching methods seem to be more suitable, e.g. students' experiments and hands-on activities, learning cycles, project learning or case studies. There is a huge amount of research projects and results concerning these teaching methods. A general result of these projects is that nontraditional teaching methods are not a gain per se, but have to be care-fully implemented into the teaching and learning process (for students' experiments see for example the overview of Harlen, 1999).

research in science education: Conceptual change (3), educational reconstruction and the development of learning environments (4), empirical research on classroom teaching (5), teacher professional development (6), gender balanced physics (7), and integrated science instruction (8). I will finish the article with a glance into the future and look at constructivism's role in the education of teachers (9) and in the development of competency models and standards in science education (10): see figure 1.

(0) A definition of constructivism

There are numerous definitions of constructivism. Although they differ in certain points, a common body of characteristics can be determined. I will outline a definition, which has been elaborated in more detail elsewhere (Labudde, 2000b). Constructivism can be classified into four dimensions:

1. The dimension of the individual, i.e. the learning process: The model of constructivism claims that knowledge is a human construction. It is the construction of the individual learner, no matter whether a little child, a student or a scientist. Learning is a permanent and continuous process, and in this sense the knowledge of the individual is always tentative, i.e. not just a mere copy of the reality outside. Glaserfeld (1995), one of the exponents of (radical) constructivism has summarised: "Knowledge is not passively received but built up by the cognizing subject; the function of cognition is adaptive and serves the organization of the experiential world, not the discovery of ontological reality." (p. 18) "The space and time in which we move, measure and, above all, in which we map our movements and operations, are our own construction and no explanation that relies on them can transcend our experiential world." (p. 74) Learning is an active process of constructing new knowledge based on existing knowledge (figure 2).

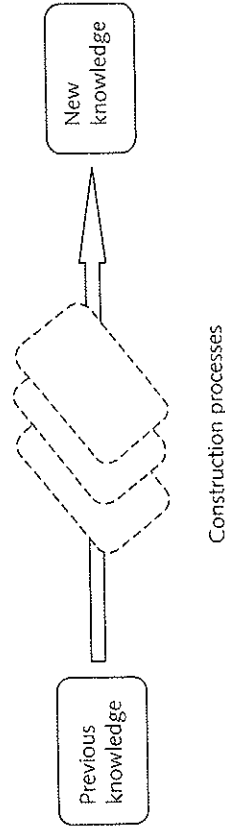


Figure 2: The constructivist view of learning (Widodo, 2004, p. 41).

2. The dimension of social interactions, i.e. the role of communication and collaborative learning: The knowledge is indeed constructed by the individual, but always in exchange with other people. For pupils and students this exchange is with parents, peers or teachers.

1 Yesterday's role of constructivism

(1) Roots of constructivism

"What would be the greatest fault and contradiction one can cause to the constructivist theory of teaching and learning (science)? – If one said, the theory had been discovered." This is just a joke. In fact, the model of constructivist teaching and learning itself is a construct – a construct which has many roots.

One of the most famous philosophers and educators of the last century, John Dewey (1859-1952), has influenced generations of cognitive psychologists, pedagogues and science educators all over the world. With his masterpiece "How we think" (Dewey, 1933), his principle of "learning by doing" and the idea that science education should aim to develop "a certain mental attitude [rather than communicating] a fixed body of information" he has laid a solid basis for the later theory of constructivism. It was not by chance that many Anglo-Saxon educators quoted John Dewey, when initiating the paradigmatic change from behaviourism to constructivism in the sixties and seventies of the last century.

In Germany, the so-called *Reformpädagogik* (progressive education) had an important influence on education until 1933 and after 1945. Many of its claims are very similar to those of constructivism. One of the later exponents of the Reformpädagogik was Martin Wagenschein (1896-1988), physics and mathematics teacher at the Odenwaldschule from 1924 until 1932, a school dedicated to progressive education. Wagenschein postulated a genetic, Socratic, and exemplary approach in science education. All three principles are strongly related to constructivism, in particular the genetic approach, which Wagenschein said to be the main one of his principles. He claims that the learner has to construct his or her new knowledge him- or herself, based on experiences with phenomena and in exchange with others. The title of Wagenschein's masterwork could be the title of a constructivist, "Original understanding and exact thinking" (*Ursprüngliches Verstehen und exaktes Denken, Wagenschein, 1970*).

However, perhaps the greatest influence on the later development of constructivism had the Swiss cognitive psychologist Jean Piaget (1896-1980). He described learning as a process of assimilation and accommodation, which implies that learning always means the construction of new knowledge based on already existing knowledge. Piaget was one of the first and main researchers performing empirical studies. Both his theory and empirical research methods had a huge impact not only on education in general but also on science education in particular. In reference to (the history of) constructivism Piaget might be the author quoted the most.

Dewey, Wagenschein, and Piaget are some of many precursors of constructivism, others are, for example, L.S. Vygotsky (1896-1934) or Th. Kuhn (1922-1996). Although coming from different disciplines all of them contributed in same way to the theory of constructivism in science education. At the end of seventies of the last century, the time became mature for constructivism.

(2) Students' pre-conceptions

"The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly." This principle of Ausubel (1963) became one of the starting shots for the main research field in science education from the seventies to the early nineties. Science educators all over the world studied – and are still studying students' so-called "misconceptions", "preconceptions", "preinstructional ideas" or "alternative frameworks". It is the merit of Pfundt and Duit (1994) to have compiled a bibliography with all publications dealing with students' alternative frameworks. From the first edition entitled "Students Alternative Frameworks and Science Education" the bibliography has meanwhile become an on-line bibliography with about 8000 entries: "Students' and Teachers' Conceptions and Science Education". It contains a lot of information about almost any science concept to science teachers and educators. See the example in figure 3.

What are students' preconceptions about energy?

Quoting different authors the on-line bibliography states among other things:

- Energy is anything that produces a force.
- Energy is a source of force or a source of power.
- Burning some materials creates energy.
- The body is creating energy by moving fast.
- Energy is needed to get things done.
- In a chemical reaction, the chemicals release some of their energy and produce heat.
- Energy can be expressed as heat.
- Water is a source of energy ... we need it to survive.

Figure 3: Students' alternative frameworks: a starting point for constructivist oriented teaching.

The knowledge of students' preconceptions is a first step to develop a teaching sequence about energy; analysing the scientific concept of energy and suitable teacher strategies are further steps. For the concept of energy (see figure 3) Duit has done this accurately and thoroughly and published articles like "Energy conceptions held by students and consequences for science teaching", (Duit, 1983a), "Students Notions about the Energy concept before and after Physics Instruction" (Duit, 1982), "Some ideas for dealing with energy de-gradation in grades 6-10" (Duit, 1983b) or "Should energy be illustrated as something quasi-material?" (Duit, 1987).

2 Since about 1990, the term misconception has been abandoned, because it was no longer politically and educationally correct. For the learner, his or her conceptions are almost always true, for him or her they are not misconceptions.

This example about students' preconceptions about energy and dealing with them in the classroom is paradigmatic for the research that has started more than 30 years ago. Parallel to this kind of research and partly relying on it the theory of constructivism has been developed. This development and the research on students' alternative frameworks have complemented one another. Also nowadays students' – and teachers' – preconceptions play an important role in constructivism and science education (see chapters 3, 4, and 9).

2 Today's role of constructivism

(3) Conceptual change

As mentioned above the first and probably main principle of the constructivist view says: learning is an active process of constructing new knowledge based on existing knowledge (figure 2). Widodo, (2004, p. 46) describes five cognitive processes of the learner:

- Retrieve and activate prior knowledge.
- Use prior knowledge to make sense of the new information.
- Develop the prior knowledge.
- Try out the new knowledge.
- Compare new and old knowledge, evaluate new knowledge.

The third process, the development of the prior knowledge, can be a continuous or a discontinuous one, or – as Piaget has said – assimilation or accommodation. In science education, the process of accommodation is known as conceptual change. Posner, Strike, Hewson and Gertzog (1982) have developed a first model of conceptual change and have claimed four necessary conditions that must meet to enable change:

1. Dissatisfaction with existing conceptions,
2. Intelligibility of a new conception,
3. Initial plausibility of a new conception,
4. Fruitfulness of a new conception.

Most of the conceptual changes are difficult, maybe due to the intellectual challenge, maybe due to the fact that abandoning a well known and estimated idea or theory, i.e. the own preconception, is always a complex and emotionally painful process. Two examples: a) The scientific definition of energy, work or acceleration does not correspond to the respective everyday concept; b) the Aristotelian explanation of motion, held by almost all people all over the world, is in contradiction with the Newtonian scientific explanation to be learnt at school. In biology, chemistry and physics, students have to accomplish many conceptual changes. This might be one of the reasons why science, in particular physics, is experienced and seen as difficult by many students.

The model of Posner et al. proved to be useful for the description and analysis of teaching and learning science. It has been widely accepted by the scientific community like almost no other model. Having been refined and improved (Duit & Treagust, 2003; Tyson & Ven-

ville, 1997; Treagust in this book) the model of conceptual change is used to analyse and develop teaching strategies in science education. Research has shown that there is not just one strategy suitable for all learners and the whole spectrum of scientific concepts, definitions, laws, and theories. Thus, one important branch of research in science education is dealing with conceptual change and suitable teaching strategies. Conceptual change has become one of the main concepts in constructivism and science teaching.

(4) Educational reconstruction and the development of learning environments

The majority of science educators are engaged in the development of new learning environments, i.e. teaching units, lessons or learning sequences, instructional material or learning activities. Many of them focus on – sometimes new, sometimes well known – science contents, others concentrate on specific educational or methodological principles like discovery learning, project learning or learning cycles. The extent to which this kind of research and development is theory-driven differs enormously, from almost zero to a well-elaborated theoretical frame.

With the model of educational reconstruction a theory exists that could provide the theoretical frame for developmental research (see the chapter of Kattmann & Komorek). As Duit, Gropengieser and Kattmann (2005) have explained, this theory consists of three strongly interrelated components: 1) Classification and analysis of science content, 2) investigations of students' perspectives, 3) design of learning environments (figure 4).

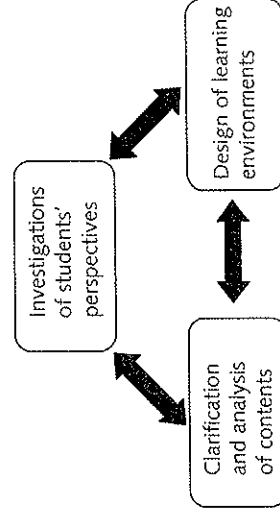


Figure 4: The model of educational reconstruction.

With the second component it is a highly constructivist approach, as it includes investigations of students' perspectives, i.e. their pre-conceptions, interests and questions on the content level, but also their views on the nature of science, as well on learning and teaching biology, chemistry or physics. Duit, Gropengieser and Kattmann (2005) specify, "Its purpose is to gather and grasp the preconditions of learning in a particular field of

knowledge. *What we aim at is a collection of students' diverse and common perspectives on a particular topic.*" This investigation is based not only on the literature about preconceptions, but also on own specific empirical studies adapted to the specific topic and the objectives being considered.

At the beginning of the third millennium, a professional development of learning environments with-out an underlying theory both in the science contents and equally (!) in the learning and teaching processes and strategies would not correspond to the state of the art. The model of educational reconstruction, including the analysis of students' perspectives, has been proven a valuable and promising model in developmental research.

(5) Empirical research on classroom teaching

In the last 15 years empirical research on classroom teaching has delivered interesting results for the scientific community. Triggered by the development of new technologies, like digital video cameras and new software for data processing, the first large-scale video studies have been performed in the middle of the nineties: the most famous of them the TIMSS video study in mathematics (Stigler, Gallimore, & Hiebert, 2000). Other studies followed, e.g. the TIMSS video study in science (Roth et al., 2006) or the German video studies in physics at the Universities of Essen (Fischer et al., 2005) and Kiel (Seidel, Prenzel, & Kobarg, 2005). Due to their tremendous complexity and costs, the number of video studies has been remained small until now.

They provide an insight into normal, i.e. real science teaching. Data can be analysed on the surface and on a deeper level. The spectrum of research questions which can be addressed is extremely broad, for example: Which teaching methods are applied? What is the role of demonstrations or student experiments? Are there specific scripts in science teaching in different countries? How do the outcomes correlate with different scripts? (See the chapter of Brückmann and Knièrim.) In almost all video studies, constructivism has proven to be essential. It has become the theoretical basis for a variety of category systems. Two examples may illustrate this:

Process-oriented teaching is the name of an observation scheme developed by Kobarg and Seidel (2005). It focuses on opportunities for learning processes allowing the students to build up new knowledge. The authors describe the theoretical background of their scheme as follows (p. 108): "*Based on current teaching and learning theories we understand learning as an active and constructive process in which the students build knowledge, competencies and skills themselves.*" The observation categories include four facets: social interaction, processing information, direct experience, and reflection. Using this coding scheme Knièrim (2008) analysed different types of process-oriented teaching, its use and outcomes in Swiss physics instruction in grade 9.

The structure of teaching learning sequences in physics instruction is the title of Gerber's thesis (2007). Relying on Piagetian and constructivist theories, he has defined different so-called basis models of learning and corresponding chains of learning operations. For example, the chain referring to the basis-model "concept building" is the following one:

1) activation of pre-knowledge, 2) introduction of and working through a prototype, 3) analysis of categories and principles defining the new concept, 4) active dealing with the new concept, 5) application of the new concept in other contexts. The basis-models, the chains of learning operations and corresponding coding schemes allowed Gerber to describe typical learning processes in physics instruction in a thorough manner that has never been achieved before.

This is not the place to discuss different empirical research projects on classroom teaching and their results. However, it should be pointed out that constructivism is the theory that underlies many of the observations schemes used in empirical research in science education.

(6) Teacher professional development

After the TIMSS- and PISA-shock, teacher professional development has been recognised as crucial for advancing daily science instruction in many countries. In Germany big programmes like SINUS-programme for increasing the efficiency of teaching mathematics and sciences (see the chapter of Prenzel in this book), Physics in context (see Mikelskis-

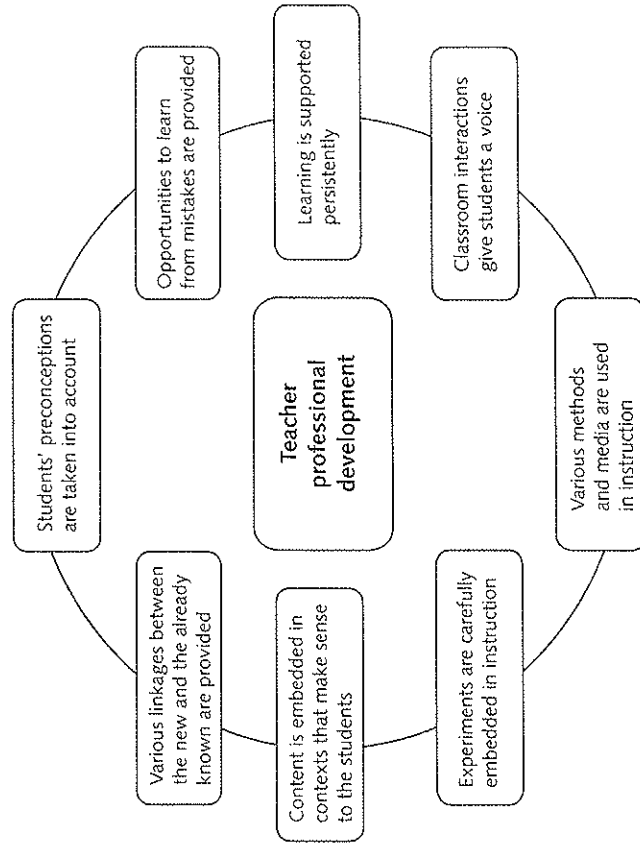


Figure 5: Characteristics of a new culture of teaching and learning sciences (see Duit & Wodzinski, 2006).

Seifert & Bell in this book). Chemistry in context, and Biology in context have been created, in Austria the programme Innovations in Mathematics and Science Teaching IMST (see Kühnelt & Stadler in this book). In each of these programmes dozens of schools and hundreds of teachers are engaged – in co-operation with science educators and researchers. The goal is to establish a new culture of teaching and learning. This culture relies heavily on principles defined for constructivist-oriented teaching and learning. This culture relies heavily on implementation and the evaluation of the new culture and of the effectiveness of the programme see the three contributions of Prenzel, Mikeskis-Seifert, and Kühnelt in this book. Constructivism proves to be one of the main bases of teacher professional development.

(7) Gender-balanced physics

From the beginning of the eighties, attitudes toward science and the achievements in science have been the foci of gender studies. Results indicate that boys have a more positive self-concept in and attitude towards physics and a higher achievement in physics; self-concept, attitude and achievement are correlated (for an overview see Murphy et al., 2006; Parker et al., 1996). Many propositions have been made and evaluated to improve the situation. The spectrum of the actions ranges from new kinds of physics curricula and assessment to new structures, e.g. only girls classes in physics, and to a new professional development of teachers. The empirical results of numerous research projects indicate that the implementation of the suggestions makes a difference towards a more gender-balanced instruction. In this (book) chapter I focus on propositions dealing with teaching and learning processes in the classroom. Most of them are strongly related to constructivist principles.

Criteria and strategies for a gender-balanced physics instruction

(Labudde, 2000b, p. 147-148)

1. *Individual preconceptions and experiences* of girls and boys should be integrated in the texts, as far as they are known and common, or/and students are explicitly asked to tell about their own experiences and ideas. During the lessons students get the opportunity to make up for unknown experiences. Relations and differences between everyday language and physics language are emphasised and discussed.
2. *Active and interactive learning environments* have to be created whenever possible: e.g. hands-on-activities, little “research-projects”, group-discussions, presentations by students, writing essays or designing posters. Teaching methods are favoured that enhance co-operation and communication between student-student and teacher-student.
3. *Contents and context* of physics instruction have to be relevant for males and females. Pay attention to the different experiences of girls and boys and to the context of physics instruction, create relations between physics and people whenever possible.
4. *Self-concept of girls*: praise girls not only for their diligence and discipline but also for their ability and talent in physics, avoid any impression that physics is only something for highly gifted people or men, emphasise that girls are not less “attractive”, not less “female”, when they are interested in and good at physics.

5. *Interaction and feedback*: pay equal attention to girls and boys, state explicitly your similar expectations concerning their abilities in physics, give all students enough time to answer a question, collect several answers to one question, give positive feedback during the lesson and in personal conversations.

6. *Atmosphere and methods of learning*: arrange conversations and discussions as often as possible, form single-sex groups for group-discussions and practicals, support co-operation and suppress open competition.

(8) Science-Technology-Society STS

In some countries, e.g. in many English-speaking countries, in the Netherlands and in Switzerland, biology, chemistry and physics are taught as one subject called science, sometimes with an even more extended claim leading to the STS-approach³ (Science-Technology-Society) or STSE, i.e. including environment. What are some of the specific aims of STS-courses? (Labudde, 2003, 2006)

- The most significant objective is fostering students’ attitudes to science. The STS-contents used should motivate students and make them feel more positive about science.
- A better motivation might result in improved learning and understanding of scientific concepts. Students should become “scientifically-literate citizens: people who can make sense of some of the many ways that science impinges on their everyday life.” (Bennett, Lubben, & Hogarth, 2007)

How can one justify the hope that STS might be a good approach for these aims? The following arguments rely heavily on the constructivist theory: Within a STS-setting the science contents are not just biology, chemistry or physics like in conventional courses, instead they are related to different domains, for example the different sciences or technology, but also to society or – within a broader context – economics, sports, music or arts. Relations to a variety of domains increase the chance to also stimulate students’ pre-conceptions in a broader spectrum of domains. It becomes easier to reach more students. They feel to be “fetched” if the STS-content is within their horizon. Relating new experiences to previous knowledge and constructing new knowledge become more feasible.

These are some of the main arguments for STS-courses. However, how does the reality look like? What are the outcomes of the STS-approach? Bennett et al. (2007) have made a systematic review of empirical studies about STS-courses and concluded that STS-courses

- provide as good a development of understanding as more conventional approaches (strong evidence),
- foster more positive attitudes to school science (very strong evidence) and to science (limited evidence) than conventional courses,

³ In Europe the term “context-based” is sometimes used as a synonym for STS.

- promote more positive attitudes to science in both girls and boys, and reduce the gender differences in attitude (moderate evidence),
- have an impact on subject and career choices (mixed evidence).

3 Tomorrow's role of constructivism

All facets of constructivism and its use mentioned in the previous chapters will play a role in the near future, too. Two other facets are starting to play a role: the education of science teachers and the development of competency models and standards. In my opinion, they will become important issues in the medium and long term.

(9) Training of student teachers

How should future teachers for primary school, lower and upper secondary school be qualified and trained? How should teacher programmes look like? Science educators all over the world are engaged in these programmes and have asked themselves these questions.

As Duit (1995) has already explained more than ten years ago, constructivism does not only apply for pupils and students from Kindergarten, Primary and Secondary School but to all learners, i.e. also to student teachers. In science education there are different fields of research: 1) studies dealing with pre-conceptions of future teachers, e.g. their knowledge in certain science topics (Trend, 2000), their belief systems about the teaching and learning of science (Koballa, Gräber, Coleman, & Kemp, 2000), or their views on the nature of science (Lederman, 1999; Murcia & Schibeci, 1999), 2) analyses of the pedagogical content knowledge of teachers (Flores, Lopez, Gallegos, & Barojas, 2000; Parker & Heywood, 2000), 3) development of new teacher programmes. For the latter we have elsewhere noted several central questions (Labudde, 2000a), for example in the dimension of the individual and of the social interactions:

Dimension of the individual

- What experiences of students can I tie on to?
- Do I give participants the opportunity to bring in their previous knowledge into course?
- Where could conceptual change take place?
- Are students repeatedly given the opportunity to reflect on their own learning processes?

Dimension of social interactions

- How can I design the course to encourage a productive learning atmosphere?
- Do I give students the chance to communicate and cooperate with each other regularly?
- How can I contribute to the emergence of a learning group/study group?

All of the questions are based on a constructivist view of learning and teaching. By questions like those, science educators are able to apply the constructivist approach in teacher programmes – also in correspondence with the motto: *Teachers teach as they are taught, not as they are taught to teach.*

(10) Standards in science education

Due to PISA (Programme for International Student Assessment) competency models, standards, scientific literacy and curricula have gained increasing interest in the last five years. Therefore, it is not by chance that the first chapter of this book is dedicated to “the development of curriculum materials and their impact on everyday school life”. I will try to elaborate how this topic is related to constructivism. As a paradigmatic example, I will sketch the Swiss project HarmoS (Harmonization of the compulsory school). The scientific part of HarmoS includes the following milestones (Labudde, 2007; Metzger & Labudde, 2007):

- 2005-2006 development of a competency model in science for grades 2, 6, and 9,
- 2007-2008 validation of the model by paper & pencil and performance tests,
- 2008 proposal of basis standards to the policy makers,
- from 2009 implementation of the standards including the development of a core curriculum for each of the Swiss language regions and establishment of an education monitoring system.

The three dimensional competency model includes the following axes: the competencies, the domains, and the levels (see Fischer in this book). The axis of the competencies is the predominant one when developing problems for validation and assessment. In other words, the problems will be competency-driven. The range of competencies includes among others: to ask questions and to investigate, to open fields of interest, to organize and structure, to estimate and judge, to develop and realize, to communicate and interchange. The model has been subjected to a complex and elaborate validation: During spring 2007, Swiss sixth and ninth graders have accomplished a nationwide assessment (a sample of 9600 students from the German and French speaking part of Switzerland). It was a pencil and paper test (P&P); each student had to solve 4 to 6 problems (with 10 minutes time for each). A P&P and experimental test for the 2nd year level has followed in autumn 2007. In winter 2007/2008, the results of the latest PISA assessment have been incorporated into the body of empirical data. Specific experimental tests for 6th and 9th graders have taken place in spring 2008. The final model, completed by a detailed description of competency levels and empirically grounded basis standards is expected for October 2008. The validated test problems of the consortium will be an integral part of the competency model. The whole process of developing standards can be seen as a cyclic one (figure 6; Labudde, 2007, p. 285):

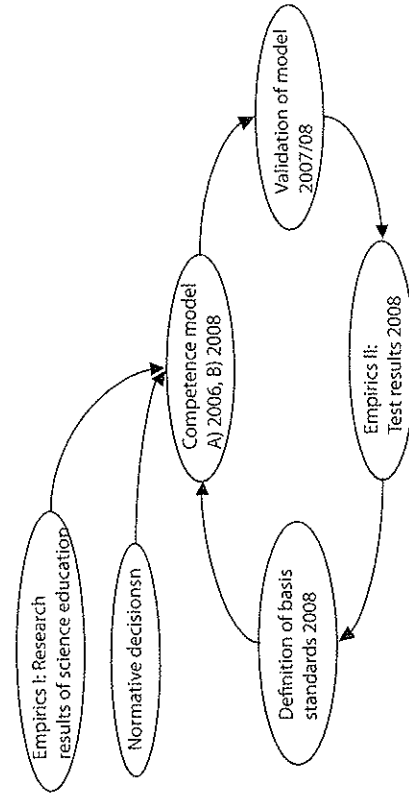


Figure 6: The cyclic process of developing a competency model and standards (with years of the first cycle).

The cyclic process can be interpreted from the perspective of constructivism: the first competence model (A: 2006) is the “pre-concept” that becomes validated and adapted, i.e. a second draft (B: 2008, the “concept”) of the model is constructed which could be a continuous or discontinuous process. As one can see: Analogous to the learning process on the individual level, the development of the model and of standards can be described – on a meta-level – in terms of constructivism.

You, the reader, together with us as constructivists

What do you think has been, is and will be the role of constructivism yesterday, today, and tomorrow? You, who have been reading this chapter, will have your own answers. These depend on your pre-conceptions. With your and our opinions and ideas we, the scientific community of science educators, will construct new knowledge, based on our previous knowledge and in a process of communication and collaborative learning.

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