

Conceptual Change

Still a Powerful Framework for Improving the Practice of Science Instruction

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*Please notice: The work presented here draws on a long standing close
cooperation with David Treagust (Perth)*

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The point of view presented is based on:

(1) A Chapter in a Handbook on Conceptual Change

Duit, R., Treagust, D., & Widodo, A. (2008). Teaching for conceptual change – Theory and practice. In S. Vosniadou, Ed., *International Handbook of research on conceptual change*. Mahwah, NJ.: Erlbaum, 629-646.

(2) Two contributions to a special issue of the Journal *Cultural Studies in Science Education* on Conceptual Change vs. Cultural Studies

Treagust, D.F. & Duit, R. (2008). Conceptual change: A discussion of theoretical, methodological and practical challenges for science education. *Cultural Studies of Science Education*, 3, 297-328.

Treagust, D.F. & Duit, R. (2008). Compatibility between cultural studies and conceptual change in science education. *Cultural Studies of Science Education*, 3, 387-395

PDF /Word files are available on request

There are the following sections:

- (1) Theoretical Developments in the Area of Conceptual Change
- (2) Efficiency of Conceptual Change Oriented Instructional Design
- (3) Conceptual Change and Educational Reconstruction
- (4) Conceptual Change and Instructional Practice
- (5) Conceptual Change and Teacher Professional Development
- (6) Challenges for Future Research and Development

(1) Theoretical developments in the area of conceptual change

Students' conceptions – towards multiple conceptual changes

Research in the 1970s: Focus on (alternative) conceptions on the content level

1980s and 1900s: Conceptions on the Nature of Science (NOS) and Science Processes
Meta-cognitive conceptions

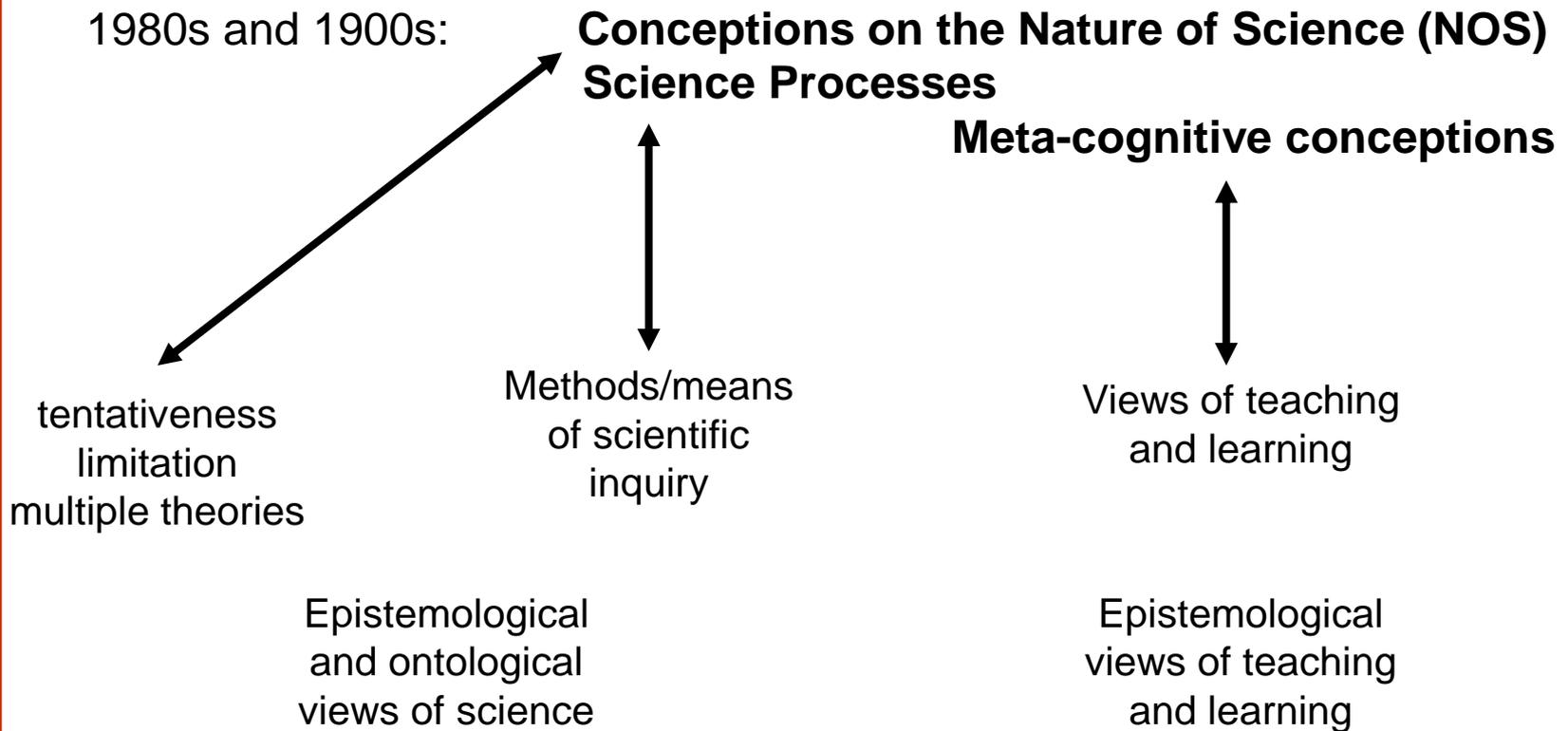
1980s: “Classical” conceptual change model
(Posner, Strike, Hewson, Gertzog, 1982)

1980s, 1990s Further development of the classical conceptual change ideas:

“Conceptual change is considered not as a replacement of an incorrect naïve theory with a correct theory but rather, as an opening up of conceptual space through increased meta-conceptual awareness and epistemological sophistication, creating the possibility of entertaining different perspectives and different point of views”
(Vosniadou, 2008)

(1) Theoretical developments in the area of conceptual change

Students' conceptions – towards multiple conceptual changes



(1) Theoretical developments in the area of conceptual change

Teachers' conceptions – a major obstacle for efficient teaching

Teachers' conceptions have proven limited

- conceptions on the content level
- conceptions on the Nature of Science and Science Processes
- views of teaching and learning science meta-cognitive conceptions

Teachers' conceptions have to undergo conceptual changes

Basically the same conceptual change frameworks for addressing students' conceptions have proven valuable to develop teacher conceptions.

(1) Theoretical developments in the area of conceptual change

The “classical” conceptual change approach

Research in the 1970s: Based on Ausubel and Piaget (accommodation versus assimilation)

Classical cc approach: dissatisfaction – intelligible – plausible – fruitful
(Posner et al, 1982)

T.S. Kuhn: revolutionary & evolutionary changes of concepts in the history of science

Toulmin: Metaphor of conceptual ecology

Piaget: Accommodation vs. Assimilation

The “classical” approach clearly has been the most influential perspective in the domain of conceptual change.

However: It has been further developed in various ways.

(1) Theoretical developments in the area of conceptual change

Affective variables

Classical approach (1982): Implicitly includes affective variables

Pintrich, et al. (1993): Beyond cold conceptual change
Affective variables primarily as
moderating conceptual change

Zembylas (2005): Cognitive and emotional variables
should be given equal status
Both have to undergo “conceptual
changes”

(1) Theoretical developments in the area of conceptual change

Constructivist views and conceptual change

- | | |
|--------------------------|---|
| Radical in the 1980s: | Focus on the constructions of the individual |
| Social late 1980s | Not only the individual conceptions are seen as co-constructors of knowledge but also the material and social features of the learning situation
Many variants, including social cultural, Vygotsky, Activity Theory |
| Multi-perspective views: | Addressing the insight that only such views allow to model the complexity of what teaching and learning includes
The Educational Complementarity Principle |

(1) Theoretical developments in the area of conceptual change

Mental Model versus Social Cultural	
Knowledge	
Meta-stable in-head entity	Entity coming into being in the interaction with the social and material “world”
Conceptual Change	
In-head changes	Changes of the way the individual interacts with the world
Research methods to investigate learning	
Questionnaires, concept maps, individual interviews	Discourse analysis

(1) Theoretical developments in the area of conceptual change

Towards more inclusive conceptual change views

- The development of conceptual change views from the early 1980s to the present state may be characterized as a progression towards more inclusive views.
- These more recent views allow addressing the dynamics of teaching and learning processes more comprehensively than the initial views.
- However, the theoretical frameworks have become more and more complicated and may cause serious problems for teachers in ordinary schools to use them.

(2) Efficiency of conceptual change oriented instructional design

It seems that conceptual change oriented instructional approaches are more efficient than traditional ones

- A more recent meta-analysis – particularly on conceptual change approaches – is missing. However, many studies, among them studies based on large scale quality development projects, show that at least the cognitive outcomes are significantly better than in traditional approaches.
- The affective variables are not often viewed as the outcomes per se. Here a few studies show that development of student interests and self-concepts are better than in more traditional approaches.
- A cautious note on the “cognitive conflict”: Research has clearly shown that much care is needed if cognitive conflict is used. Success is by no means guaranteed.

(2) Efficiency of conceptual change oriented instructional design

Research findings on instructional quality in general have shown:

- A single intervention (like addressing students' pre-instructional conceptions) usually does not lead to better outcomes per se
- Quality of instruction is always due to a certain “orchestration” of various instructional methods and strategies
- Instruction needs to be viewed as a highly complex non-linear system. Such systems may be guided to a certain outcome only to a limited extent
- That means: Conceptual change strategies may only be efficient if they are embedded in a conceptual change supporting learning environment that includes many additional features

(2) Efficiency of conceptual change oriented instructional design

Characteristics of Quality Development Approaches

(Beeth, Duit, Prenzel, Ostermeir, Tytler, Wickmann, 2003)

- Supporting teachers to rethink the representation of science in the curriculum.
- Enlarging the repertoire of tasks, experiments, and teaching and learning strategies and resources.
- Promoting strategies and resources that attempt to increase students' engagement and interests.

These characteristics are – principle – at the heart of inclusive constructivist conceptual change approaches.

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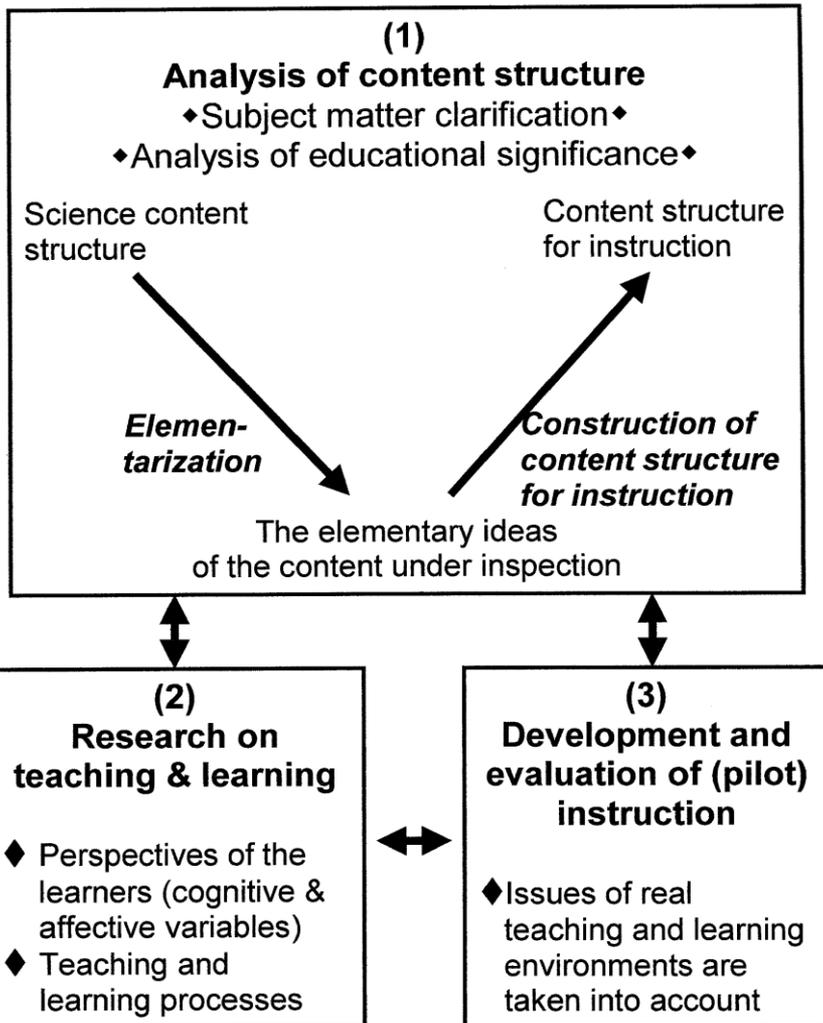
These characteristics are – principle – at the heart of inclusive constructivist conceptual change approaches.

However: In many studies under the heading of conceptual change the major emphasis is on implementing new instructional methods not on rethinking the representation of the particular science topic in relation to the designed instruction.

(3) Conceptual Change and Educational Reconstruction

The Model of Educational Reconstruction

(Kattman, Duit, Großengießer, & Komorek, 1995)



Key idea:

The science content is not given but has to be (re)constructed by taking the aims of instruction and student perspectives into account.

Science Content Structure and Science Content Structure for Instruction have to be clearly differentiated

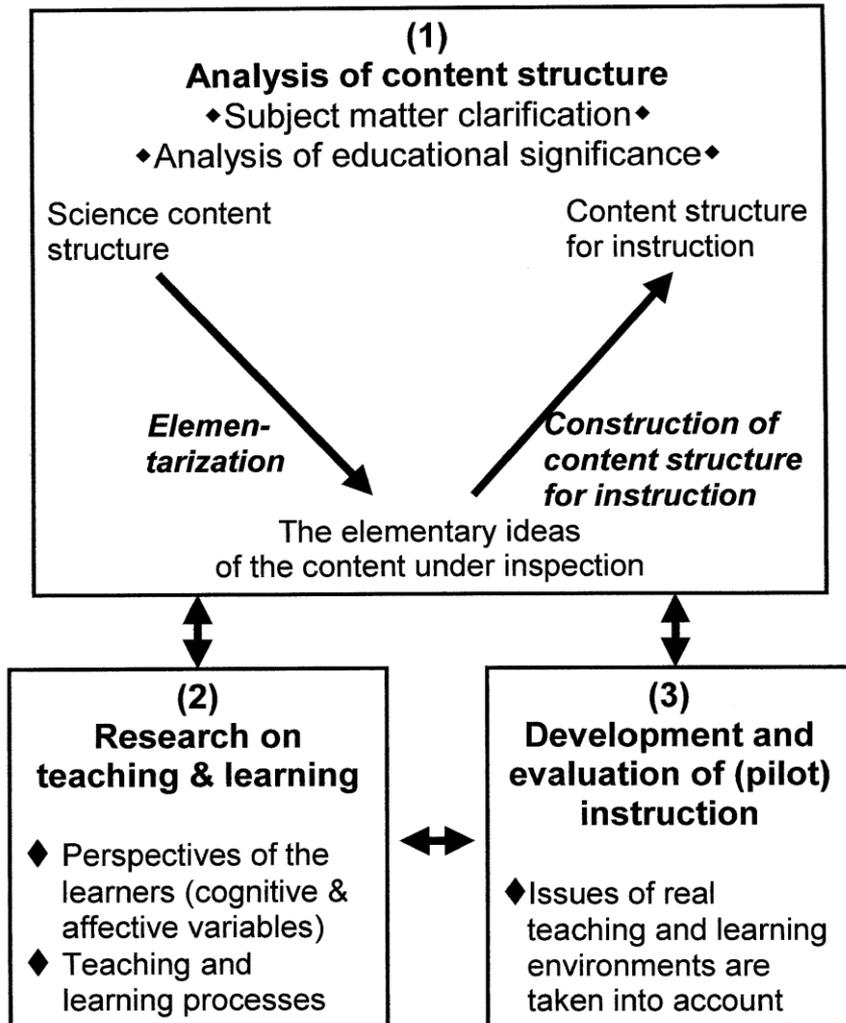
Science Content Structure

Science content elements
PLUS
relations between the elements

(3) Conceptual Change and Educational Reconstruction

The Model of Educational Reconstruction

(Kattman, Duit, Großengießer, & Komorek, 1995)



It is necessary to rethink the “traditional” science content structure dominating in science instruction *and* the way science is taught from the perspectives of the aims set and the perspectives of the learners.

Rethinking of science content structure for instruction and conceptual change oriented instructional methods need to be closely linked.

(4) Conceptual change and instructional practice

It seems that conceptual change ideas do *not* inform practice to a considerable extend

Various studies (among them large scale video-studies) show:

- Transmissive views of teaching and learning prevail.
- Most teachers' thinking about instruction is focussed of science content and does not sufficiently take into account student learning.
- Instructional scripts based on transmissive views of teaching and learning predominate:

“Students in the three countries (Sweden, England, Australia) frequently described school pedagogy as the transmission of content expert sources – teachers and texts – to relative passive recipients” (Lyons, 2006)

Still there is a large gap between instructional design based on recent findings on conceptual change and what is normal practice in most of the classes observed in various studies.

(5) Conceptual change and teacher professional development

Teacher Professional Development may be viewed in terms of Conceptual Change

- The process of teacher professional development can be viewed as a series of substantial conceptual changes teacher have to undergo
- Theoretical approaches of conceptual change are also suited to model teacher professional development
- Two major issues:
 - (a) To make teachers familiar with the recent state of research findings on teaching and learning science
 - (b) To make teachers familiar with theoretical positions that allow to intimately link science content issues and issues of student learning (such as PCK or the Model of Educational Reconstruction)

(6) Challenges for future research and development

Challenge 1. Is conceptual change still an adequate term to indicate its actual meaning?

- The meaning of conceptual change changed substantially – from the 1980s to now
- The term change invites several misunderstandings, such as “exchange”
- Should the term “conceptual change” be exchanged by another term?
Kattmann proposed: “***conceptual reconstruction***”

(6) Challenges for future research and development

Challenge 2. Research on inclusive conceptual change approaches needs to take into account multiple perspective

Demands:

- ***On the theoretical plane:*** It is necessary to further investigate in which way the various theoretical perspectives are linked and may constructively interact in a complementary way.
- ***Regarding the interplay of cognitive and affective outcomes:*** So far it is not clear (theoretically and empirically) what it means to give both variables equal attention and claim that they are closely linked.
- **On the plane of embedding conceptual change into models of instructional planning** (see below)
- ***On the plane of research methods*** (see below)
- ***On the plane of improving practice*** (see below)

(6) Challenges for future research and development

Challenge 3. Conceptual change approaches of teaching and learning science need to be embedded in more inclusive models of instructional planning.

Demands:

- ***Avoid the major focus of conceptual change on improving the instructional method side.*** It is necessary to give rethinking traditional science content structure for instruction from the perspectives of the aims of instruction and learners' perspectives the same attention as the instructional method side.
- ***Development of models of planning science instruction.*** Existing models (like the Model of Educational Reconstruction) need to be further developed.

(6) Challenges for future research and development

Challenge 4. Determine the necessary and sufficient evidence for identifying conceptual change – towards mixed methods studies

- In approaches near to the “classical” conceptual change model data collected include tests, interviews, and less frequently thinking aloud protocols.
- Research from multi-perspective conceptual change views require a wide spectrum of research methods including variants of learning process studies with a certain focus on discourse analysis (a standard method used by social cultural researchers).
- Mixed methods studies including quantitative and qualitative data have to be further developed and applied.

(6) Challenges for future research and development

Challenge 5. Bring successful conceptual change approaches to normal classes

- It seems to us that this is the major challenge at this time.
- Practice usually is quite far from what inclusive conceptual change approaches recommend. Also teachers' beliefs about good instruction and their instructional behavior are difficult to develop.
- The frameworks of student conceptual change have proven also powerful in teacher professional development – but more work is needed to further develop such approaches.
- A closer cooperation between science education researchers on teaching and learning, curriculum developers, and science education policy people is needed.
- Additionally: Instructional quality is not due to certain instructional methods but due to the interplay of various methods.

(6) Challenges for future research and development

In a nutshell:

Challenge 1. Is conceptual change still an adequate term?

Challenge 2. Clearing the theoretical frameworks for inclusive conceptual change approaches based on multiple theoretical perspectives

Challenge 3. Conceptual change approaches of teaching and learning science need to be embedded in more inclusive models of instructional planning

Challenge 4. Towards mixed methods studies

Challenge 5. Improving instructional practice