Content-specific research in science education

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Overview

Four main perspectives of science education research (SER):

1. Focus on content
2. Theory and practice
3. Some ideas about theory development
4. Visions for improving the teaching of science
1. Focus on content
Why focus on content?

- Learning is content specific (Seiler 1971)
- Learning is always the learning of something (Marton & Booth 1998)
- Content-oriented theories (Andersson & Wallin 2006)
- Pedagogical **content** knowledge - PCK (Shulman 1986; Loughran 2001)
- Content structure ("Sachstrucktur") (Niedderer 1972; IPN curriculum physics; Duit & Brückmann 2008)
This means …

- Fachdidaktik
- Didactics of special subject areas
- Science education
- Content-oriented theory
- Domain-specific theory
"On Developing Content-oriented Theories Taking Biological Evolution as an Example"

"... for example, understanding conditions for learning of given topics under regular classroom conditions."

"Some methodological problems ... are discussed, as well as the role of content-oriented theories in strengthening science education research as an autonomous specialization within educational science"

Different type of theoretical contribution: "How design work in general can be planned and carried out, and can be applied to different contents."
"What seems to be apparent from the literature is that science education research does not aim to develop content-specific didactical knowledge ... but to contribute to ... general educational and/or psychological theories. I consider this flight away from content detrimental ...”

"Through reflection on such practices, one might come to formulate **content-specific theories** regarding the teaching/learning of particular topics, ..."
"Domain-specific theories"

- "Design experiments are conducted to develop theories, not merely to empirically tune “what works.” These theories are relatively humble in that they target domain-specific learning processes. [...] A theory of this type would specify successive patterns in students’ reasoning together with the substantiated means by which the emergence of those successive patterns can be supported."
Content-oriented theory

What means “theory”? Generalisable empirical or theoretical results
Types of research for “content-oriented theory”

1. Determining content-specific objectives and relevant contexts
2. Students’ conceptions
3. Students learning pathways and learning processes
4. Developing content specific tests
5. Generalisable results about approaches
6. Determine content specific interest and motivation
7. Select those concepts, which are helpful/necessary to work with in relevant contexts, take away concepts that are not needed
Content-specific SER, aspect 1: Determining objectives and relevant contexts

- “content-oriented norms”, ”Discussion about why the given area should be taught at school.” (A&W 2006)
- More research on context-based approaches (David Treagust)
  e.g. to determine relevant contexts
  - Noise pollution for teaching sound
  - Sustainable energy for teaching energy (Susanne Engström Lic 2008)
  - STS
- Asking experts
  e.g. Delphi method
  Several doctoral projects at FontD
"Old" areas with more and more theoretical results

New theoretical background:
- conceptual profile (Mortimer 1996);
- parallel conceptions (Hartmann & Niedderer, 2005);
- cognitive tools (diSessa 1993; Stavy et al. 1998; Niedderer 2001)

New areas
- conceptions around chemical concepts like enthalpy (Tor Nilsson)
- Conceptions related to STS contexts
Content-specific SER, aspect 3: Learning pathways and learning processes

- Driver 1989
- Duit, Goldberg & Niedderer 1992
- Scott 1987, 1991
- Petri 1996
- von Aufschnaiter & Welzel 1999
- Tasar, M. F. 2001
- Clement & Steinberg 2002
- Givry 2003
- Niedderer, Budde, Givry, Psillos, Tiberghien 2007
- Roger Andersson (ongoing doctoral project)
Content-specific SER, aspect 4: Developing content specific tests

- FCI Hestenes, Wells & Swackhamer (1992)
- ...
- Thermodynamics test inventory TTI Einhaus & Schecker (2007)
Content-specific SER, aspect 5: Generalisable results about approaches

- “How can one deal with clashes between religious beliefs and scientific ideas about evolution?” (A&W 2006)
- General features in teaching a special content
- E.g. “electronium” approach in QAP
  - Deylitz 1999
  - Budde 2004
“How can one get students to think actively and with interest about the various aspects of evolution?” (A&W 2006)

  SDT, tests
Content-specific SER, aspect 7: To determine those concepts …

… which are helpful/necessary to work with in relevant contexts, take away concepts that are not needed

- **Frequency** instead of **oscillation time** for noise pollution
- **Efficiency, energy quality** and **exergy** for teaching sustainable energy
How do you classify the contributions of this Summerschool:

( ) Working on content-specific theories
( ) Working on general pedagogical or psychological theories and apply them to a science content
( ) Some aspects of both
2. Theory and practice
Aspects for theory and practice

- Our final aim is always to improve practice
- BUT: to some extent SER must develop its own theory and for that purpose be “off-practice”
Cedric Linder and his group at Uppsala university

Variation theory (Marton et al) used for improving science teaching at university level

- Quantum physic
- Chemical engineering
- Several doctoral dissertations
Fred Goldberg and his group at San Diego State University

Constructivist pedagogy used for improving science teaching at upper secondary level

- Constructing physics understanding (CPU)
- 12 units in mechanics, optics, heat and electric circuits with computer simulators for each (can be bought or using for free the simulators at internet)
- 3 doctoral dissertations
Hans Niedderer and his group at Bremen university

Students’ conceptions and learning processes used for improving science teaching at upper secondary

- Quantum atomic physic
- 5 doctoral dissertations
- Teaching material, both in German and English language, to be downloaded
Theory and Practice – Example 4

- Communicative approach (Scott)

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3. Some ideas about theory development
Some ideas about theory development 1

- Students’ conceptions 1: Conceptual profile (Mortimer 1995) Parallel conceptions (Hartmann 2004)

- Students’ conceptions 2: The idea of content specific cognitive tools ("cognitive atoms") (diSessa 1993; Stavy et al. 1998; Niedderer 2001)

- Students’ conceptions and conceptual change
  - types of learning (Tiberghien)
  - The idea of a triadic model (Strömdahl 2006)
  - Conceptual profile change (Mortimer 1996)
An example of conceptual profile change
- A reconstruction based on data

Example: conceptions of an atom

Strength/status

- Planetary conception
- Smeared orbits conception
- Quantum particle conception
- Quantum cloud conception
An example of conceptual profile change
- A reconstruction based on data

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Example: conceptions of an atom

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- Smeared orbits conception
- Quantum particle conception
- Quantum cloud conception

Strength/status vs. time
An example of conceptual profile change
- A reconstruction based on data

Example: conceptions of an atom

Strength/status

Planetary conception

Smeared orbits conception

Quantum particle conception

Quantum cloud conception
Some ideas about theory development 2

- Learning pathways – learning process studies: The idea to follow students’ own constructions during learning for a specific content (Driver, Scott, Tiberghien, Clement, Niedderer ...)

- Impact of “inputs” on “learning”: The idea of content specific resonance (Glasersfeld 1991; Budde 2004)
The idea of resonance (Glasersfeld 1991)

Learning environment
- teacher's statements
- other students' statements
- textbook

Learning effects
as resonance

Learning steps of a single student as conceptual evolution

Resonance or Non-resonance

Cognitive system of student
4. Visions for improving the teaching of science
Visions for school

“Syllabus teaching” : “Project teaching” = 50:50

Equal teaching time for
teaching of basic concepts (according to syllabus)
AND
project learning with individual and social relevance
Visions for better motivation in science teaching

- Relevant new content/contexts related to actual problems of individual and society (vision II of Roberts 2006)

- Group work with ownership of learning (Margareta Enghag 2007)
Vision for teacher education

- PCK as main focus and content


Mortimer 1995

References


## References