Shared regulation and knowledge construction in inquiry-based science learning

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Theoretical framework I: SRL

Self-regulated learning

- Active and constructive engagement in a process of meaning generation
- Adaptation of thoughts, feelings, and actions as needed
- Influenced by contextual and individual differences

(Pintrich, 2004; Boekaerts & Corno, 2005)

Shared regulation of learning

- Multiple others regulate their collective activity
- Learners share a common problem-solving plane
- Co-construction of learning

(Hadwin & Oshige, 2011; Vauras et al., 2003)

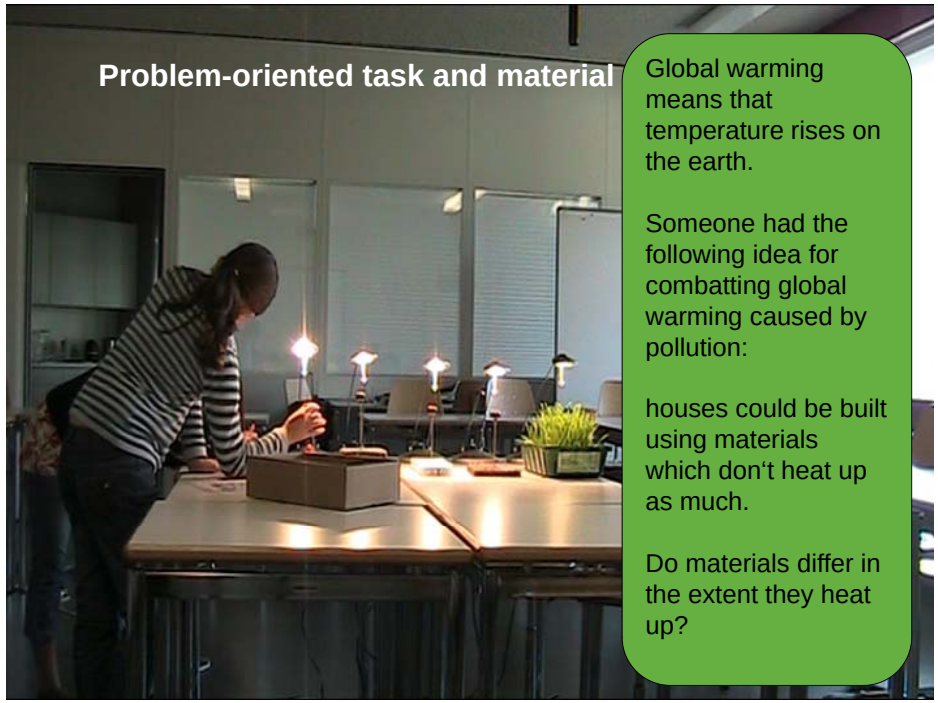
Theoretical framework II: inquiry learning

Inquiry learning: students carrying out their own investigations, hands-on, open ended, explorative (Llewellyn, 2007; Rocard et al., 2007)

		How much information is given to the student?		
Level of Inquiry		Question?	Method?	Solution?
1	Confirmation	X	x	x
2	Structured Inquiry	X	x	
3	Guided Inquiry	X		
4	Open Inquiry			

(Bell, Smetana & Binns 2005)

Problemoriented task with step-by-step instruction (level 2) versus problem oriented task without step-by-step instruction (level 3)



THE INDEPENDENT

Obama's climate guru: Paint your roof whit

By Steve Connor, Science Editor

Wednesday, 27 May 2009

Some people believe that nuclear power is the answer to climate change, others have proposed green technologies such as wind or solar power, but Barack Obama's top man on global warming has suggested something far simpler – painting your roof white.

Steven Chu, the US Secretary of Energy and a Nobel prize-winning scientist, said yesterday that making roofs and pavements white or light-coloured would help to reduce global warming by both conserving energy and reflecting sunlight back into space. It would, he said, be the equivalent of taking all the cars in the world off the road for 11 years.

Speaking in London prior to a meeting of some of the world's best minds on how to combat climate change, Dr Chu said the

Houses with white roofs, like these in G would be able to reflect light back thro

Step-by-step instruction

1.) Fünf verschiedene Gegenstände stehen euch zum Experimentieren zur Verfügung: schwarzer und weisser Stein, Gras, Teer, Ziegel

2.) Schreibt Eure Vermutungen auf:
Bei welchem Material erwartet ihr die höchsten, wo die niedrigsten Temperaturen, wenn die Sonne darauf scheint?

höchste: _____

niedrigste: _____

3.) Notiert, mit welchen Gegenständen ihr experimentiert und deren Anfangstemperaturen.

Anfangstemperaturen:

Gegenstand 1: _____	_____ °C
Gegenstand 2: _____	_____ °C

Task for the study

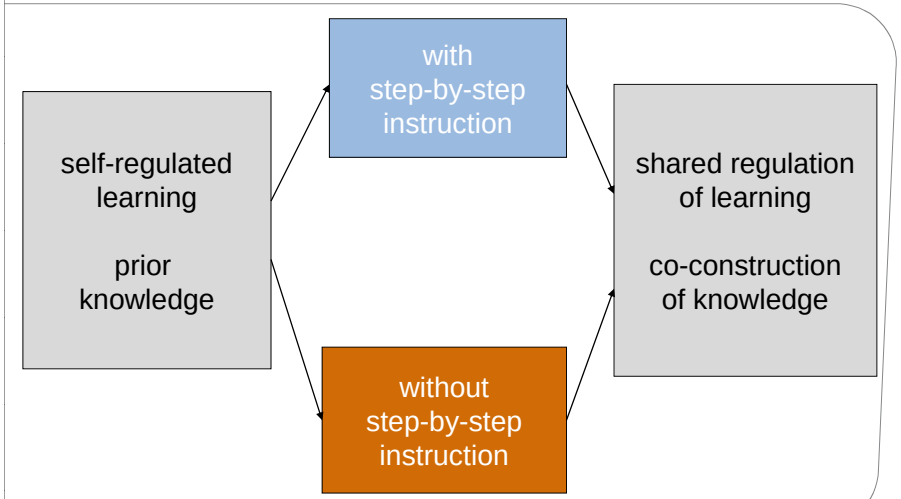
Problem-oriented task **with** step-by-step instruction

- Problem and material for problem-related experiments are provided
- Prompt to think about the problem
- Directives of how to solve the problem are provided with a step-by-step instruction

Problem-oriented task **without** step-by-step instruction

- Problem and material for problem-related experiments are provided
- Prompt to discuss the problem and the experiment they want to pursue
- Free choice of how to approach problem

Research design



Research questions

- How do pairs of primary school children co-construct knowledge when given a step-by-step instruction for a problem-oriented task compared to a problem-oriented task without step-by-step instruction?
- How do pairs of primary school children share the regulation of the activity-oriented learning process under these two conditions?

Method

- Pre and post measurements
  - knowledge of natural sciences and climate change
  - interest for topic
  - familiarity with environmental issues
  - ability to self-regulate learning
  - achievement goals
- Two conditions
  - Problem-oriented task with step-by-step instruction (10 teams)
  - Problem-oriented task without step-by-step instruction (10 teams)
- 4th - 6th grade students (mean age 11.2 years ; range 9-14 years)
- Videotapes of 20 teams working together on task
- Video-recall with each team immediatly after completion of the task

Units for data analysis

- Statements
  - Analysis of communicative elements

    "Statement units, defined as a codable unit of speech (i.e., a word, a phrase, sentence, or sentences) within a turn, are the units of analysis for microcoding."

    (Hogan et al., 1999, p. 387)
- Episodes
  - Analysis of knowledge construction

    "… an episode was the analysis unit used. An episode can be characterized as an event where there is an activity reflecting one meaningful aggregate of interaction"

    (Veermans & Järvelä, 2004, p.276)

    "A new segment started when there appeared to be a significant shift in the mathematics content."

    (Jacobs et al. 2003, p. 118)

Data

10 Videos with step-by-step instruction
10 Videos without step-by-step instruction
Videos and video transcripts with added description of students' actions as basis for coding (using MAXQDA)

	M_{with}	$M_{without}$	t	df	sig
Video duration	22.9	21.2	-1.17	18	.259
Statements	204	224	.603	18	.556
Episodes	20	22.6	.744	18	.472
Interest for science	4.20	4.10	.05	37	.963
Interest for climate change	3.20	3.00	-1.0	38	.324
Pre-test knowlegde about science	495	553	1.61	36	.117
Perceived difficulty of science topics	3.00	3.10	-.53	38	.603

Coding system for statements

- Development of categories: Inductively from video footage and deductively from existing literature (Pauli, 1998; Hogan et al. 1999)

- Statement
  - about the material, temperature
  - how to proceed, what to do next
  - conclusions, reflections about the process
- Question
  - about the material, how to proceed, asking for help
- Response
  - Agree, disagree, ignorance

Interrater-Reliablity
  - Satisfactory for all categories
  - For 5 Videos (25% of all statements) a total of 85% agreement was observed

Results: statements I

Code	with	without
incomprehensible	90	89
nonsubstantive	446	419
S_about material	163	244
S_temperature	177	180
S_based on text	68	34
S_read aloud from text	96	50
I_looking at text/ instruction	77	38
S_procedure	306	365
S_guess	48	80
S_prior knowledge	7	28
S_situated prior knowledge	3	5
S_statement (justified)	4	33
S_justification	5	46

Results: statements II

Code	with	without
S_inference	31	41
S_reflection	21	35
S_emotion	18	10
Q_about material	126	114
Q_help	18	9
Q_understanding	23	51
Q_procedure	100	103
R_agree	139	169
R_answer	36	36
R_ignorance	17	19
R_contradiction	18	42
off task	1	6
Total	2038	2246

Different levels in cognitive processing

- “Identifying levels in cognitive processing is critical when researching informal, student-led learning activities because not all peer interactions lead to high-level of learning and understanding.”

- “Despite challenges, the literature on collaborative learning unanimously describes high-level cognitive/metacognitive processing as the most desirable focus of group interactions.”

(Volet, Summers & Thurman, 2009, p. 130)

4 levels in cognitive processing

- Non-substantive: incomprehensible, R_agree / R_ignorance …
- Low-level processing: information about material / temperature …
- Medium-level processing: planned procedure, guess, understanding...
- High-level processing: justification, inference, reflection …

	M_{with}	$M_{without}$	t	df	sig
Non-substantive	69.2	69.6	.035	18	.973
Low-level	76.1	70.5	-.477	18	.639
Medium-level	49.5	64.1	1.265	18	.227
High-level	7.1	18.8	2.368	18	.039

Coding system for episodes

Development of categories:
Inquiry Cycle (Lllewllyn, 2007)
Competent Problem Solving Model (Verschaffel et al., 1999)

- Understanding of the problem
- Elaboration of the problem
- Hypotheses for outcome
  - Understanding instruction
  - Handling material
  - Planning experiment
  - Measuring temperature
  - Difference in temperature
  - Difference in warming

  } carrying out the experiment
- Interpretation of results
- Evaluation of experiment

Results: episodes

Code	with	without
Understanding of problem	11	34
Elaboration of problem	0	12
Hypotheses for outcome	11	8
Understanding of instruction	56	0
Handling material	33	41
Planning experiment	23	47
Measuring temperature	30	35
Difference in temperature	18	18
Difference in warming	3	10
Interpretation of results	11	14
Evaluation of experiment	1	5

Shared regulation **with** step-by-step instruction: extracts

1st extract:
Tamara: Okay. And now the lamps, okay?
Tamara: At what distance? *Tamara moves a lamp towards the grass and consults the step-by-step instruction*
Sophie: ten, fifteen *Sophie reads from the step-by-step instruction*
Tamara: Is it seventeen approximately? *She switches the lamp near the grass on. Then she moves a lamp to the white stone and switches it on.*

2nd extract:
Tamara: How many shall we?
Tamara: I don‘t know.
Both consult the step-by-step instruction.
Tamara: Now it‘s your turn.
Sophie: (Should I) place each lamp above one object? *Sophie points at the step-by-step instruction, at the photograph of the lamps and objects.*
Tamara: Aha, yes. Okay, lets do it like this.

Shared regulation **with** step-by-step instruction: extracts (cont.)

3rd extract:
Tamara: Okay, and what is missing?
Both consult the step-by-step instruction and turn over to the second page.
Tamara*:* (Did you...)
Both read on the second page of the step-by-step instruction. Sophie points at a line " Thermometer must not be in the light of the lamp" Sophie and Tamara look at each other. Tamara puts her hand at her head. Sophie laughs.
Tamara: Aha. ohoh – we got it wrong. *Tamara moves the thermometer out of the light.*

Shared regulation **without** step-by-step instruction: extracts

1st extract:
Colin: We first have to… *Colin switches the fifth lamp off. David switches the fourth lamp on.*
Colin: David, switch them off first of all, so that everything starts at the same time

2nd extract:
Colin: Okay, now we measure it before, the - well, how warm it is
David: No, we don‘t need that, Afterwards//
Colin: // Yes, then we can assess the difference.
David: Yes, you are right.

3rd extract:
Colin: Somehow I‘ve got the feeling that one could do something else with the grass.
David: Anyway, it‘s just some kind of greenery. Some people do that, they plant it on their houses.

Shared regulation **without** step-by-step instruction: extracts (cont.)

4th extract:
Colin: This is strange now, that, hhm, that the different materials differ in how warm they are. *Both consult their notes on their note pad*
David: Yes, it depends on the colour, black
Colin: Well, I thought, no, I thought before we placed the lamps, - aha perhaps it was still a bit warm from those [the group] before

5th extract:
Colin: So black is the Winner, second, third, forth, fifth,
David: super () paint all houses white
Colin: yes, to be cold, yes.

Summary

- Pupils working with a step-by-step instruction concentrate on understanding the text and putting it into action.
- They spend less time on understanding the problem or extending the problem space.
- The regulation of the learning process is guided by the step-by-step instruction.
- If there is no step-by-step instruction students discuss the problem more extensively.
- Without step-by-step instruction the regulation of the learning process has to be negotiated between students.
- There are more high-level statements in groups working without step-by-step instruction.

Further directions

- Analyze the regulation of the learning process more in-depth by looking at different types of shared regulation
- Include individual differences in prior knowledge, goal orientation, ability to self-regulate for case-studies
- Analyze video-recalls and compare to findings from the video-study
- Second part of this study: Larger sample of students responding to short questionnaire after completion of different tasks with or without instruction.

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