Do instructional explanations foster learning from worked-out examples? A cognitive load perspective

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Example-Based Learning

• Worked-out example:
  (1) Formulation of a definite problem
  (2) Solution steps
  (3) Final solution

• Superior to problem solving in early phases of skill acquisition (e.g., Atkinson et al., 2000; Renkl, 2005; Sweller & Cooper, 1985)
Cognitive load theory and example-based learning

Organization of the learning material:

- Attention to operators necessary for problem solving
- Development of appropriate problem-solving schemata
- Freeing up of cognitive resources
  
  Devotion to understanding underlying principles
  (= deep and flexible understanding)
- Better transfer
Example-Based Learning

But processing worked-out examples often needs improvement: Guidelines for example processing (Renkl, 2005)

- **Self-explanation elicitation guideline**: Prompting for self-explaining (e.g., Renkl, 1997)

- **Help guideline**: Providing instructional explanations
  - Reducing faulty self-explanations
  - Filling in gaps in understanding
  - Reducing an illusion of understanding
  - Making sense of the worked-out examples (“why” and “how” information; Van Gog et al., 2004)
Example taken from Gerjets et al. (2006):

At the Olympics, seven sprinters participate in the 100-m sprint. What is the probability of correctly guessing the winner of the gold, the silver, and the bronze medals?

*Find 1st event probability*

In order to find the first event probability you have to consider the number of acceptable choices and the pool of possible choices. The number of acceptable choices is one because only one sprinter can win the gold medal. The pool of possible choices is seven because seven sprinters participate in the 100-m sprint. Thus, the probability of correctly guessing the winner of the gold medal is $\frac{1}{7}$. 
Main Research Question

Do instructional explanations enhance example-based learning?
Review of Empirical Studies

• **Search** in databases with different terms: Example-based learning, worked-out examples, (instructional) explanations, elaborations, information

• **Criteria for inclusion**: Example-based learning with and without instructional explanations

• Relevant articles or proceedings contributions: N = 12

• Work in progress: Meta-analysis
Review of Empirical Studies

- **Empirical studies:**
  - **Participants:** Undergraduate students
  - **Learning domain:** Mathematics, Computer Sciences, Physics, Didactics (in Mathematics and Physics)
  - **Information** provided in instructional explanations about goals, principles, and operators
  - **Experimental condition:** Instructional explanations added to worked-out examples
  - **Control conditions:** a) No instructional support, b) Prompts for self-explaining, c) Self-explanations combined with instructional explanations
  - **Dependent variables:** Learning measures
Thesis 1

- Example-based learning with instructional explanations can be more effective than example-based learning without any instructional support
  - Renkl (2002): Especially for more novice learners
  - Van Gog et al. (2008): Higher efficiency (performance relative to mental effort)
  - Atkinson (2002): Orally given instructional explanations improve example-based learning
  - Schworm & Renkl (2006): Better than no support
  - But: E.G., Van Gog et al. (2006); Catrambone (1995); Hoogveld et al. (2005): No additional benefits
• Instructional explanations can be redundant or even detrimental to example-based learning when provided in later phases of skill acquisition

  – Van Gog et al. (2008): Lower efficiency for learners on later tests
  – Gerjets et al. (2006, 1st study): No effects of instructional explanations due to redundancy
  – Renkl (2002): No redundancy because advanced learners were free to choose explanations

Redundancy is a problem: Less and (or) more time-consuming learning
Thesis 3

- Instructional explanations are usually equally or less effective than self-explanations in example-based learning
  - Gerjets et al. (2006, 2nd study): No difference between instructional explanations and self-explanations
  - Große & Renkl (2006): No difference between instructional explanations and self-explanations with regard to learning procedural skills
  - Schworm & Renkl (2006); Hilbert et al. (2004): Self-explanations superior to instructional explanations
  - Brown & Kane (1988, 7nd study): Self-explanations better than instructional explanations (children)
Thesis 4

- Instructional explanations and self-explanations have no additive effects on example-based learning
  - Schworm & Renkl (2006): Combination of instructional explanations and self-explanations superior to instructional explanations alone but inferior to self-explanations alone
  - One mechanism: Instructional explanations reduce self-explaining activities and, thus, learning

  Smooth transition from instructional explanations to self-explanations might be promising
Thesis 5

• Instructional explanations can cause an illusion of understanding and a feeling of success
  – Gerjets et al. (2006, 1st study): Correlation between feeling of success and level of elaboration provided in the instructional explanations although no performance differences
  – Schworm & Renkl (2006): Assuming better performance in condition with instructional explanations only but opposite was true
  Less effort put into processing worked-out examples due to instructional explanations?
Thesis 6

- The effectiveness of instructional explanations can be increased by prompts for active processing
  - Berthold & Renkl (2008): Processing of instructional explanations through answering questions improves learning (e.g., conceptual knowledge, far transfer)
  - Hausmann & VanLehn (2007): Fewer errors and less assistance needed when self-explaining worked-out examples together with instructional explanations as compared with paraphrasing worked-out examples together with instructional explanations
Conclusions to Be Drawn From the Empirical Studies

• The instructional design is important: Providing instructional explanation in a way that it...
  – Fosters germane load (e.g., through active processing of the explanations)
  – Reduces extraneous load (e.g., only learners who really need instructional explanations)
  – Does not induce intrinsic “over”-load (e.g., changing the nature of the task)

• More research is needed to systematically investigate the interrelations between learner prerequisites and instructional design aspects
Conclusions to Be Drawn From the Empirical Studies

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Fig. 2. Effectiveness of help depending on the level of prior knowledge.
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Recommendations for Future Research

• Consistent use of a term such as instructional explanations

• Information about the type of explanations:
  – Are the information provided really explanations (e.g., in terms of theories from the philosophy of science)?
  – Are different types of explanations (e.g., on operators, principles, causes) associated with different types of cognitive processing?

• Researching how active processing of instructional explanations (= passive instructional events) can be supported
Thank you for your attention!