Nature of Science and Science Content Learning

Can NOS Instruction Help Students Develop a Better Understanding of the Energy Concept?

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NOS and Science Content Learning

"An understanding of the nature of science supports successful learning of science content." (Driver et al., 1996, p.20)

"This assumption, as is true with other assumptions related to the purported value of NOS as an instructional outcome, has yet to be systematically tested." (Lederman, 2007, p. 871)

- Students of all ages show inadequate and naïve views about nature of science (NOS) (Abd-El-Khalick & Lederman, 2000; Dogan & Abd-El-Khalick, 2008)
- Explicit-reflective NOS instruction can change students' NOS understanding (Khishfe & Abd-El-Khalick, 2002)
- Teachers have difficulties integrating NOS explicitly into their science lessons, one reason for that is a lack of tested material (Abd-El-Khalick & Akerson, 2004, Allchin, 2012)
- Generic NOS activities foster NOS understanding and can be used either as a stand-alone content or connected with other science content (Lederman & Abd-El-Khalick, 1998)
- For an authentic approach to NOS, as well as to science content, NOS should be taught contextualized, embedded in science content (Clough, 2006)

Research Question and Hypotheses

How does NOS-oriented instruction influence students' physics content learning and NOS understanding?

Hypothesis 1: NOS-instruction prior to an instructional unit about science content positively influences science content learning.

Hypothesis 2: Contextualized NOS instruction, where NOS aspects and science content aspects are supporting each other in a meaningful way throughout the instructional unit, better fosters both NOS and content knowledge than instruction on science content only or a combination of science content instruction and decontextualized NOS instruction.

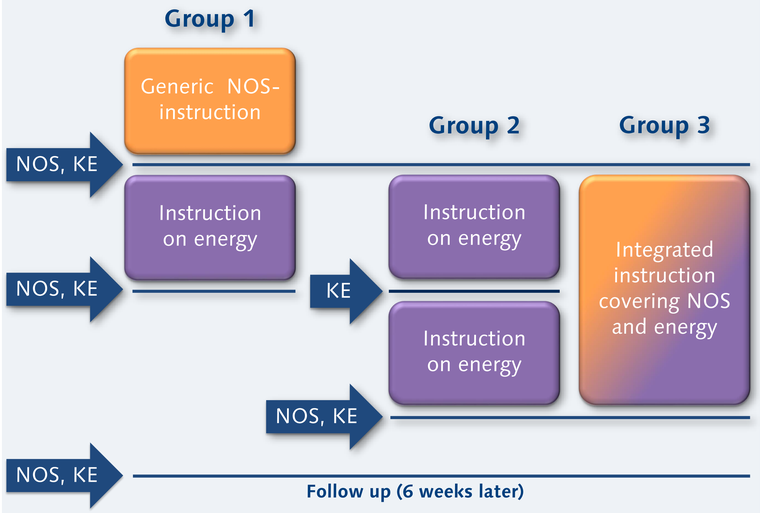
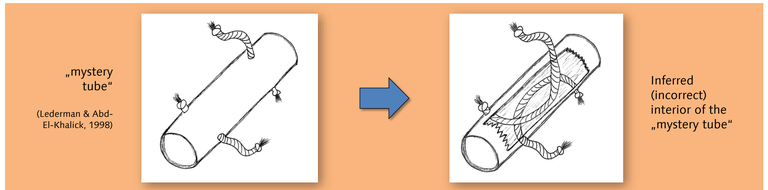


Fig. 1: **Study design.** Arrows indicate when tests are administered (NOS = nature of science, KE = knowledge about energy).

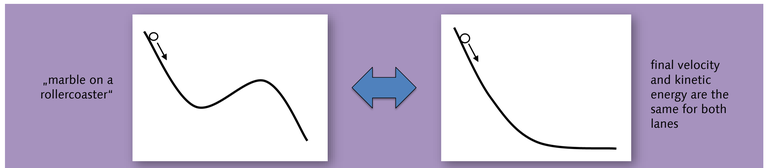
Generic NOS instruction



Sample activity: *Students observe that when they pull one end of the rope, another end will be pulled in with a seemingly random pattern. They are then asked to infer possible interior of mystery tube from what they observe, thus learning about the difference between observation and inference.*

NOS aspects covered in the generic NOS instruction are the **difference between observation and inference** and the **nature of scientific theories**, as these aspects are considered important for promoting students' integrated knowledge about energy.

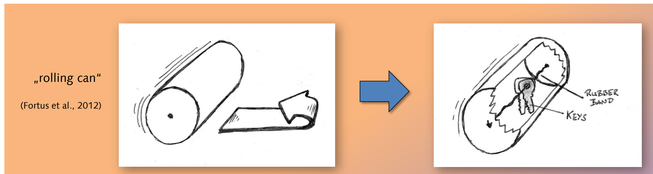
Instruction on Energy



Sample activity: *Students observe marbles running down differently shaped lanes and compare their final velocity, and thus their kinetic energy. They infer that the kinetic energy of the marble depends on its starting height and mass, but not on the shape of the lane.*

Energy experiments and examples are put in the context of an adventure park. Rollercoasters, bungee jumps and bumper cars are used to explore different forms of energy as well as transformation processes. Energy aspects covered in the intervention are **energy forms** (kinetic, potential and elastic energy), **energy transformation** and **energy conservation**.

Integrated NOS instruction



Sample activity: *When set rolling, the can will continue rolling in one direction until enough energy has been stored in the rubber band running inside of the can. Then it will stop and start rolling back in the opposite direction. As with the "mystery tube", students infer the possible interior of the rolling can from what they observe, unless in this case, the NOS activity is directly linked to the content of energy.*

Additional contextualized NOS activities include the discussion of historical case studies referring to energy and reflection on students' own scientific actions with regards to inherent NOS aspects.

NOS and energy aspects addressed in the integrated NOS instruction are the same as in generic NOS instruction and instruction on energy, respectively. However, an additional focus is put on the **nature of energy as a scientific theory**.

Study design

- Intervention study with three randomized treatment groups (see fig. 1)
- Holiday science course covering three days per treatment group
- Sample: ~120 grade 6 & 7 students of German gymnasiums
- Pre- and post-tests on NOS and energy understanding
- Follow-up-test six weeks after the intervention

Assessment instruments and control variables

Test instruments

- **NOS:** multiple choice test (NOSSI, Neumann, 2011) and open-ended questionnaire (VNOS-C, Abd-El-Khalick et al., 2001)
- **Energy understanding:** multiple choice questionnaire and open-ended items focusing on declarative and integrated knowledge about energy
- Student interviews and analysis of student material (science notebooks) shall allow for investigating how students use NOS understanding to approach energy content

Control variables

Cognitive abilities
Motivation
Science, math and German grades

Conclusion and Outlook

Overall, the study aims to shed more light on the interaction between NOS instruction and science content learning. Thus, the study contributes to the overall line of study if and how NOS should be addressed in science instruction in order to improve students' learning processes. Results aligned with the investigated hypotheses may not only provide insights into the learning of NOS and science content knowledge, but may also inform teachers about the importance of fostering NOS understanding in school in order to promote student learning – a research goal which is of special importance in Germany, where NOS is not explicitly part of curricula and educational standards yet.

Further studies could then focus on investigating the influence of NOS on the learning of scientific contents other than energy, as well as possible mediating factors, such as students' interest, motivation, or self efficacy.

Literature

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