

## Abstract

Students' naïve concepts of physics are a well-known reason for learning difficulties in science education research. Naïve concepts, either stemming from everyday experience or developing in lessons at school, often differ from scientific explanations. Within learning processes, they interact continuously with students' understanding (internal representations) of scientific schemata and concepts taught in lessons. Students' internal representations and mental models influence the external representations they create while solving tasks. Especially in physics, problem-solving regularly requires learners to find an appropriate and useful representation of a given problem or task. To solve the task, they then continue to operate on the representation they have found.

This work aims at investigating the mutual relations between widespread naïve students' concepts, external representations, and the construction of mental models in the context of learning from physics experiments in middle-school classrooms. For this reason, it refers to two recent strands of research in science education: fostering representational competence via learning with multiple representations and conceptual change. Considering the theoretical implications and related empirical results from these strands of research, instructions were developed that aimed at supporting students both to create scientifically appropriate representations and successfully operate on self-developed and given external representations.

To evaluate the effectiveness of the developed instructions, two quasi-experimental conditions were implemented that differed with regard to the extent of cognitive activation while dealing with (multiple) representations in ray optics.  $N = 10$  teachers from ten different schools and  $N = 21$  classes participated in the study. The analyses were based on data from  $N = 443$  students attending German "Gymnasium" (secondary-school track for high achievers) or comprehensive schools.

Students in the treatment condition worked on cognitively activating tasks that required them to overcome widespread naïve students' concepts in ray optics. Students in the control condition worked on similar representations and were encouraged to overcome the same widespread naïve students' concepts. However, the control group was not explicitly activated to create own representations, to re-

think their representations, or to operate on them. Multilevel analyses investigated whether significant effects could be ascribed to the treatment.

The results indicate that the use of challenging learning strategies (cognitively activating tasks) while dealing with (multiple) representations leads to a significant but small improvement of physics achievement in a test immediately after the treatment for students at a German “Gymnasium”. However, there were not any significant effects in the learning increase of conceptual understanding or in the development of students’ motivation when comparing the treatment and control groups.

Furthermore, the results referring to the learning increase in conceptual understanding were compared with results from a related study (Scheid, 2013) from the same research project. The outlined comparison revealed that representational tasks addressing widespread naïve students’ concepts lead to a significant improvement of conceptual understanding for students from both types of schools even two months after the intervention.

Lernen mit multiplen Repräsentationen aus  
Experimenten

Ein Beitrag zum Verstehen physikalischer Konzepte

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