New physics lessons help girls catch up

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With Stern's new method the gender gap became much smaller (Symbolic photograph). Credit: Colourbox

Many school pupils fail at physics because they misunderstand the fundamental concepts. A new teaching method can change this – ETH researchers have now proven its effect. It particularly helps intelligent girls to learn more effectively.

What is the difference between mass and weight? How is force defined in physics? Very few school pupils can properly explain fundamental physics concepts, not even the most intelligent. The problem is not with

the pupils, says Elsbeth Stern, Professor of Empirical Learning and Instruction Research at ETH Zurich: "Our research shows that when good students don't understand physics, it's mostly due to the teaching methods."

A study conducted by the research team led by Sarah I Hofer and Elsbeth Stern has now shown that even small changes to the lessons can have a big effect. The results have been published in the *Journal of Educational Psychology*.

Targeted failure

The method is based on getting the pupils to grapple with their prior knowledge. This is particularly important in physics, says Stern: "In almost no other subject do intuition and reality lie so far apart as in physics. Our everyday experiences do not help." Understanding physics concepts requires a huge mental effort from pupils. Learning formulas by heart isn't enough: "Plenty of school pupils know the formula 'force equals mass times acceleration', but they have a false understanding of the concepts of force, mass and acceleration." Only those who recognise these misconceptions are ready to understand physics.

The teaching unit developed at ETH Zurich's STEM learning centre begins with these misconceptions. For example, it lets the pupils fail in a specific way: they receive a task that they cannot solve with their existing knowledge. Only after they have attempted it does the teacher explain the underlying concept. Or they let the students work out the principles for themselves using different examples before they are given the formula.

Successful in-school test

Stern and her group have now shown that the method works in regular school lessons as well as in the laboratory. In an experiment, the researchers demonstrated that pupils performed better in physics when they were taught using the method developed at the STEM centre. They not only improved their conceptual understanding; they also became better at calculations.

Stern and her group found the biggest difference in performance in particularly intelligent girls – with the new method, they significantly caught up the boys. The gender gap did not disappear entirely, but it became much smaller.

For the experiment, the team worked with experienced physics teachers to develop a teaching unit with 18 lessons about Newtonian mechanics. Four secondary school teachers then spent a day being trained in the new method before teaching parallel classes with the conventional method and with the new method. The effectiveness was measured with three tests, one before the teaching unit, one just after it was completed and one three months later.

Rethinking physics teaching

The results are very positive, but this is only the beginning, says Stern: "I am sure that we can further increase the effects of the teaching unit." She next wants to fine-tune the method with the teachers involved in the experiment. She also hopes that the study will help people rethink their approach: "We will now turn even more confidently to those physics teachers who still primarily teach the subject using calculation exercises. That approach does not work."

More information: Sarah I. Hofer et al. Enhancing physics learning with cognitively activating instruction: A quasi-experimental classroom intervention study., *Journal of Educational Psychology* (2018). DOI:

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