



## Further Information

### Experiences

This teaching material was tested with the refraction, buoyancy and Boyle's law experiment in three different classes.

Students discover the functional relationship between both variables. Most of them first describe the functional relationship, by noting the changes, e.g. change of one measurand by ... causes change of other measurand by ... or they describe the relationship by differences between force in air and force in water. After that thought, they checked the quotients. Students chose words, letters or units as names of their variables.

On a descriptive level many students realize that changing the pillar causes a change of the formula. Only stronger students could transfer that to the formula and tell what changes or came up with a more general formula. This task could be used as an introduction of a specific unknown, though.

At task 4, when finding a formula, teacher should give hints to apply elementary arithmetic operations on the pairs of measurands. Particularly weaker students will benefit by that. Some students had trouble to grasp the term pillar and height of the pillar. Parts of them thought the pillar would be the thermometer. Students would benefit as well if a classroom discussion is done after the experiments. During that students may ask questions and misconceptions can be reduced.

The worksheet artificially considers variables only. It could be expanded by a task to graph the measurands, so that it may serve as an introduction to the concept of function as well.

Further investigations done by problem-oriented interviews have shown that the different aspects of the concept of variable can be touched on a descriptive and abstract level. Hence introduction to the concept of variable by thermal expansion allows differentiation within a class. Besides the concept of variable, aspects of the concept of function, equivalent equations and modelling competencies can implicitly be touched.

The Experiments should be rather used to introduce the concept of variable than to show an application of it. When doing the interviews some students had preknowledge of the concept of variable and some hadn't. A lot of students who got to know the concept in class thought that a formula should be "something with x". Students who didn't cover variables in class, approached to the problem more naturally without thinking about this "ominous" x.

The **ScienceMath**-project: **Thermal expansion and Concept of Variable**  
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## Literature

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