The Mechanical Equivalent of Heat: James Prescott Joule
Didactical Scenarios in the Classroom

Illustrating the the possible transformation of heat into work and work into heat experimentally as a special case of energy conservation must be a part of physics education. To achieve this goal different didactic scenarios could be imagined that are explicated in the following. The components of the scenarios listed can be mixed - depending on the situation and preconception of the learning group. The lesson topic equivalent of heat is usually embedded in the overall energy theme.

Phenomenological approach

Students are aware that energy is needed if things are to move. So they have to expend energy to ride a bike. They also need energy to jump over an obstacle, or if they run up a flight of stairs. To make this aware in an introductory class discussion, leads to the following research question:
Could kinetic energy be converted into thermal energy ?

One can assume that students suggest solutions in their environment, e.g.:

- Brakes on bicycles get warm,
- Palms will feel warm when they are rubbed,
- If one slips down a rope, one can burn the palms.

To let pupils demonstrate this phenomenon of energy conversion themselves, the following experimental setting is proposed:

1. A stick made of hardwood is pressed onto a base made of wood, and is reciprocated between the palms as quickly as possible. After a certain time one is sensing an increase in temperature.
2. This test can be modified in the way that a short hardwood dowels is clamped into a drill. Well, the anchor is also pressed on a wooden base and the drill is set in motion. The phenomenon occurs in this case on a much greater scale than in the first experiment.
3. If one makes the second Experiment and simultaneously cools the friction between the wooden board and plug with water, the increase in temperature can be determined relatively easily with a thermometer.

This phenomenological approach could be a motivation to treat the transformation process of work into heat in school by taking accurate measurements.

The standard experiment

As a standard experiment to determine the mechanical equivalent of heat in many schools the so called "Schürholzversuch" is used. Both the experimental procedure and the evaluation of the experiment are time consuming. Only students who are particularly interested and high-achieving will tackle this experiment without the assistance of the teacher. The "Schürholzversuch" is constructed in the following way: The correlation between the mechanical work and the increase of the cylinders' internal energy could be determined by measuring the the frictional work, and the change of temperature of the cylinder. By calculating the mass of the cylinders, this correlation could be expressed mathematically. Anyway, in choosing this approach to the subject "mechanical equivalent of heat" steps must be taken to ensure that the experiment and its theoretical analysis is not an end in itself, but is placed in an understandable context for the students.

The experiment with everyday objects (food processor) and the
Historical-Genetic approach *(Story and Video)*

More promising than the use of the standard experiment is the opportunity to look at the

question of the conversion of heat into work historically-genetically.

As in the phenomenological approach, students are aware that energy is needed if things are to move or when masses are heated. A class discussion lends itself to it as a motivating introduction.

Guiding the attention of the students on the historical context of this question, they do not feel like the "ignorant" who do not understand what has already been researched. They stand in historical observation on the same level as the investigator of experiments. They feel the same skills as the investigator and may subsequently learn the skills of competence enhancements like the first explorer itself.

With an appropriately motivating story, students are able to face the same researcher's questions as J.P. Joule . They experience the circumstances and conditions with which Joule attempted to answer the questions about the relationship between work and heat.

In order to carry out the experiment of J.P.Joule for the students it is necessary to fill a bowl, equipped with a mixing device with a specific amount of water. One such device is the mechanical beater available for making whipped cream. Those are commercially available.

A defined quantity of water (room temperature) is filled into the vessel and the stirrer used. By rotating the agitator is put in motion, and after 100, 300, 500 and 1000 rpm, the increase in temperature is measured.

The fact that only very small increases in temperature can be measured in spite of the perceived major mechanical work that was put into the system by turning can lead to creative discussions.

The video entitled "The Mechanical Equivalent of Heat: James Prescott Joule" finalises the lesson. Ultimately the active involvement of students is confirmed by the historical-genetic discovery process.