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SCIENCE ON STAGE GERMANY

Strong as a bear through leverage

Students are introduced to the principle of levers. They investigate where they can be found in their daily life and how they work.

Keywords: Levers, leverage, balance, force

Disciplines: Physics, science in primary school

Age level of students: 7-9

Conceptual introduction

The oldest machines known are so called simple machines. Among them are for example levers and pulleys. A simple machine is a mechanical device that changes the direction or magnitude of a force. In general, they can be defined as the simplest mechanisms that use mechanical advantage (also called leverage) to multiply force. Levers are for example crowbars, scissors, screw drivers, bottle openers, scales and seesaws.
A lever works by reducing the amount of force needed to move an object or lift a load and does this by increasing the distance through which the force acts. The following formula applies:

Work equals force times distance ($W=F \cdot s$)

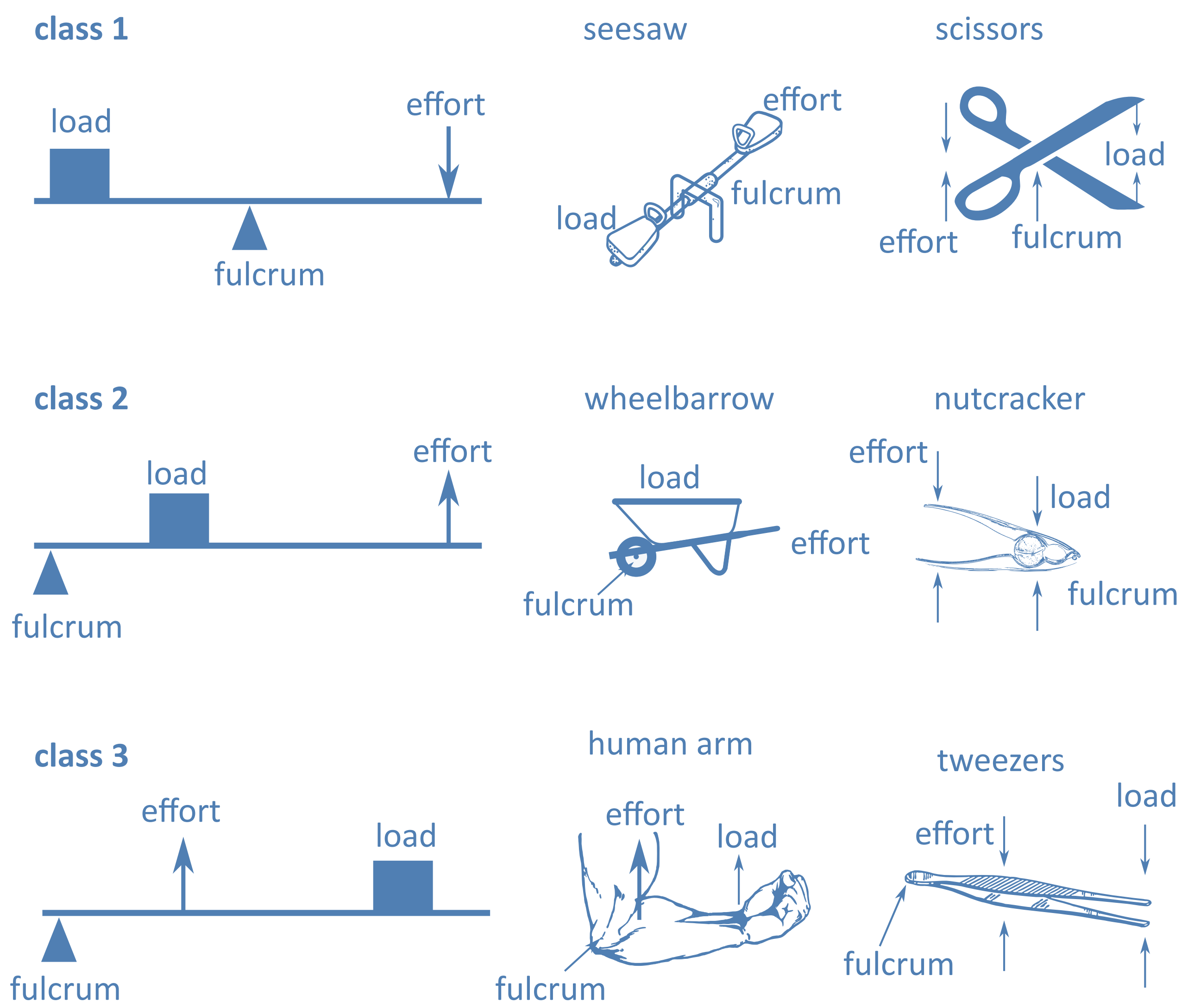
All levers are one of three types, usually called classes. The class of a lever depends on the relative position of the load, effort and fulcrum:

- The load is the object you are trying to move.
- The effort is the force applied to move the load.
- The fulcrum (or pivot) is the point where the load is pivoted.

A class 1 lever has the load and the effort on opposite sides of the fulcrum, like a seesaw or scissors. A class 2 lever has the load and the effort on the same side of the fulcrum, with the load nearer the fulcrum. Examples of a class 2 lever are a pair of nutcrackers or a wheelbarrow. In the diagram, the wheel (fulcrum) on the wheelbarrow is helping to share the weight of the load. This means that it takes less effort to move a load in a wheelbarrow than to carry it.

Class 1 and class 2 levers both provide mechanical advantage. This means that they allow you to move a large output load with a small effort. Load and effort are forces.

Fig. 1 lever classes



The longer the lever the less effort is needed.
The shorter the lever the more effort is needed.

A class 3 lever does not have the mechanical advantage of class 1 levers and class 2 levers, so examples are less common. The effort and the load are both on the same side of the fulcrum, but the effort is closer to the fulcrum than the load, so more force is put in the effort than is applied to the load. Examples of class 3 levers are the human arm or a pair of tweezers.

What the students do

1. CONCEPT

The goal of this teaching unit is for the students to grasp the concept of leverage through hands-on experience with objects from their daily life. The first part of this teaching unit consists of a station learning course. Later the students strenghten their understanding of levers using seesaws and a mobile.

2. FIRST STATION: SOLVE THE TASKS WITHOUT TOOLS

For this part a few tasks are prepared for the students (Fig. 2-6) which they need to solve without having the proper tools.

Fig. 2 lifting a student on a board

Fig. 3 pulling and hammering nails

Fig. 4 opening doors

Fig. 5 opening bottles

Fig. 6 carrying heavy boxes and cracking nuts

The children discuss which tasks were the hardest to do. They realise they need a lot of force to do simple tasks from daily life if they are missing the appropriate tools.

3. SECOND STATION: SOLVE THE TASKS WITH TOOLS

For the second round the teacher provides the students with a bunch of tools. The children assign the tools to the proper stations and try them out (Fig. 7-11).

Fig. 7 using leverage to lift students

Fig. 8 tongs and hammer for the nails

Fig. 9 opening the door with a handle

Fig. 10 bottle opener and hand truck

Fig. 11 nutcrackers

The students discuss the different stations and share their experiences with the different tasks.

4. THE LEVER

To introduce the students to the physical principles of levers and mechanical advantage a very easily rebuild experimental setup is used. More students can test their theories at once if the teacher prepares more than one experimental setup. One door is needed per setup.

Material needed to prepare one door handle:

- a thin, hard board (60-70 cm) with a scale from 1 to 5
- 2-3 cable ties or parcel string

It is important that at this point the students are not yet allowed to try out the prepared door handle. The questions they should discuss among themselves are: “At which point on the handle do you need the most force to open the door?” and “At which point on the handle do you need the least force to open the door?”.

After they discuss their theories all students can try out the doors and compare the practical experience with their theories and discuss them with each other.

Using the door handle as an example the students define with assistance from the teacher various terms concerning the lever, such as lever arm and fulcrum.

Fig. 12 setup to demonstrate principle of levers

In the end the students should remember the following or a similar phrase which they develop together with the teacher:
"The longer the lever arm, the less effort I need.
The shorter the lever arm, the more effort I need."

5. DEFINING THE STATIONS

With this new won knowledge the students go back to the stations and point out lever arm and fulcrum on the different tools.

6. SEESAW

The students build their own seesaw to experiment and test theories about the principles of levers.

Material needed for one seesaw setup:

- ruler (30 cm)
- levelled cork (see Fig. 14)
- 3 tea lights

Fig. 13 bringing tea lights into equilibrium

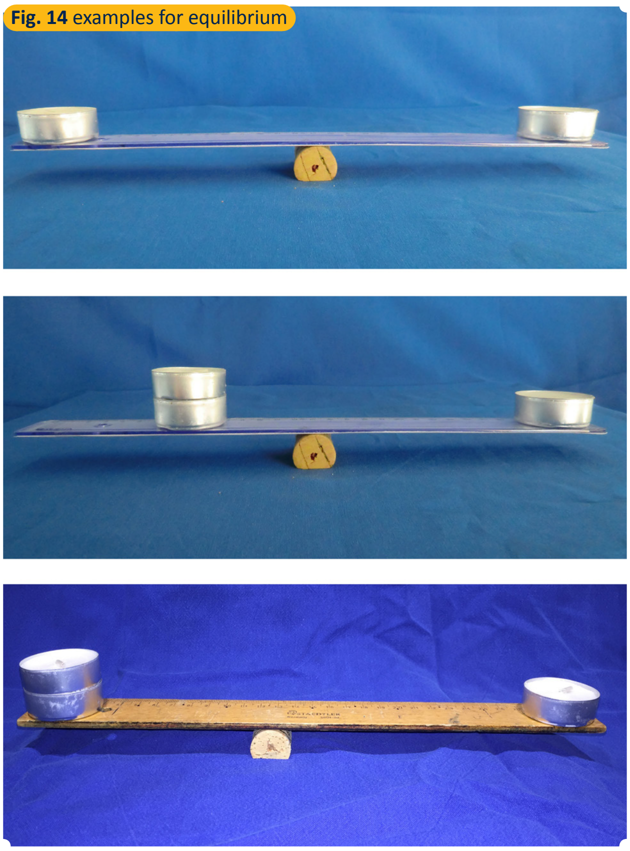


Fig. 14 examples for equilibrium

The students try to bring first two and later three tea lights into equilibrium (Fig. 13). The students discuss their findings and recognize the principles of levers in the seesaw. If there is a playground with a seesaw nearby the students can also recreate the experiment there.

7. MOBILE

Materials used:

- 2 wooden rods (70 cm long, 1 cm in diameter)
- 3 small plastic buckets (volume 500-1000 g each, e. g. from prepacked food)
- 30 glass nuggets
- 6 foldback clips (3 cm x 1.5 cm)
- yarn, parcel string or similar

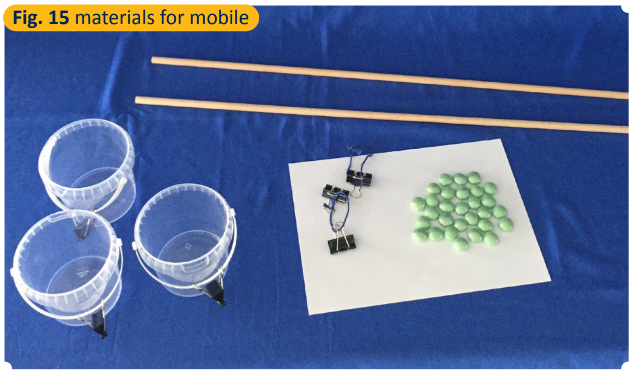


Fig. 15 materials for mobile

What the teacher needs to prepare:

- Fasten 3 of the foldback clips to the plastic buckets (for step-by-step instructions see Fig. 19)
- Connect 2 foldback clips using parcel string. Fasten another piece of string to the last foldback clip in a loop. This will be used to hold the mobile. (Fig. 16)
- Fix 2 buckets to one rod using the clips on the buckets. Connect the string with 2 clips to this rod (Fig. 17).
- Connect the last bucket to the other rod and the clips with the string holding loop as well (Fig. 18).

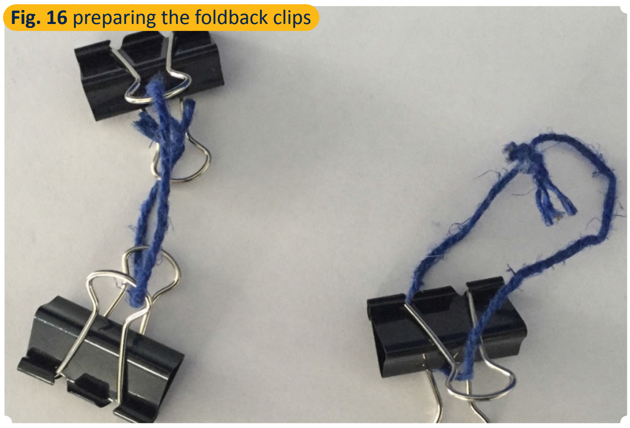


Fig. 16 preparing the foldback clips

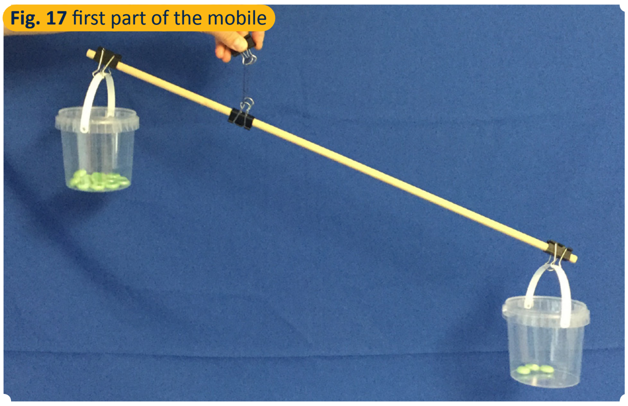


Fig. 17 first part of the mobile

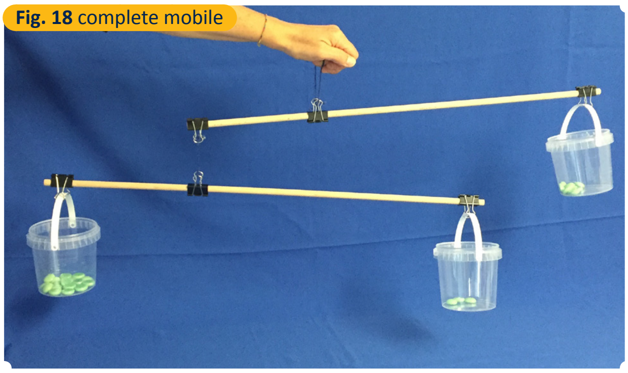


Fig. 18 complete mobile

There are many tasks for the students to do with the mobile:

- Task 1: The students fill each bucket with glass nuggets. In each bucket needs to be a different amount of nuggets.
- Task 2: The students are asked to balance the two connected buckets without changing them or the number of nuggets in each bucket. They realise they need to move the holding clip in the middle.
- Task 3: The students connect the two rods using the holding clips. Now they are asked to balance out all three buckets without changing the number of glass nuggets.
- Further tasks: The students can add or remove glass nuggets or move them from one bucket to another. They then should balance the mobile out again.

For all tasks it is important that the teachers asks the students to first make assumptions such as: "I need to move the clip to the left/right to balance the buckets out because..." and after that they test their theory. This strengthens their scientific reasoning.

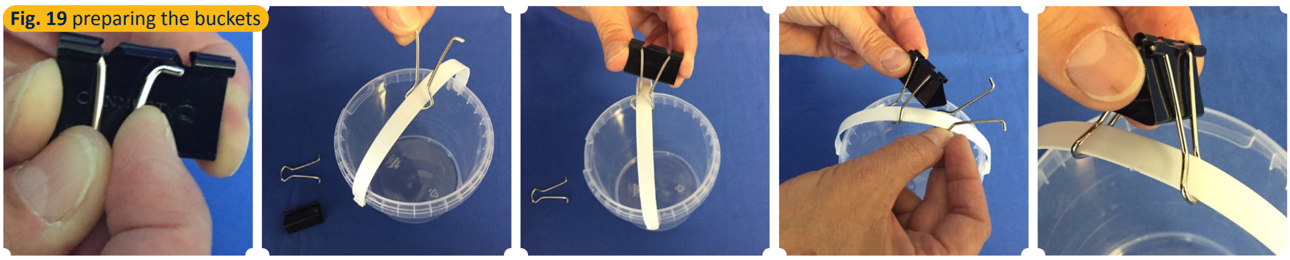


Fig. 19 preparing the buckets

Conclusion

Children today grow up in a more and more technology-rich environment. Of course this is also true for students in primary school and it is essential to use their curiousity and their own first explanations on how things work. It is important to make technology and machines as well as the underlying scientific principles tangible for the students. In this teaching unit they are encouraged through inquiry-based learning to investigate their surroundings and objects from daily life. By using household items to convey fundamental principles the children experience firsthand the science that surrounds them.

Further authors

Christa Müller

Sources

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