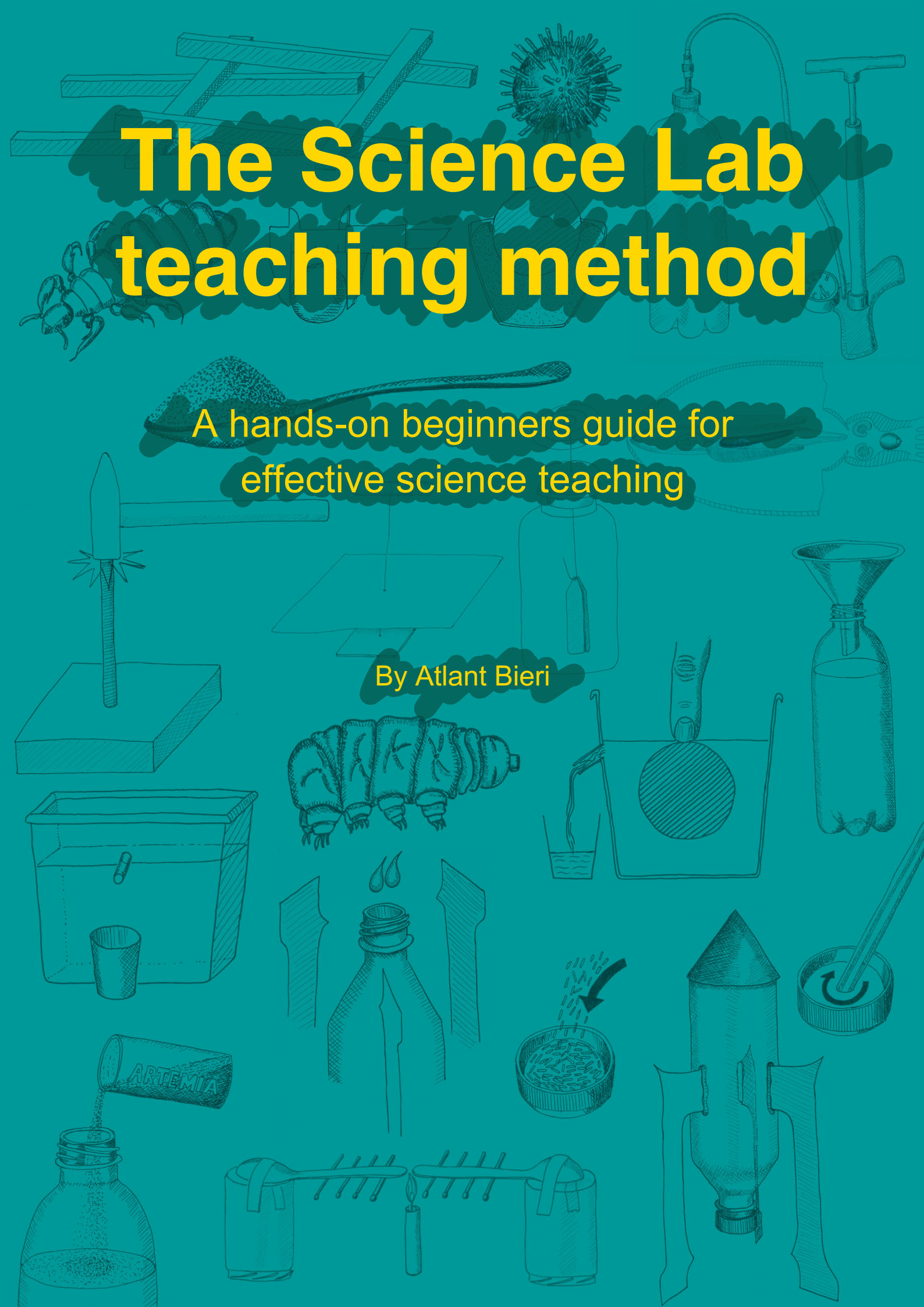
The Science Lab teaching method

A hands-on beginners guide for effective science teaching

By Atlant Bieri



Complicated and time-consuming?

For many teachers, teaching sciences (STEM) initially sounds complicated and time-consuming. How can biology, chemistry or physics be taught in a clear and understandable way? And all this in the short time available each week. How can teachers acquire the necessary specialist knowledge? It takes years, you might say. In the end, it's easier to just leave it alone, or pick up a teaching material and have the pupils dutifully memorise one page of it each week. The result is that they will dislike the subject very soon.

The following pages show you how you can quickly become a successful science teacher and make your lessons entertaining and exciting. After reading this, you won't know how aphids reproduce, what the internal structure of a carbon atom is, or how to calculate the speed of a sound wave, but you will learn how to guide the scientific process in a classroom and encourage children and teenagers to become researchers themselves and work out the answers to their questions. You will also understand the scientific process, which is actually quite simple and a powerful tool for teaching.

The term "science lab" is derived from the real laboratories at universities and scientific institutions. A science lab is organised as follows: the head is a professor or research director. He or she is not omniscient but coordinates the researchers and guides them in their scientific work. The researchers create new knowledge with the help of the scientific process. This is the "science lab" method. Conducting research together without knowing exactly where the journey will take you.

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Physical experiences

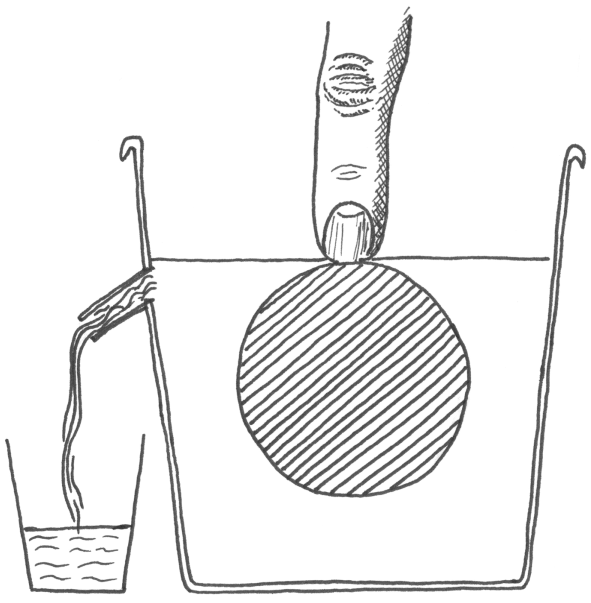
Children are natural explorers. From birth on, they investigate their environment with all their senses: they touch, smell, taste, hear, see and observe. Researchers do the same. In fact, all our knowledge comes from these sensory perceptions.

These are often neglected in traditional school lessons. Worksheets dominate science lessons. Instead of using their own senses to explore and discover, pupils read, copy and memorise.

This quickly makes lessons monotonous and boring. It doesn't have to be this way, because the world of biology, physics and chemistry offers a wealth of impressions and insights that are practically right under our noses.

The Science Lab method is based heavily on haptic experiences and sensory perceptions. It's all about touching, observing and recording observations.

Instead of using loose worksheets, all observations, experiments and final reports are written and drawn in a personal science notebook. More on this on page 7.



An easy-to-build apparatus for measuring the volume of an object. This could also be explained perfectly using a worksheet. However, a physical experience ensures that the information is stored in the mind for the long term.

The Science Lab

With the Science Lab method, students do not learn facts by heart, but train their ability to think about the world, observe, ask questions, design experiments, interpret results and communicate their findings. These are fundamental skills for every researcher. But they are also skills that are very valuable in life.

You, the professor

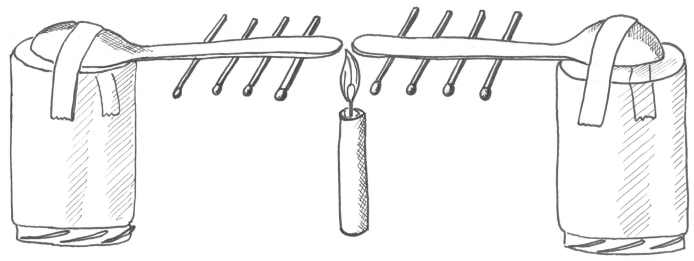
The teacher takes on the role of professor. You do not necessarily need to know about the research topic yourself. You simply need to understand the knowledge creation process and guide the young researchers through this process to success. It should be noted that “success” in this case does not mean memorising the floral formula of primroses, but rather carrying out and completing a research project.

Choice of topic

The pupils choose their own research project. In the initial phase, the teacher can specify a topic. For example, “Structure of the soil” or “Which animal species live in a meadow?” or, even more narrowly, “Observe the formation of a cloud. What are the different phases? What exactly happens in these phases?” Later, the pupils can choose their topics more freely and independently.

Input and assignments

All lessons in the Science Lab are divided into input and assignments. This means that the teacher either provides information on a specific topic or gives the pupils a specific assignment. An example of input could be an introduction to the biology of vertebrates. Or an experiment such as the combustion of hydrogen gas. You as teacher explain as much as you want or as much as you can. Then it is the pupils’ turn. They record the experiment, ask questions and try to answer them.



Experiment on thermal conductivity: The matches are stuck to a silver spoon and a copper spoon with a drop of candle wax. The matches fall off the copper spoon first. Why? The pupils should try to answer this question themselves. And it doesn’t matter if the teacher doesn’t know the answer at the beginning either. This is because the teacher interprets the results in the same way as the pupils and draws conclusions from them.

What does knowledge mean?

Some teachers get nervous when they hear that pupils should find their own answers to a question. What if some of the answers are wrong? Won't the pupils then sink into a swamp of false facts? How can the teacher restore order and divide the world into true and false? Here are some thoughts on this:

Truth meter

Consider this claim: "Tardigrades live exclusively in ponds." To test the truth of it, we only need to ask the following question: Do all tardigrades live in ponds? It could also be that some tardigrades live in rivers. Well, there is only one way to find out: through perception. So, we have to go to a river and see if there are any tardigrades living in it. If we find some, we know that some tardigrades also live in rivers. Perception is therefore our truth meter.

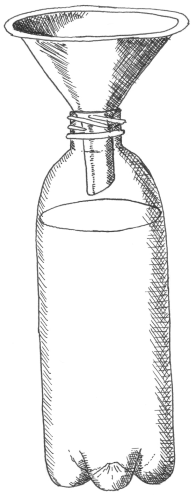
I know that I don't know everything

A large and important part of our knowledge is also everything we don't know. So, when I see a tardigrade, I know that tardigrades exist. But I don't know what the tardigrade thinks, how it sees, or perhaps even feels. Nor do I know where tardigrades can be found. Some of these mysteries can be solved through observation and experimentation, others cannot. In the latter case, we are left with assumptions and speculation. These are very important in science because they point towards future research. For their part, pupils learn to deal with different possibilities of reality through assumptions. There is a spectrum of possible truths out there. As scientists, we are slowly feeling our way forward.

Critical thinking

Even if the teacher takes out the latest edition of the geography book and it says that the Earth is a sphere, pupils should always ask themselves whether this is true. Because our knowledge is constantly evolving. What is considered "true" today may be outdated tomorrow. Nothing hinders free thinking and the development of new ideas more than clinging to old ideas. It is not a bad thing for teachers to be questioned by their pupils. After all, teachers are not omniscient gods. Even the teacher's knowledge may be outdated tomorrow. One should stand in front of the class with at least as much humility.

The scientific process



The scientific process is at the heart of the Science Lab. It is how children explore the world. It never stops but continues on and on. When you reach an impasse, you use the scientific process to turn in a different direction. In its basic form, the scientific process consists of three steps:

1. Observation

This means using your senses and perceiving your surroundings or the object of your research with your eyes, ears, hands or nose. Measuring instruments such as thermometers, stopwatches or telescopes can also be used for this purpose.

2. Ask questions

Perception automatically raises questions about the world. Why does the surface of grass feel rough? How many insects live in a meadow? Why does a planet glow red? Why is the ground warmer than the air?

3. Try to answer the questions

The final step is to try to answer the questions. For example, by going back to step 1. This means making even more ***observations*** about the temperature of the ground and the air. Over time, this will give you a more complete picture and at least some of the questions can be answered.

Questions can also be answered through ***comparative studies***. For example, you can identify the tree species in the mountains and compare them with the tree species in the valley. This will reveal that some tree species prefer cooler conditions, while others prefer warm and dry conditions.

Or you can answer the questions with the help of an ***experiment***. You plant different tree species in the mountains and in the valley and measure how much each species has grown each year. This allows you to determine that some species prefer cool conditions and others prefer dry and hot conditions.

The research process constantly leads to new questions, which in turn lead to further observations, comparative studies and experiments, and so it goes on and on.

Working with the science notebook

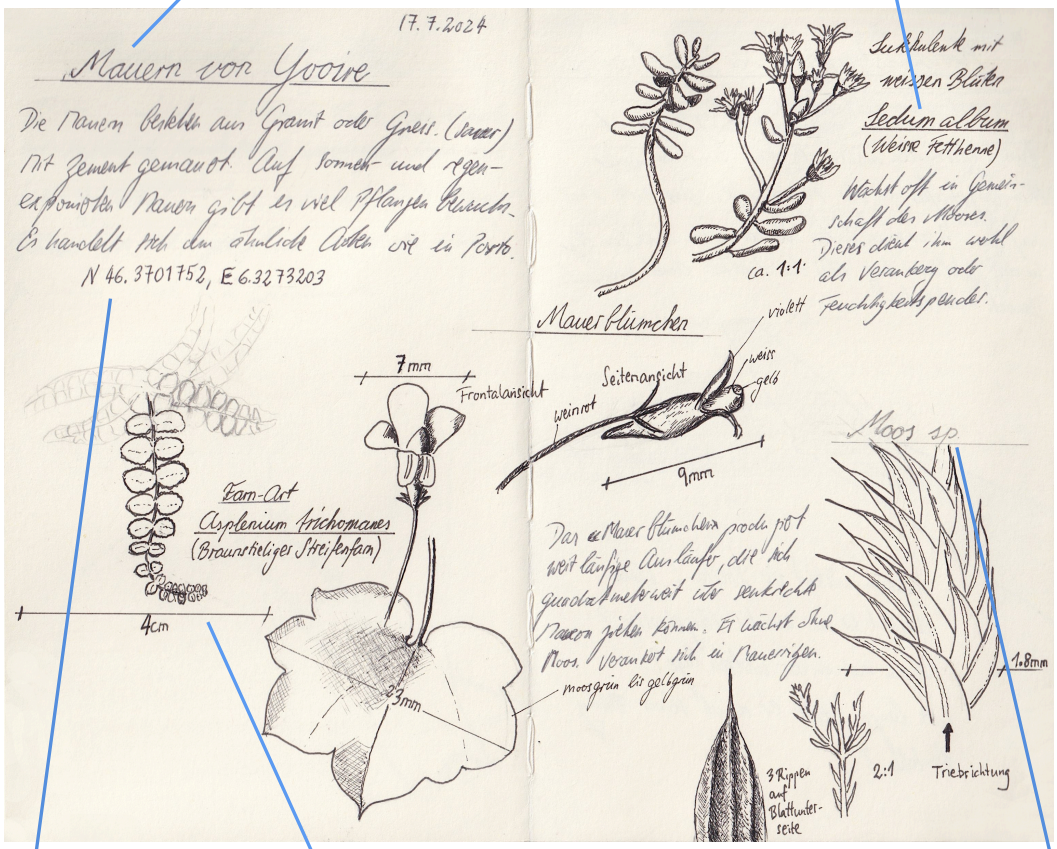
The pupils work with their personal science notebook. In it, they write and draw their observations, questions, assumptions, plans for experiments and final reports. In this way, they build up their own knowledge of a subject area and, more importantly, a personal relationship to it.

Here are the most important rules for keeping a science notebook:

- Each entry must be dated and include the exact location. It is best to record the location using coordinates.
- Drawings should be fully labelled. A scale should be provided.
- All activities and observations should be described with as much detail as possible using words and sentences.

Titles give structure to the research diary.

Where possible, the full species names should be given.



By specifying the coordinates, the location of the data collection can be determined without doubt in the future. This is what makes an entry scientifically relevant.

Scales can be indicated in the margin or in the drawings.

If you do not know a species, you can simply write “moss species” in pencil. Perhaps the species can be identified later.

Assessment and grading

The research diary enables teachers to objectively assess pupils' performance and, if desired, to award marks. The entries quickly reveal who is thinking carefully, drawing conclusions, asking questions or planning experiments. See also the help sheet below.

The research diary allows the teacher to provide direct written feedback to the pupil. The feedback can intervene in the research process in a corrective manner and steer it. The teacher collects the research diaries on an announced date for the purpose of providing feedback. Here is an example of a possible assessment:

> 23 April 2025
> You take lots of good notes. All your sketches are labelled. Keep up the good work! In your conclusions, you could be more precise in what exactly you have learned from your observations. For example, in your observations on the candle flame. You write that there is light. What can be concluded from this? What further questions arise from this observation? What is a possible explanation for the presence of light? Do you have any ideas about this?

Research diary

Criterion	**Assessment**
Handwriting	The handwriting is legible and neat.
Drawings	Drawings are carefully made.
Labels on the drawings	Drawings are labelled with the place and date. A scale is provided. The objects (animals, plants, etc.) are labelled.
Descriptions	Descriptions of objects or activities are precise and detailed.
Line of thought	All steps from the idea to the conclusion are formulated in full.
Research process	Own questions or ideas are pursued. Assumptions are made, experiments are planned, experiments are carried out, the results are evaluated, and conclusions are drawn.

Help sheet for evaluating research diaries. It is best to copy, cut out and distribute it to the pupils so they can stick it on the first page of the research diary. This way, it is clear to the pupils at all times what is required.

Let’s get started

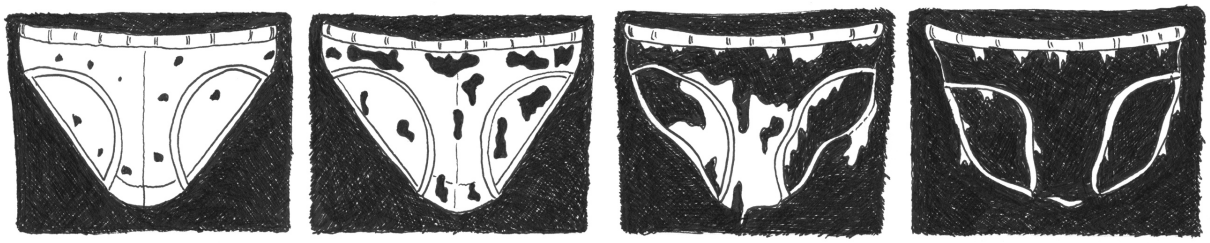
1. Get a research diary for each pupil. Hardcover diaries are best, as they allow for neat entries even in the field.

2. First, explain the scientific process (see page 6). Write the three major steps down on the first page of the research diary.

3. Choose any topic, object or experimental setup and show it to the class. Write a new title in the research diary with the date. Draw and describe the experimental setup. This is where the journey into the unexplored land of knowledge begins.

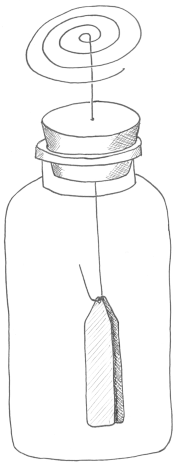
A word on the importance of language

You will quickly realise that science has a lot to do with language. However, many pupils are not very good at written expression. So, you cannot expect them to automatically write down everything that has been discussed in their research diary from the outset. As a teacher, you can specify what should be included in the research diary as a minimum. It is best to write this in your teacher’s research diary under the visualiser or on the blackboard.



A nice experiment for investigating the biodiversity of soil organisms. Four cotton underpants (or simply pieces of cotton fabric) are buried in the soil for 2, 4, 6 and 8 weeks. The longer the underpants remain in the soil, the more they are eaten away by bacteria, fungi, springtails and woodlice. Different types of soil, such as garden soil, farmland, park soil, gravel, and sand in a sandpit, can also be examined for soil biodiversity. The more the underpants are eaten away, the greater and more active the biodiversity.

Tips and tricks



Thinking hurts

The scientific process has a lot to do with thinking. This can be a bit tedious for some pupils, especially in the early stages. As a teacher, however, you should not shy away from letting the pupils think intensively. Even the smallest details can reveal a lot of insight if you are willing to think about it. Teachers need a certain amount of persistence here.

Asking questions is difficult

Pupils often find it difficult to ask questions. It is therefore helpful for teachers to give a lesson in which they go through the six basic questions. These are: Who? What? When? Where? Why? How? A nice task for this is: Write down ten questions about X. X can be any topic, object or person.

Submitting proposals

In most cases it is better for pupils to write or draw their experiment or project as a proposal in their research diary. The teacher decides whether and how the project can be carried out. You can also issue safety regulations or specify other conditions.

The magic number 4

Dividing the class into research groups can be very helpful and save time. A good number is 4, which means dividing the class into four groups. This means that the teacher does not have to deal with 20 or 30 different research projects, but only 4.

Define the focus

If you send the pupils outside with the task of “Explore the world!”, they will deal with all kinds of topics, from the feeding behaviour of beetles to the effect of gravity on the erosive power of water. The focus can be controlled by defining what is to be researched. For example: Which animals live in the pond? How are clouds formed? Or: Count the different types of grass in a meadow and report your findings.