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Teaching Science in Europe 2



ENGLISH



What European teachers can learn from each other

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SCIENCE
ON STAGE
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Teaching Science in Europe 2

What European teachers can learn from each other

Under the guidance of the non-profit association Science on Stage Deutschland e.V. (SonSD), hundred teachers from twenty European countries discussed concepts and materials for science lessons.

**SCIENCE
ON STAGE**  **Deutschland**

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The international teaching-workshop is to be continued

The overwhelmingly positive reception of the series of European educational conferences and workshops, hosted by the association Science on Stage Deutschland e.V. between 2004 and 2006, was a clear signal to continue.

The participants from all over Europe made the central idea – “What can European teachers learn from one another” – their own. They peered across national borders to challenge their own teaching scripts, found inspiration in “good practice” examples and took the insights gained back home to inform their national teacher training platforms.

To kick off a second series of seminars, the association Science on Stage Deutschland held an event from 22 to 24 September 2006 in Wolfsburg (Science Centre Phaeno and Ratsgymnasium). This event was understood as a genuine continuation of the European dialogue started back in 2004 on the German Science on Stage platform regarding the difficulties that have to be addressed in the education of our youth in sciences, as well as the quality of formal teaching and learning. (An overview of conference dates and participants can be found at the back of this volume.)

The series of workshops “Teaching Science in Europe 2”, again attended by groups of international teachers, focuses on three main topics, two of which are a reprisal and more profound examination of unresolved questions from the first workshop series.

All countries are increasingly committed to introducing children as early as possible to questions regarding science and technology in a way that maintains and supports their natural desire for discovery and strengthens their cerebral powers.

The working-group **Science in kindergarten and primary school**, however, clearly points out the problems nursery- and primary-school teachers face, which often arise from the lack of confidence in their own competence to teach science and technology in a way that meets the requirements of scientific correctness. Practice examples can encourage experimenting with one’s own class, while “tool boxes” of exciting teaching methods help to combat possible time-management problems for acquiring a broader and deeper knowledge.

The desire is unanimous in all countries: to foster a youth that is fit for a dynamic Europe. This youth needs a general education in science and technology that is supported and led by interdisciplinarity. The working-group **Interdisciplinary Teaching, scientific and non-scientific subjects** picks up and delves deeper into the topic of the first teaching workshop. It is important that participants clarify the scientific and historic background of interdisciplinary teaching for the readers and for themselves. The examples presented are therefore preceded by a theoretical summary of interdisciplinarity.

Internationally, as well as in the federal republic of Germany, educational politics are changing – a change that is often referred to as shifting the paradigm from input to output control. Educational standards and competence models are developed, decreed and tested. In the whole process of learning the individualisation of learning receives particular attention, and teaching therefore gains a psychological dimension. Models of





good teaching, general rules and principles are still the undeniable basis for formal teaching in schools. However, they are in danger of failing if there are no tools in place to register or check the effects of the specific teaching methods in the current teaching situation. To put it simply: if teachers do not address the problem of favoured thinking structures and behavioural patterns, if they possibly do not know how they themselves “tick”, successful teaching-arrangements will be difficult to produce.

Self-perception and self-evaluation of science teachers, the topic of the third workshop, is a very difficult, highly sophisticated subject-matter, exactly because it leaves the realm of feasible science topics valued so highly by science teachers. The contribution from this working-group can therefore only serve as an introduction to a less familiar area of experience and research. The challenge to construct successful learning-landscapes, based on the knowledge of one’s own (as well as the student’s) thinking preferences and behavioural patterns remains a pressing task for further workshops.

The participating international groups of all workshops again used this intercultural working platform provided by the organiser with benefit and enthusiasm to enlighten and enrich the house of European culture with “their” scientific windows to the world. All participants knew that none of the demonstrated principles or concepts, which have been shown as productive and effective in one country, could be transferred into other national systems without respecting national contexts. But they are strong impulses to reflect and develop own national standards and educational systems on the basis of this enriching experience. Educational systems are historically-grown social and cultural configurations, which have to be considered in reform policies.

The task is to modernise without losing one’s own cultural background. But it needs to be done!

The organiser would like to thank the participants for their great commitment and wishes all teachers luck and success for the work in their local schools.

In order to include the reader in the ongoing dialogue, we would like to ask you to fill in the questionnaire at the end of this book and return it to us.

The programme and the publication of the results would not have been possible without the generous support of THINK ING. (an Initiative of the German association of Metal and Electrical Industry Employers), the Andrea von Braun Foundation and Aulis Verlag Deubner & Co KG. All participants and the organisers are very grateful for this support!

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Science in Kindergarten and Primary School

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Science in Kindergarten and Primary School

Abstract

In discussions with kindergarten- and primary school teachers, we have gained the impression that teachers often lack the confidence to deliver science within the curriculum or only have limited time to build up their resources. If you hate the thought of teaching physics, chemistry or biology, we hope this publication will change your mind!

We want to encourage you to start using experiments in the classroom. We present you with a "toolbox" of exciting teaching methods, enabling you to work with the children's natural interest in scientific questions and to encourage and inspire them. Children learn about nature and technology in everyday life by discussing, observing, exploring ideas and through "hands-on" activities.

The following examples are chosen and designed for teachers who are not experts in natural sciences, using everyday materials. They incorporate a variety of teaching methods, involving all the senses.

Using drama sketches in science teaching

1

Motivation

In the UK, there is a requirement to introduce the concept of "Ideas and Evidence" in scientific enquiry. This includes exploring how outstanding ideas of famous scientists evolved in history and how scientists used evidence to back up their theories.

While it is important that children understand how scientific ideas and theories have been developed over time, it is sometimes difficult to incorporate the "history of science" in the lessons. Presenting the history as a drama sketch, to be acted out by the pupils themselves, provides a completely novel approach to this topic.

Keywords

Theatre, sketches, history, famous persons

Background information

It is well-known that children benefit from working in groups and that they need to develop their presentation skills. Providing short drama sketches to be performed in small groups not only gives the pupils an opportunity to explore scientific ideas, it also boosts their confidence when they appear in front of an audience.



The sketches can be used to introduce a topic to a class or to reinforce a theory previously taught in class.

The four sketches available at present are:

- "What is everything made of?" The story of Democritus and Aristotle.
- "Where do all living things on earth come from?" The story of Darwin.
- The story of Edward Jenner and smallpox vaccination.
- The story of scurvy.



Activities and educational goals

The children are divided into groups of four or five pupils and assign the different roles on their own. After a short rehearsal period, the children perform the sketch to the rest of the class.

At any stage, the teacher can initiate a discussion about the content of the sketch to check the understanding of the pupils. The aim is to deliver the "history behind the science" with plenty of fun. You will find that the children themselves will quickly adapt to the script and establish their own focus in order to create even more interesting aspects and enjoyment! Props can be useful to help with the dramatisation of each sketch.

Box of materials

The scripts of the drama sketches are available on www.science-on-stage.de.

Building a small purification plant – soil as a filter

2

Motivation

The idea is to introduce children to questions of natural science and ecology. With the experiment, we want to show how dirty water can be cleaned. In this context, the children should become aware of the fact that soils have important properties for cleaning water. Children can recognise that soils with their many inorganic and organic components can vary considerably.

Keywords

Environmental education, soil, filtration



Background information

The ground water oozes away and on its way through the soil layers it is bound to a varying degree by inorganic or organic soil particles, purifying the water in the process.

For further information, see also the website of the *Gesellschaft für Umweltbildung Baden-Württemberg e.V.* www.gub-bw.de



Activities and educational goals

This experiment is part of the theme of water. The children recognise that clean water is not a matter of course and that soils play a very important role in the purification of ground water. They can clearly see that the polluted water is a lot cleaner after it has passed through the soil layers.

We make some holes in the cap of a plastic bottle to enable the water to flow out. We divide this plastic bottle into two halves.

Subsequently, we take the upper part and stick it into the bottom part of the plastic bottle with the opening facing downwards. Now we can experiment with gravel, sand, soil and garden soil in the upper part of the bottle. The children pour dirty water through the different soil samples and can watch how quickly the water is flowing and where it is cleanest. With a beaker they can measure which substrate binds the largest amount of water. Finally, the children can put different layers of soil samples into the bottle and conclude which substrate combinations clean the dirty water best.

Box of materials

Dirty water with plant particles, a bucket with gravel, sand, soil and garden soil

2 Projects: "Boats with Various Propulsions" & "Flying Devices"

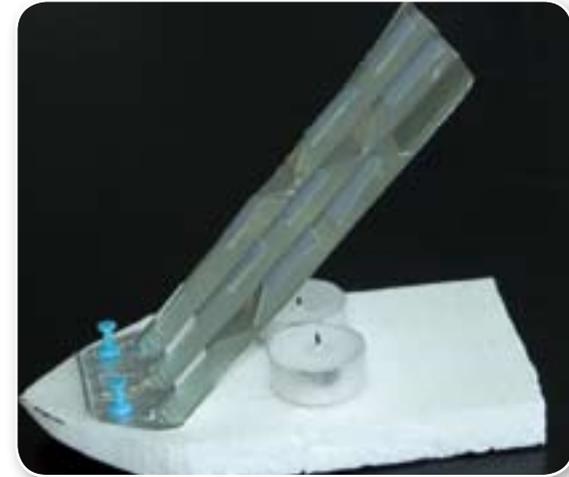
3

Motivation

The experiments presented here are ideally suited for a project or for project-orientated teaching. These methodical lessons allow for the students to work and experiment independently. For this purpose, a wide variety of possibilities is offered to the students and they are responsible for their sequence.

For all projects, the methodical emphasis is on the following three aspects:

- **Interest:** Children are always fascinated to play with water or to craft things floating on water. The task of building boats propelling themselves is very appealing to children and needs no extra stimulus. Flying objects moving through air do not differ from this at all. The use of everyday materials does not only keep the material costs low, but also increases the acceptance for the project idea and embeds the tasks into the empirical world of the students.
- **Crafting components:** Boat- and flying models need to be built. The level of difficulty varies depending on the model. Crafting capabilities, skill and a strategic approach when building are competences which can



be particularly supported in children. The advantage of this project is that the children create a concrete object with their work. Thus, they can judge for themselves if their reflections and constructions were successful or not.

- **Backtracking to basic principles of physics:** The projects contain (natural) scientific and physical components. The working principle of a boat or a flying object shall be observed and explained. In addition, models can be compared according to their properties and working principle.

Keywords

Speed, force, Newton's Third Law, pressure, resistance in a medium, falling of objects, buoyancy

Background information

Despite the variety of the models, equal physical principles can be applied, i.e. the principle of recoil (for boats) or the resistance which a moving object experiences inside a medium (air- and water resistance).

Children who are not acquainted with these fundamental laws and values are introduced to them from a playful, empirical and observing perspective. Also comparisons from biology, e.g. upon the locomotion of octopuses and cuttles can be very helpful.



Activities

→ **Location (boats):** Inflatable pool, public swimming pool, bath tub, natural waters, long flower boxes

Location (flying devices): Variable according to model

→ **Procedure:** Younger students need more advice and coaching than older ones. They are more confident when offered a portfolio with construction plans for the various models. They can hence select one or more models and build them. A more open approach can be offered to older students, who can work with an experimental box with materials and tools. From this, they can build models without any detailed specification which either move on water (without propulsion) or in the air.

→ **Comparison of models**

Boats:

- Which boat reaches the highest speed?
- Which boat shows the highest range?
- Which boat runs for the longest time?
- Which boat is more resistant to perturbations, e.g. wind?

Flying devices:

- Measurement of the flying altitude and the average velocities (flying trash bag, tea bag rocket, film canister rocket, air rocket, water rocket)



Educational goals

- Recognition of interrelations, e.g. equal physical propulsion principles
- Observation that acting and reacting forces are the preconditions for the propulsion of vehicles
- Recording and analysis of measurements (distances, time intervals)
- Empirically acquired knowledge concerning other physical parameters such as air- or water resistance or pressure
- Calculation of derived parameters (speed)

Box of materials

Construction plans for the boat models and flying devices can be found on the website of science on stage Germany - www.science-on-stage.de.

LITERATURE:

Wilke, Hans-Joachim: Projekt Rückstoßantrieb. Herstellung von Booten mit Rückstoßantrieb im Physikunterricht, Unterricht Physik 12 (2001) No. 63/64, Page 54

Sunny side up – Air and Airless Space

4

This part of the project “Sunny side up” is an example for a successful cooperation with students of a secondary school with a focus on physics. It gave our primary school children a very interesting insight into the world of air and vacuum to compare living on earth and in outer space.

Motivation

The children should get a better knowledge of the concepts of “air” and “vacuum” for a better understanding of different phenomena on our earth and in space.

Keywords

Air, vacuum, pressure, density, height, darkness

Background information

- Astronauts have managed to live in space for a short period of time. However, they always have to take air with them.
- Air pressure is caused by the upper levels of air exerting pressure on the lower levels. You can compare it with diving: The deeper you dive, the higher the pressure.
- In space, there is no pressure left at all.
- Water boils at different temperatures depending on the height and the density of the air.
- Air surrounds the surface of the earth (atmosphere). Because of the gravitational pull of the earth, hardly any air escapes into space.
- While we see the atmosphere of the earth as beautiful colours, there is absolute darkness in space. The sun’s rays are invisible in space. Only when they hit the earth, a planet or an astronaut, they become visible.
- Outer space is also absolutely soundless. Sound waves can only be transmitted by air and other objects.

Activities and educational goals

The children were encouraged to ask everything they found interesting. The questions were allocated to different topics. With the help of photo presentations and the Internet, it is possible to relate the questions and the experiments.



Educational aim: They should understand that life on earth is only possible because of the existence of the atmosphere. They should learn that it is important to protect this life – otherwise there will be unexpected danger. They should also understand that space research offers us a different view of our planet and helps to create a more comfortable life on earth (weather forecasts, improved clothes, mobile telephones, satellite TV, etc.).

Experiments

Air has some weight

Take a glass ball, extract the air with a vacuum pump and you will see that it is lighter than when filled with air. The fine differences are measured with electronic scales.



Vacuum – air pressure – atmosphere

A blown-up rubber glove (compressed air) shows clearly how the air expands when external pressure is reduced.



That's why space-suits have to be made of material that does not inflate or burst and also protects against heat, coldness and dangerous rays.



Quelle: NASA

Boiling water in vacuum

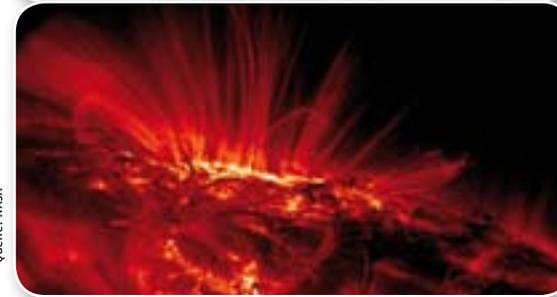
At a certain height, a boiled egg will not become hard at all. In a vacuum, boiling water is cool.



Sound waves spread out in the air but not in a vacuum.

It is assumed that the sun is not only very loud inside, but also produces a lot of noise when solar winds are ejected into space, travelling millions of kilometres. Yet nobody can hear anything.

This phenomenon is demonstrated by a bell that is glued into a glass pipe and then put on the vacuum pump and switched on. The more air is sucked out, the less the sound is audible, although the bell keeps ringing all the time.



Quelle: NASA

Let's play a book... let's read the environment!

5

Motivation

Reading a book can be an exciting way to start studying the environment. By playing and reading together, an amazing amount of topics can be picked up, thus having the child approach the process of reading itself, studying the environment at the same time.

In fact, by reading and acting out, the child becomes the active protagonist of the tale.

Background information

The Education Department of the Town Hall of Bologna selects a number of different locations as classrooms, including museums or schools.

One of the sites is Casaglia, named after its location in the park in the hills of Bologna. It was founded by Anna Selva – primarily for children at kindergarten age. There the children can approach the observation of nature in a beautiful, natural environment.

Keywords

Read, experience, collect, classify

Activities

In order to involve the children, we suggest using an OHP and pointing at every single word while reading out from a passage on the wall. In this way, the wall will 'come to life' through the backgrounds and the characters of the tale. This will be possible thanks to the aid of the teacher, who will move the characters. The children can take part in the scene by moving the characters, by creating new characters or by inventing a story from their imagination – thus creating a new version of the tale. Please note that the characters and the backgrounds should be drawn on a transparency. The ones you will see in this work have been inspired by the book *Cappucetto verde* (Little Green



Hood), written by Bruno Munari, author of children's books, who also developed drawing workshops focused on very young children.



While reading this book, the teacher will highlight all the words related to the environment – leaves, animals or little stones.

The teacher will take the children out to look at the things (like special trees, leaves, branches etc.) which were focused on in the passage.

These 'things' will then be classified by following the instructions in the book. In this way, the pupils will first learn how to collect things with the same characteristics and as a consequence of that, they will naturally get to a basic concept of classification.

The discussion is an essential teaching phase in the project in that it leads the children to share their own knowledge through the comparison with other points of view. This process will allow them to reach a common level of knowledge.



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Grow Your Own Potatoes

Motivation

Many of our children thought potatoes grew on trees! So the British Potato Council launched the *Grow Your Own Potatoes* project for primary schools. This is a simple, convenient and fun way to support primary teaching on:

- How things grow
- Where food comes from
- The importance of a balanced and healthy diet

Keywords

Potato plant, growing process, agriculture, alimentation

Activities and educational goals

It is a flexible hands-on activity centred around growing a potato plant, only requiring a large pot in the playground or on the window sill. The children's activities provide a structured and fun way to explore potatoes through the curriculum. The activities provide an innovative way to plan and deliver lively lessons that will both inform and entertain the children as they learn.



Box of materials

The book "Cappuccetto Verde" by Bruno Munari, backgrounds and characters on transparencies, OHP (overhead projector).

Source of pictures: Casaglia - Comune di Bologna



Box of materials

The worksheets and activities are a useful resource for exploring programmes of study in science and other areas of the curriculum.

- Experiment with different types of compost (sandy, loamy). Try placing the potato containers in different locations (direct sunlight and shade).
- Keep your own 'Potato Cam'. You can record the growth of your potatoes using video, photographs drawings and by keeping a diary.



For more information, ideas and a multitude of resources, visit the project's official website

<http://www.potatoesforschools.org.uk/>

Puppets in the classroom

Using puppets in the classroom to develop teaching methods and generate learning conversations amongst children.



Motivation

Despite some teachers' efforts to keep children quiet in the classroom, we must remember that children do learn by talking, both to the teacher and to each other. Talking about their ideas helps them clarify their thinking and develops their reasoning skills. Such skills are required for the analysis of data, interpretation of results and conceptual development. Unfortunately, this type of talk is frequently absent in science lessons and time is limited for discussions. Various reasons may account for the lack of time devoted to children talking, including the limited knowledge of appropriate teaching methods.

Keywords

Puppets, discussion, argumentation

Activities and educational goals

Puppets engage children in science and help capturing their attention. They prompt children to talk more about science and talking about science helps them to understand it better.

Puppets enable children to think more and to use more reasoning in their science lessons.

Children say that they understand science better when puppets are used to explain some of the ideas.

Puppets help to give children confidence, especially children who are shy and do not normally speak out in class.

There are different ways of using the puppets. One way would be the puppet making some suggestions for the children to discuss, to share with the puppet and to try out themselves. The teacher does not need a strange voice but has to believe in the puppet!

Puppets work especially well when they are involved in a story where they have a problem to solve. Children will want to help them by solving the problem. At the end of the story, the children can talk directly to the puppet about how they think they can solve the problem.

Example of lesson using two puppets

Set up a scenario where one puppet (Benny) disagrees with the other (Jasmin).

They explain that they have been given some special seeds to grow and they are not sure how to do it.

Jasmin: I think we should put the seeds in a dark cupboard

Benny: But seeds need light to start to grow

Jasmin: I think they need water, but they don't need light

Benny: If you give them too much water, they will drown and not grow at all

Jasmin: What do you think? Can you help us?



The puppets then invite the children to ask or answer a question and join in the discussion. Children are usually keen to tell the puppets what they know, but also listen more attentively. They get very involved in the process and very excited.

The most successful use of the puppets is when the teacher has introduced the puppet slowly to the class and has developed a strong sense of identity for the puppet. Care should be taken to retain the puppet's character even when not being used. An effective use of the puppet has been when the puppet introduces the lesson and then talks to small groups when the children are discussing their ideas.

The children talk to the puppet as if it was a different person than the teacher. They know it's the teacher talking yet they talk to the puppet 'like a new friend' or another pupil in the class.

Box of materials

For more information about ready-made projects with puppets and stories working together, please visit the following websites

<http://www.millgatehouse.co.uk>

<http://www.puppetsproject.com>

Why doesn't the polar bear freeze?

8

A

Motivation

Many children are fascinated by reports about unknown worlds. A journey to the land of "eternal ice" and a visit to the polar bears also offer a glimpse of bionics, "learning from nature". Parallel questions from different areas like geography, astronomy, biology, physics and technology additionally support networked thinking.

Background information

Polar bear hair is not white, but transparent and hollow inside, it's comparable to a straw. Like glass fibres, the hair absorbs the sunbeams and leads them to the black skin (according to a popular doctrine). The sunlight warms this skin layer, the dense fur now prevents the warmth to radiate to the environment – with short hair your head gets cold sooner.



Activities and educational goals

At the beginning, you show the children a clip of a documentary about polar bears or of the cartoon "The Little Polar Bear – Lars". You can also read a suitable story.

→ We visit Lars, the Little Polar Bear

It is important now that the children themselves ask questions about what they would like to know. This is the only way you can find out about the specific interests of the boys and girls.

Before the actual journey to Lars begins, these questions certainly need to be answered.



→ Where does Lars live?

A globe with illustrations that are suitable for children facilitates orientation.

→ How do I get to Lars?

The car is not sufficient (adequate) for the journey, a plane will have problems when trying to land on the icy slope – that leaves the ship as a further opportunity since the Arctic Ocean lies between Europe and the natural habitat of the polar bear. A first orientation session by working with the globe is thus integrated. It will get even more impressive for the children if you attach little cars and ships to the globe.

→ Which equipment do I need for the journey?

Now it's time to pack for the journey, of course, you mustn't forget to take food and drinks with you. Choosing suitable clothes sensitises the children for the climatic conditions. Food and drinks also need to be packed in a way that ensures they won't freeze. Additional questions will naturally arise here.

→ Why is the Arctic so cold?

With the help of a torch, you show the reduced insulation of the Arctic Zone in the experiment.

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→ **What has nature done to avoid that the polar bear never freezes?**

The children surely know about fur as a protecting and warming cover. By comparing human hair with polar bear hair, you can already discover some differences. A microscope should be used. Polar bear hair is hollow – like a straw. The hollow hair “leads” the sunlight to the skin of the polar bear. Nature also uses another trick. In order to absorb the radiation in an optimum way, the polar bear has black skin (see part of the head where the fur is less dense in the illustration).

This phenomenon of absorption can easily be checked by radiating a white or black cloth with a halogen desk lamp or sunlight and then check the warmth by touching it. If you wrap a thermometer into both pieces of cloth, the experiment will be even more impressive. Alternatively, you can show the different speed of warming by using an ear thermometer.

The children get to know magnifying glasses and microscopes as suitable tools for observing smallest textures and learn how to use them. It is also motivating to build a small magnifying glass with the children. For that purpose, you only need a piece of cardboard, clingfilm and a drop of water as a lens. And now a first “expedition” into the microcosm The observed objects should be recorded in small drawings.

The effect of light-conducting fibres can be illustrated by using a “fibre-optic torch”.

Box of materials

Polar bear (soft toy), globe, torch or desk lamp, polar bear hair (from zoo), straws or macaroni, fibre optic torch (optional), magnifying glass (tenfold magnification) or microscope with lightning, 2 microscope slides, ear thermometer, black and white pieces of cloth



The Candle under the Water Glass

Motivation

With this experiment, the children learn about the extension of gas when heated. The children can see what is meant by the Laws of Conservation – basic principles for scientific understanding.

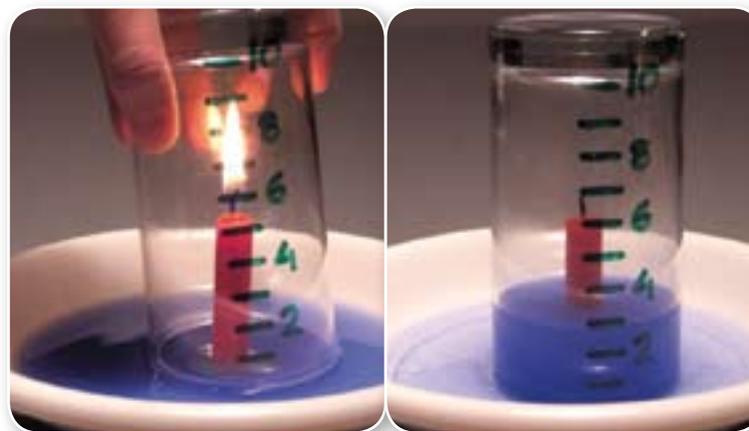
This well-known experiment about the composition of the air is frequently explained incorrectly with the chemical transformation of air in a combustion process.

Key Words

Expansion through warming, cooling, gas, candle flame suffocates, oxygen burns and turns into carbon dioxide, water level rises, misconception

Background information

A candle is standing on a plate which is filled with water. If you place a glass upside down over the burning candle (picture 1), the oxygen inside the glass is used up by the flame. Then the flame burns out and the water level inside the glass rises (picture 2).



Picture 1: The candle burns under the glass.

Picture 2: The candle is extinguished, the water level has risen.

A common explanation for the rising water level is that the water fills the volume of the oxygen that was used up. But if – simplified – one part of oxygen is converted to one part of carbon dioxide through the combustion process, the volume of the gas does not change!

The actual reason for the rising water level is quite different: As soon as the glass is held over the flame, the gas inside the glass begins to heat up and therefore to expand. Once the glass is placed on the plate and the flame dies, the enclosed gas cools and thus its volume decreases. The outside air pressure forces the water into the glass.

Learning Goals

Learning goals of this experiment are:

- The conversion of gases through the combustion process. It implies that no matter is lost.
- The expansion of gases when heated.

The misconception that oxygen burns and therefore “disappears” is a stark contradiction to the Laws of Conservation, which are fundamental for scientific understanding.

Box of materials

A more detailed description of the experiment, a critical examination of the process and several related experiments can be found under www.science-on-stage.de. For example:

- a) The basic experiment “The candle under the water glass”
- b) Large water bottle instead of a small glass
- c) Without candle: The experiment also works with a hot blow-dryer

LITERATURE

Examples for misconceptions can be found in many experimentation books as well as in several Google search results after typing in “candle, water, oxygen”.

A correct description with additional background information can be found in the highly recommendable youth book “Anita van Saan, 365 Experimente fuer jeden Tag”.

Motivation

In this project, action-oriented learning opportunities are given to children. They become actors in a story taking place in Ancient Egypt. Thereby they get motivated to invent simple technical devices like the lever, the wheel and the inclined plane in order to build a pyramid.



Keywords

Action-oriented problem solving, improvisation in role plays, interdisciplinary and self-exploratory learning, physics, mechanics, understanding of time and history, use of technical devices

Background information

Simple machines like the lever, the wheel and the inclined plane have been used for many millennia. The principle of the wheel can be found in a tree trunk, which is placed underneath a load, so it can be moved more easily (reduction of friction). To lift a load, a lever can be used. To bring a load to a higher level, one can use an inclined plane. (2nd layer of stones in a pyramid). The longer way lowers the effort of force (like a serpentine on a mountain).

Note: To move a wheel “around”, it is not obligatory to use a circular profile, also angled forms are possible (see also Reuleaux-Triangle or curve of constant width).



Activities and educational goals

The children go on a time trip. In their imagination, they are in charge as builders in Ancient Egypt. For the Pharaoh's birthday, they are commissioned to build a pyramid. They only have a stone pit (two big, heavy stones) and a little forest at their disposal. In the forest, some trees have already been cut down (logs in various sizes).

To build the base of the pyramid, the children must transport the heavy stone to the building site. They find logs, which they can use as wheels or levers for the heavy load.

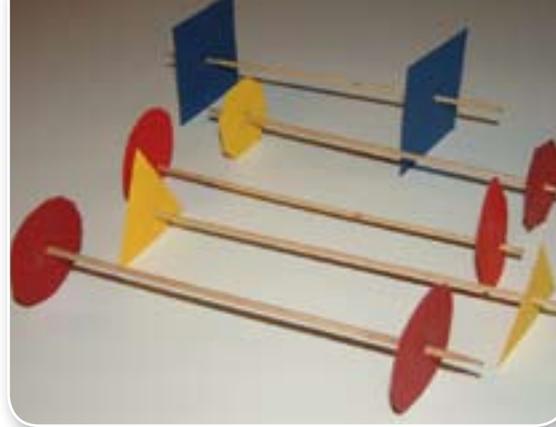
The base is ready. How can they add a second layer of stones? Usually the children understand quickly that they can use a longer and broader board as a ramp or inclined plane to move the stone by putting wheels under it.

After or between these experiments, the children can explore the following questions:

The wheel: Which one is rolling best?

Inclined plane: The stronger stretch shows the greater expenditure of force. (Energy remains constant!)

Lever: On a longer lever, the weaker has a chance.

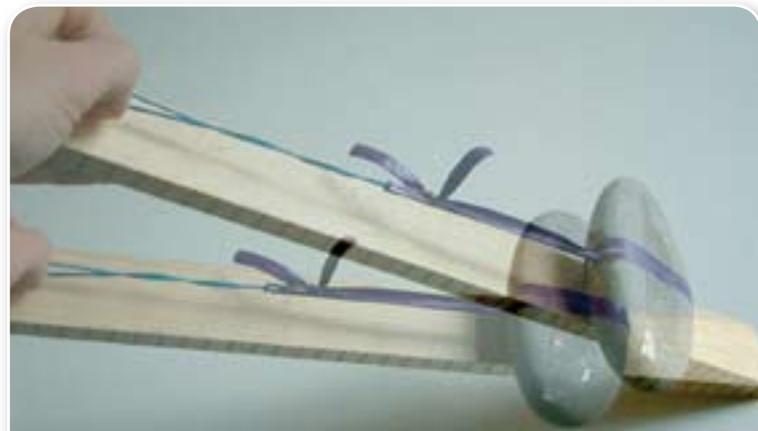


The topic “Ancient Egypt” can be deepened and broadened using an interdisciplinary approach, incorporating the subjects of art, geography and history.

Box of materials

2 big and heavy bricks (38 x 25 x 17cm). For the first task, a stable cardboard box with a child sitting in it can also be used. Sufficiently stable logs, e.g. a broomstick which is cut into three pieces, with its ends partly flattened (as a lever), wooden building blocks (support for the lever), board for the inclined plane, painted instructions.

Source: www.kleine-experten.de

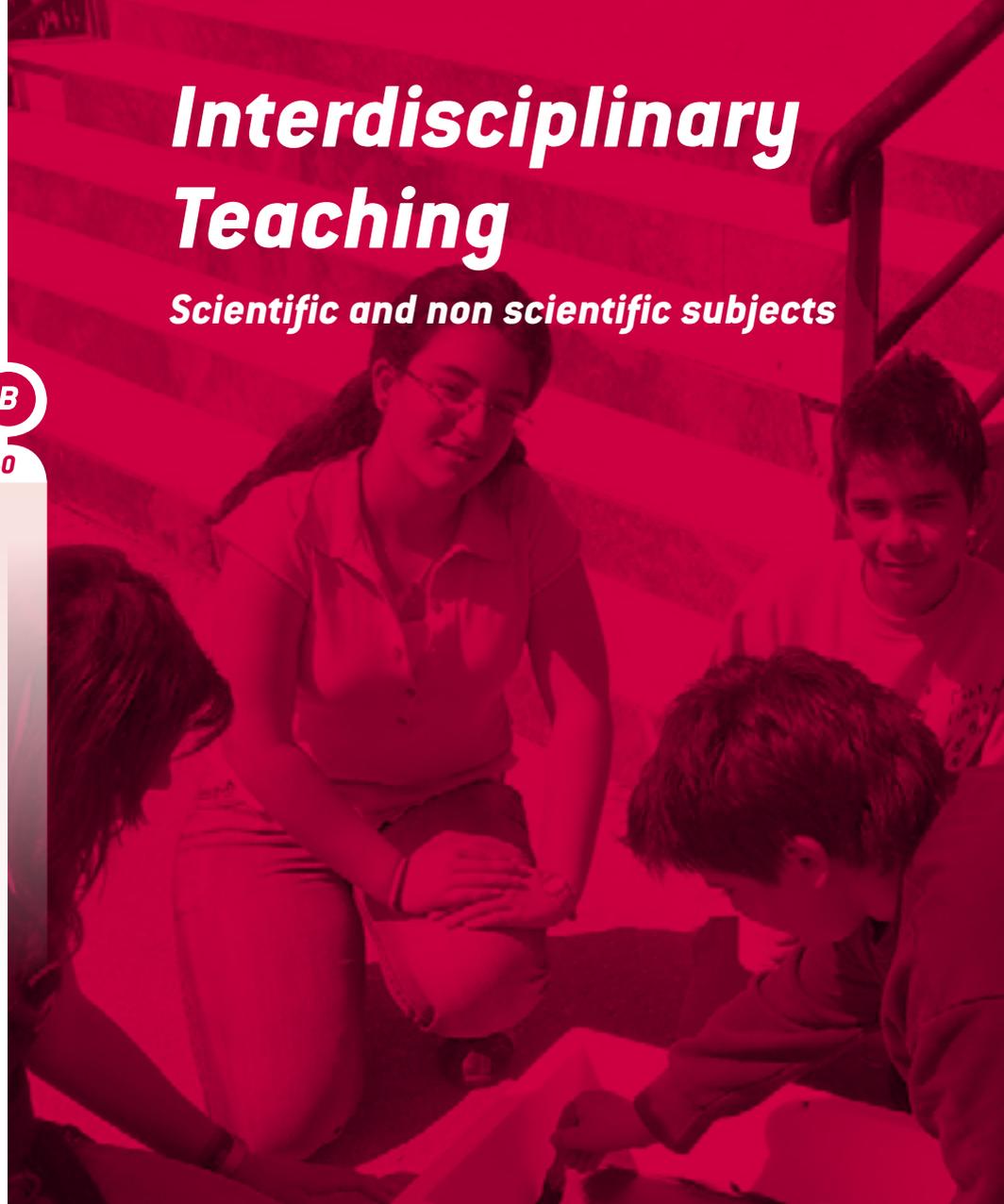


Interdisciplinary Teaching

Scientific and non scientific subjects

B

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B

Introduction

Following the initiative of Science on Stage Deutschland e.V., a group of teachers from several European countries took the opportunity to gather diverse views on interdisciplinarity resulting from specific approaches and needs. In the national curricula, a variety of interdisciplinary approaches already exists, ranging from a mere additive amalgamation of several scientific subjects to the classic project method. However, a combination of science and non-science is rarely described or explicitly favoured in those contexts.

So our cooperation aimed at innovation on several levels:

- Exchange of approaches already developed in the participating countries,
- Initiating new ways of interdisciplinarity as far as the contents are concerned, but also using innovative settings and
- International cooperation of teachers at our conferences and in the sub-projects.

This multiperspectivistic adventure was held together by a common format. At the first meeting in 2006, the group not only planned the specific activities, but also reflected on the epistemological and historical background of our approach. Referring to these aspects ensures that our teaching is linked to and legitimated by general demands and tendencies in modern societies where science is a crucial factor, not only determining the knowledge-based economy but also influencing cultural paradigms and world views.

B

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Interdisciplinary Teaching

Some Background Reflections

What do we mean by interdisciplinarity? Not only in education, but also in the academic world itself, interdisciplinarity is a broadly discussed question, motivated by three main aspects:

- Economic motivation: Science with its applications is a productive power – probably the most important one in European countries – which is more effective if several scientific competencies and economic key qualifications interact.
- Political, social and ethical motivations: Science is looked at as a problem solver for the big issues of our time – like ecology, peace or employment – which are all situated at the intersection between nature and culture, science and technology.
- Epistemological motivation: The growth of knowledge is less determined by traditional disciplinary ramifications, which were above all established for the sake of teaching and administration.

Very often, research topics do not present themselves within these frameworks. Even if research is nurtured and practised within one discipline, the demands on research are rarely confined to any single discipline. This does not only apply to major topics such as energy, gene technology, consequences of technology, etc., but also to many detailed research projects – if one does not have the wisdom to confine oneself to the paradise of pure mathematics.

Beyond this synchronous view of the international situation of education and science, a glance back into history can be enlightening, too. One of the first and long-lasting educational canons in Europe stems from the Roman Empire and persevered throughout the Middle Ages. It was distilled from the Hellenistic *“enkyklios paideia”* and was called the *“septem artes liberales”*, the seven liberal arts – or skills – of the freeman (!): Grammar; rhetoric; logic (the *trivium*) followed by arithmetic; geometry; astronomy; music (the *quadrivium*). These subjects had the character of formal education and were taught in quite a practical way. In combination, they formed a kind of ladder – to be climbed by a student in order to get access to the university where one could study in the *faculties* of theology, medicine and jurisprudence. Later on, when

the “lower” faculty of philosophy with the intrinsically philosophical subjects (metaphysics; moral philosophy and mathematics) – but also including a history department with history studies, anthropology, geography and empirical sciences – had been added, these three faculties were called the “higher” faculties. Whereas the *septem artes* formed a hierarchy which had to be passed through in chronological order, the higher faculties were conceived as independent from each other. Immanuel Kant’s “Quarrel between the Faculties” discusses the problem of the relationship between the “higher” and the “lower” faculties and concedes with a sense of irony that the philosophical faculty had to be *ancillary* to the theological faculty – an exemplary metaphor for the entire academic system with its disciplines. In the epoch of Enlightenment, other metaphors for the system of knowledge were the *library*, fostered by the encyclopedists, and the famous *Houses of Knowledge* envisioned by the philosopher Francis Bacon, whereas the metaphor “*curriculum*” designates the idea of a pathway or rather of a racetrack the learning subject has to run through.

Throughout the history of the European academic and educational systems, the different fields and disciplines had to compete and fight for appreciation and probably all of you know about the affronts and impediments mathematics and the natural sciences had to face even into the late 20th century. This was not only a superficial contest for territory and resources, but a question of deeper significance. In the famous *Rede Lecture* in 1959 by the chemist and poet C.P. Snow, a severe clash of “*the two cultures*” was highlighted. Snow was worried by the radical split between arts and humanities on the one hand and the natural sciences on the other hand. Not only did he deplore the lack of mutual understanding and respect among the representatives of these cultures, but strongly insisted that this situation caused deep problems in the educational system and was dangerous for welfare of the nation as a whole.

Both metaphors mentioned above – the *Quarrel between the Faculties* and the *Houses of Knowledge* – were revived in our times by the philo-

sopher Jürgen Mittelstraß in his discussion of interdisciplinarity, which nevertheless cannot resolve the asymmetry between general problems and special skills. It is too short a shirt for two reasons:

- Interdisciplinary projects are usually only temporary activities and lack long-term commitment.
- Interdisciplinarity does not seriously challenge the boundaries between the individual disciplines and often only serves as an alibi.

In contrast, Mittelstraß advocates a primordial awareness of concerns and problems which are not defined within the constraints of traditional institutions and disciplines in the first place. This focus has been labelled *transdisciplinarity* by Mittelstraß and others. The intellectual endeavour necessarily connected with transdisciplinarity is second-order knowledge production, a level which nevertheless presupposes flourishing disciplinary work. This work and its results are then referred to from a point of view which transcends to every single discipline.

The academic studies of education and teaching are inherently interdisciplinary because their task is to link the standards of society and its culture to people, especially to hand over its values and knowledge to the next generation. Therefore, we have a clear bipolarity of approaches: We can start with the learning person where we certainly should look carefully at the neurological, psychological and social conditions of learning. From the point of view of interdisciplinarity, we are presented with an example of an ancillary relationship in two steps: Relevant disciplines such as neurology, psychology and sociology support educative/pedagogical designs, which enable academic work.

Starting with the material pole of teaching and education, we have all been brought up with the traditional disciplines and it is not a minor task to study at least one of them thoroughly. Without having dwelled deeper in any single academic domain, it seems risky to open one's mouth on an interdisciplinary level. It is possible to try and understand another subject from the viewpoint of one's own subject, detecting common features and differences in equal measure. However, without being firmly anchored in one's familiar territory, one remains in a state of pre-disciplinarity rather

than interdisciplinarity. Unfortunately, that is the case in some of our teacher training curricula where the studies of certain subjects are reduced to as little as twelve lessons per semester.

If you try to imagine the whole ensemble of disciplines taking some kind of spatial view, you might conceive it as a complex structure of domains, with some domains distant from each other and some overlapping, some ordered in hierarchies and some independent. Furthermore, this whole cosmos is developing in time, where different parts have different speeds. Therefore, an appropriate metaphor for interdisciplinarity could be *evolution*.

If we want to transmit an idea of this evolutionary process in our teaching, we cannot possibly show it as a whole but have to start focusing on precise points, for example:

- We could focus on *concepts* which are common to several disciplines. Prominent examples are the concept of energy, the concept of life, the concept of probability, etc.
- We could focus on certain objects or systems: The bicycle, the atom, the rainforest, the brain. These are examples of technical or physical and biological systems, with all of them requiring tools from several sciences to be fully understood. We could complete the list of systems further by adding chemical-, information-, social and many other types of systems and thus take into consideration a *system-theoretical point of view* as a structuring principle for interdisciplinarity.
- A very strong motivation for intellectual and moral efforts derives from questions and problems which arise in "life" rather than in science. We need not necessarily try to face the global climate in the first place, but can e.g. honestly tackle the conditioning of our daily transport tools like motorcycles and underground trains. This kind of approach is one of the characteristics of the *project method*.

Insofar our approach is founded on life-related assessments and can be understood as an adaptation of the project method.

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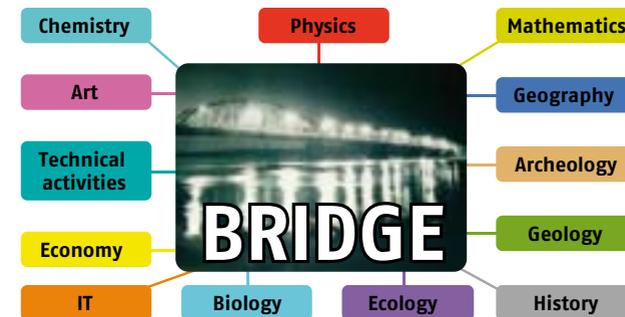
1 Build a Bridge!

Context:

The local council decides to build a bridge to connect two parts of the city separated by a river (or two villages, two regions, etc. ...). The mayor contacts architects, engineers, mathematicians, artists, sociologists, journalists and investors about building the bridge. He wants to take all aspects connected to the building of a bridge into account – cultural, sociological, historical, geological, economic, etc. ...

Disciplines involved:

Mathematics, chemistry, archaeology, history, art, IT, biology, geography, geology, physics, economics



Sub-assignments:

→ **Preparatory part:** All students have to identify (through interviews) the best location for the local community to realise this project. They will meet and discuss to compare the results of their research and take a decision about the location.

→ **Group 1:** Draw an aerial map of the area which includes surroundings of the bridge. Measure distances on the site using adequate methods. Sketch in a key with symbols and use a certain scale. Recognise the geomorphology of the area. Contact local authorities about the town development plan.

→ **Group 2:** Review the surrounding area, taking flora and fauna into account. Observe carefully and list all the threats that the bridge may pose for the natural environment. Propose solutions to these problems.

→ **Group 3:** Find similar constructions in this area in the past, using different information sources. Research on any related historical facts. Based on this information, design the bridge in harmony with local tradition, using your creativity and taking aesthetic aspects into account.

→ **Group 4:** Work on aspects of physics and technology concerning traffic (cars, public transport and pedestrians). Anticipate the weight and frequency of the movements. Carry out experiments to discover properties (mechanical, thermal, climatic, etc.) of the materials used, for example iron, wood or stone.

→ **Group 5:** Estimate the economic aspects of this investment. Draw up the simulations of the costs. Try to find partners for this project and some companies which are able to conduct it. Identify the prospects



and the economic advantages of this investment. Try to find any other potential benefits for the local community and formulate reasons which could convince the local authorities to participate in this project.

→ **Group 6:** Build a model of the bridge made of chosen materials. Use an adequate scale.



The different groups will have to coordinate their work in preparation, timing etc. They will present reports (class meeting, school meeting, meeting with parents, with local community, local authorities ...).



Conditions:

Framework: In class and beyond the classroom

Age of the pupils: 14–16 years

Duration: 24 lessons

Materials: Different materials (art and engineering), photo and video camera, etc.

Evaluation method:

Presentation, report, preparation, test, self-evaluation.

Further details on www.science-on-stage.de.

Caesar and the Aqueduct

Context:

Caesar (the teacher) commissions his experts (pupils) to build a water supply for a city situated at the slope of a mountain. Among these experts are also scientists: Mathematicians, architects, engineers, designers, economists, constructors, etc. They have to consider all the aspects concerning the construction of a dam and an aqueduct including canals, waterspouts, bridges and whatever is needed to transport the water from the spring near the top of the mountain down to the city. They must try to solve every problem (including deep gaps in the envisaged path of the water) they are faced with.



Disciplines involved:

Mathematics, physics, economy, chemistry, geography, sociology, technology, history, art.

Sub-assignments:

- **Group 1:** Use various resources and find existing similar constructions of the Roman era to transfer water, possibly in different parts of the world.
- **Group 2:** Carry out experiments to discover properties (mechanical, thermal) of the materials used, e.g. water, wood and stone. *(See also the following experiment.)*
- **Group 3:** Imagine and design the structure of the bridge as it should be constructed, considering the weight of the canal and the water.
- **Group 4:** Build a model of the aqueduct, using your creativity and including aesthetic aspects.
- **Group 5:** Work on the physical and technical aspects of transferring water from the dam to the city through the canal.
- **Group 6:** Examine the economic aspects of the structure: Materials, transport and building costs.
- **Group 7:** Describe the social system in the Roman Empire.



Conditions:

Framework: During school lessons

Age of the pupils: 14–16 years

Duration: 16 lessons (It is recommended that each meeting should last two successive lessons.)

Materials: Various construction materials (e.g. cardboard, wooden sticks, tinfoil, painting materials), balance, water and water containers, dynamometer

Evaluation method:

Details on www.science-on-stage.de.

EXPERIMENT

"Caesar and the Aqueduct"

"Develop an experiment to discover as much as possible about thermal expansion and define the coefficient of linear expansion of a material"

Pupils construct a rather simple device and define the coefficient of linear thermal expansion. The device consists of a rod, thermal sources, a set of stands and sensors of temperature and motion. A suitable software is required. Dealing with this activity, pupils have the opportunity to learn about thermal expansion and some of its impacts on everyday life and on technical applications. They also obtain or improve skills to find solutions for practical problems and how to cooperate.



Duration: 2 successive school hours

Materials: A rod of 0.7– 0.8 metres of the specific material, two stands with fastening spots and an aluminium rod of 0.8 m, a source of heat

Infrastructure required: A tape measure, a temperature sensor, a motion detector, the relevant Lab interface and software and a computer with printer

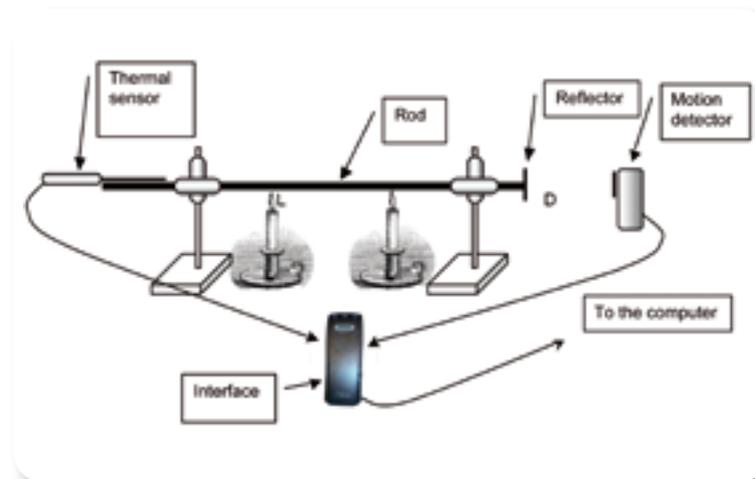
Way of working:

- Pupils work in groups of 4–5.
- Before the actual experiment, they have to research using several sources, learn about linear thermal expansion and describe the impact of expansion phenomena in our everyday life and applications.
- Pupils have to solve several problems of a technical nature related to the setup of the experiment.
- The teacher guides them, helps them, answers questions and solves conflicts if any exist. Pupils and teacher cooperate throughout the entire process.

Description of the experiment:

1. Measure the length of the rod while it is at laboratory temperature, fasten the temperature sensor at one end and the metallic reflector at the other end. Put it on the stands in a way that allows it to expand freely. The left end should be fastened on an unmovable object, so that all expansion (or contraction) can be detected by the motion detector, which is close to the free right point of the rod.
2. Expose the rod to heat until its temperature increases up to 80–90°C (about 10 minutes). Then let it cool down until its temperature decreases to the temperature of the room (about 15 minutes). When the procedure of cooling starts, energise the recorder of temperature and distance between the motion detector and the reflector. As the distance between the detector and the reflector increases, the rod contracts in equal measure.

Diagram of the experiment setup:



Context:

Travelling through space, pupils exchange information about their experiences.

Disciplines involved:

Mathematics, physics, astronomy, economy, chemistry, geography, sociology, technology, history, language, art, music, I-technologies

Sub-assignments (examples):

- **Group 1:** Calculate your route.
- **Group 2:** Find artistic aspects.
- **Group 3:** Listen to noises/sounds in space.
- **Group 4:** Recognise celestial objects.
- **Group 5:** Classify various celestial objects.
- **Group 6:** Planning of the journey through space and solving all related problems.
- **Group 7:** Use observational tools.

**Conditions:**

Framework: In class and beyond the classroom

Age of the pupils: 10–18 years

Duration: 20 lessons

Materials: Observational tools, computers, web pages, literature, photographing tools, printers, cardboards, lenses, boxes, sticks ...

Expected effects:

Deeper understanding of the interconnection between subjects. Ability to study various situations from different viewpoints. Ability to predict outcomes for new situations. Understanding of the limitations of each discipline.

Evaluation method:

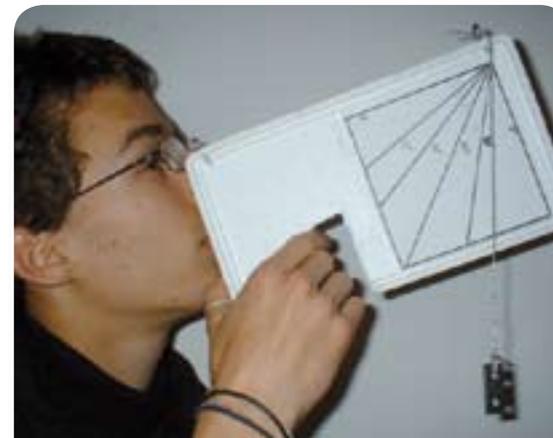
Notes, test, class delivery, project (model/presentation)

The 5 E-method:

How to approach the picture of the universe from a geocentric or heliocentric point of view with students? The primary school teachers' group of SonSD suggests the following teaching – learning method (5 E-method, see Teaching Science in Europe I).

For us, teaching is characterised by the following: Firstly understanding the student, secondly understanding the teaching/learning process and how to enable the development of "significant" knowledge, creating a stimulating and favourable learning environment, favouring co-operation between students and answering the expectation of society, not forgetting the peculiarity of each single school. Referring to the **5E concept** (*Engage Explore Explain Elaborate and Evaluate*) developed by a former SonSD team, we propose the following approach which we call **5 E in 7 steps**.

1. Introduction and motivation. Discussion. Comparison of ideas and previous knowledge of the students in the topic "geocentric world view versus heliocentric world view"; **Engage**.
2. Activity. Investigation. Observation of sun shadows. Cardinal points. Polar star. A box with 2 points lines of vision to observe a constellation. Parallax, reference frame; **Explore**.



3. Historic investigation. Ptolemy, Brahe, Copernicus, Galilei. The difficulties to observe a parallax in Galilei's time to verify his proposal. Venus phases. Jupiter moons. Observation with hands-on devices: Galilei's telescope; a "controlled" use of the web. To explore and learn more about Galilei, the pupils build an easily built/simple Galilei telescope of their own. Discussion. **Explore and Explain.**



4. Co-operative learning. Jigsaw method for working groups. Development of activity: A coordinated activity to acquire deeper knowledge. **Elaborate.**
5. From astronomy to: Philosophy, art, religion and history. The political situation in Italy in Galilei's time, the environment of the Church / the Pope, the heresies; **Elaborate.**
6. Summary and presentation: The point of view of an inhabitant of the earth, from the earth into space and vice versa (posters, CD-Rom, web page); **Elaborate.**
7. Evaluation test (multiple choice, essay). Follow-up: Comprehension of astronomical concepts after some months. **Evaluate.**

Christopher Columbus and the journey towards the New World

4

Context:

In 1492, Christopher Columbus can realise his dream at last: The journey to "the Indies". Queen Isabella of Castile has granted funding to equip three vessels (Santa Maria, Pinta and Niña) and a team of collaborators planning the journey.

He is assisted by engineers, architects, geographers, navigation experts, doctors, etc. ...

There are problems to be solved:

- to check that the ships are in good condition: Sails, the condition of the hull, accommodations,
- to equip the ship with suitable instruments of navigation,
- to choose the course and plan the journey during the most favourable time from a meteorological point of view,
- to prepare the necessary provisions and medicines,
- to recruit the sailors, the naval officers, the experts of navigation and some doctors,
- to assess the costs.

Disciplines involved:

History, geography, meteorology, earth sciences, physics, biology, economics, technology, sociology, medicine.

Sub-assignments:

- **Group 1:** Collect historical information about the time of Columbus's travel.
- **Group 2:** Carry out experiments on buoyancy and sailing, build a model ship.
- **Group 3:** Choose the course and the navigation instruments, study favourable weather conditions, geographical and astronomical maps.
- **Group 4:** Study the recurrent diseases in crews that do not have fresh food for a long time.

- **Group 5:** Decide on the diet of the sailors.
- **Group 6:** Analyse the travel costs.
- **Group 7:** Discuss the recruitment of the crew.

→ **Conditions:**

Framework: In class

Age of the pupils: 14–16 years

Duration: 12 lessons

Materials: Materials to build a model boat, equipment for experiments on buoyancy and sailing, navigation instruments: Sextant, geographic and astronomical maps.

Evaluation method:

Reports of the different activities of each student (individual and team), presentation of results, test, project diary.



Source: Thorsten Pohl

Produce a Self-Designed Coloured T-Shirt with Plant Colours

5

Context:

A newspaper article deals with the withdrawal of children's clothes containing harmful pigments. The pupils should discuss organic alternatives to chemical colouring substances to colour the T-shirts. Different teams should find and produce alternative plant colours to create their own non-toxic T-shirt.



Disciplines involved:

Biology, chemistry, physics, history, art.

Sub-assignments:

- **Group 1 – Biology I:** Examine the cells under the microscope and find out where the colour pigments are situated. Draw the cells with the vacuoles, plastids and crystals.
- **Group 2 – Chemistry I:** Carry out experiments to extract colours from plants, vegetables and fruits. Think about useful plants, fruits, vegetables and methods of separation to isolate the colours.
- **Group 3 – Biology II:** Find out how to practice the chromatography and realise it
- **Group 4 – Chemistry II:** Find out how you can fix the colours to make them resistant e.g. to (sun-)light, the washing process, etc.



- **Group 5 – Physics:** Find out how people can see colours and about additive and subtractive colour synthesis.
- **Group 6 – History:** Find out how people coloured their clothes in former times.
- **All Groups – Art:** Design a nice coloured T-shirt and produce it.



Conditions:

Framework: In class and – if possible – beyond the classroom

Age of the pupils: 15–16 years

Duration: 20 lessons

Materials: Different plants, fruits (e.g. lemon, oranges, blueberry, raspberry, strawberry) and vegetables (e.g. spinach, carrots, green, yellow and red peppers), solvents (e.g. water, oil, ethanol), glasses, microscopes, vessels to store the isolated coloured preparations ...

Evaluation method:

Project diary (individual mark), presentation of the results, test, T-shirt.

Further information on www.science-on-stage.de

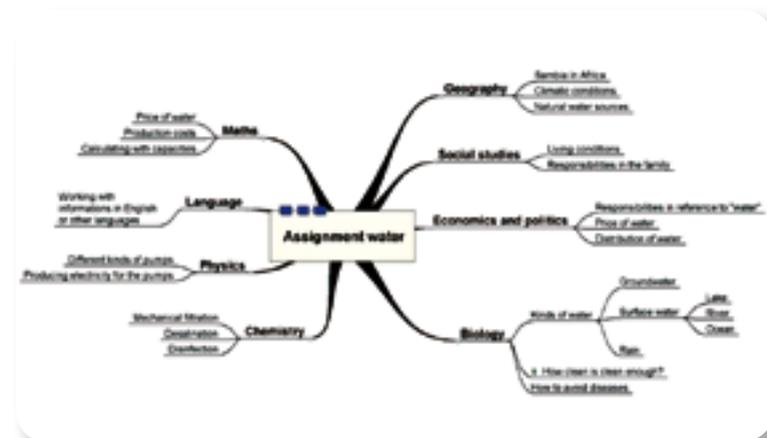
Plan to Provide Clean Water for a Village in Zambia

Context:

You are a member of a development team. People in a poor village in the western part of Zambia have no access to safe drinking water. You are responsible for solving this problem. There are other teams who want to get the contract to provide water. Prepare a presentation about how your group would solve the problem.

Disciplines involved:

Mathematics, language, physics, chemistry, geography, social studies, economics and politics, biology.



Sub-assignments:

- **Group 1:** Familiarise yourselves with geographical-, political-, social and living conditions in Zambia.
- **Group 2:** Provide water for people, animals and farming.
- **Group 3:** Is the water clean enough for the given purpose? Familiarise yourselves with mechanical cleaning, desalination and disinfection.
- **Group 4:** Make a plan how to distribute the water.

The members of the group will have to coordinate their work for the final presentation.

**Conditions:**

Framework: Project days or optional courses

Teachers involved: 2 teachers (1 with a natural science background) or 1 leader of the project with co-teachers for special parts

Age of the pupils: 15–17 years.

Duration: 12 to 14 hours.

Materials: Map of Africa, Internet access, materials for experiments

Evaluation method:

Details on www.science-on-stage.de.

Sun-oven**Context:**

We participate in the project “The sun-village, a pilot community independent from external energy sources” and we have to organise everything related to nutrition. We have to solve any problem concerning the chain “from the wheat grains to bread” and materialise this chain. We also have to convince other persons to participate in this project describing the advantages of ecologically beneficial activities.

**Disciplines involved:**

Physics, chemistry, biology, history, technology, meteorology, psychology, art, mathematics and cooking

Sub-assignments:

School books, libraries, the Internet or specialised persons are meant wherever a reference to “several resources” is outlined below. Pupils are encouraged to use several resources in order to respond adequately to all sub-assignments.

→ **Group 1:** Wheat and other cereals. How is flour obtained from wheat and how is it transformed into bread? Visit a windmill or a watermill and describe the way they work. Research several sources and describe the role of carbohydrates in our body.

→ **Group 2:** Which social transformations caused the transition from the hunter-gatherers to the agricultural society? What was the impact of this transition on the food? Describe some differences between the diet in our days and in previous periods of human history.

→ **Group 3:** How is energy produced in the sun? How is it transferred to the earth? Describe a greenhouse (if possible organise a visit to a greenhouse) and how a temperature can be achieved that is higher than in its surrounding.

→ **Group 4:** What is the "greenhouse effect" in the atmosphere? Which human activities worsen the green house effect? Could you propose alternatives to some of these activities?

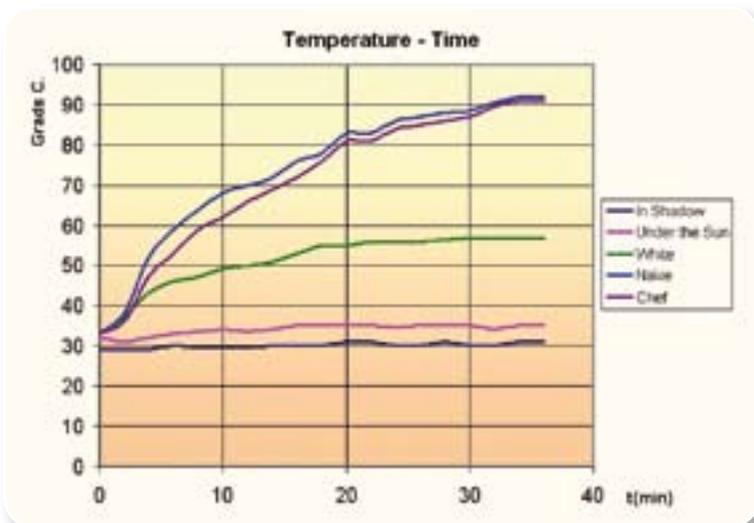
→ **Group 5:** Design and construct a sun oven, using simple materials, make experiments to measure the temperature in it. Propose ways to make it work.

→ **Group 6:** Ask a chemist to explain how cakes rise. Look for the effect of baking powder. Experiment with the effect of different amounts of baking powder on the volume of the cake.

→ **Group 7:** Ask a mathematician to help you measure the volume of the cakes and to identify suitable quantities.

→ **Group 8:** Ask both a biologist and chemist to explain the stiffening of egg whites.

Experiment with different factors influencing the stability of the white of eggs (the ways of mixing, the additives, etc....)



Conditions:

Framework: During school lessons

Age of the pupils: 14–16 years

Duration: 16 lessons (It is recommended that each meeting should last for two successive lessons.)

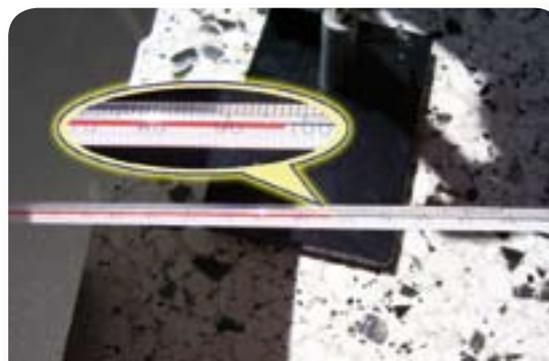
Materials: Glass, a box of polystyrene, black watercolour, thermometer, pottery clay.

Expected effects:

This interdisciplinary project will give the pupils a global view about complex topics. It will increase their sensitivity and awareness for environmental problems and gives the opportunity to deal with practical problems. This approach should stimulate and increase different competences of the pupils because it requires different kinds of intelligence. The acquired competences might be transferable to other situations at a later stage.

Extract of a pupil's report

"The 14th of May was a sunny day. The temperature was 29–31°C. We started at 11:30. Someone brought the dough that he had prepared at home, we cut it into thin pieces and put them on a griddle. At 11:50, we place the oven under the sun for pre-heating. After 10 minutes, we put the pieces of dough into the oven. When the temperature had stabilised at 82°C, we used a mirror to send more solar radiation into the furnace and a few minutes later we added two more mirrors. After that, the temperature increased to 98°C! At 12:35, we removed the mirrors and a few minutes later we tasted some delicious cookies."



Another very interesting and multifaceted project is

“THINK & BUILD BRIDGES” by Linda Giannini (1) and Carlo Nati (2)

(1) Teacher, calip@mbox.panservice.it

(2) Teacher and supervising teacher training students specialising in Art and Design at SSIS, Università del Lazio, carlo.nati@istruzione.it

They have carried out very interesting interdisciplinary experiments about 'BRIDGES' with pupils of different ages. A detailed description is available on:

http://www.descrittiva.it/calip/0708/teaching_science_in_europe_II.htm

<http://www.descrittiva.it/calip/0708/mappa-bridge/index.html>

Self-perception and Self-evaluation

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Models, Mirrors, Learning Environments, Glasses Tools for successful science teaching

1

Ideas from the workshop addressing a difficult issue

1.1 Models

Models of good practice are an essential precondition for formal teaching. On the one hand, they are provided by the government (teacher training, directives, curricula), are allegedly based on didactically and methodically valid findings of academic research (guidelines based on general pedagogy, subject didactics and input from universities) and in terms of advanced professional daily routine ultimately exist in a highly differentiated form in teachers' minds – often without further reflection and mostly inaccessible. These models – so-called “secret curricula” – are normally the most powerful guidelines for any activity in the school environment.

A great many models, rules and manuals are available to support good teaching practice in general and good practice in science teaching in particular. In the following, the chapter 'Models' is going to present an

example from the workshop, providing a comprehensive checklist to scrutinise habitual routines and to readjust them.

However, in teaching practice, it does not seem sufficient to celebrate excellent regulations based on models. Many exemplary models fail when adopted for one's own



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Self-perception and Self-evaluation

teaching practice, if instruments capturing the effects in the actual learning situations are not used or if there is a general lack of insight into one's own thinking preferences and their impacts.

Evaluation is highly necessary.

1.2 Mirrors

Evaluation takes place through mirrors. Direct mirrors are the individuals or learning groups facing the teacher every day. Indirect mirrors can be feedback from evaluated surveys (local questionnaires, supraregional studies such as TIMSS or PISA).

The authors have monitored classroom activity over many years and reached the conclusion that evaluation seems to be particularly necessary for science teachers. Even the enthusiasm teachers express for their subject or a particular topic is generally not automatically transferred to the learning group to the extent that would be desirable if the subject is stigmatised as being highly difficult. In many cases, the three didactic qualities appropriateness, subject suitability and accessibility of a particular topic are perceived as sufficient evidence for successful teaching.



by Ruth Koser-Michaels
from "Märchen der
Brüder Grimm",
Droemer Knauer Verlag
München

When mirroring activity, it is important to consider "who" the mirrors are. In the case of the individuals in the learning group, the allocation of the different types of intelligence (see for example H. Gardner) has to be taken into consideration.

LITERATURE:

Howard Gardner, "Intelligenzen. Die Vielfalt des menschlichen Geistes", Publisher: Klett-Cotta, Stuttgart 2002, ISBN 3-608-94263-7 (German edition)

Howard Gardner, "Intelligence Reframed. Multiple Intelligences for the 21st Century", Basic Books, New York 1999, ISBN 0-465-02611-7 (English edition)



1.3 Learning environments

It is exactly the multiplicity of intelligences that obstructs interviewing the learning groups and ensuring the validity of interviews with adolescents is a very complex task. Therefore, it was

discussed within the workshop how incorporating multiple intelligences can support a teacher in designing learning environments like maps, providing the necessary large variety of diverse learning approaches for individual- and self-directed learning. This will improve the quality of the feedback from the learning group.

1.4 Glasses

Scientists also know that perception is a constructive process in the human brain. What we "see" is in our head and we also "see" through the glasses of our psyche as a whole, which has evolved and still evolves through a large number of external and internal influencing factors.

Thus, the perception of our own actions and activities – our self-perception – is essentially influenced by "how we tick". In order to evaluate our self-perception, a toolkit to inform us about our preferred styles of thinking as objectively as possible is required. Only if we know what we prefer and what we want to avoid, we can find a way to overcome "home-made" barricades that interfere with our thinking. And what is particularly remarkable in this context – we can



gain access to the wide range of intelligences within the individual learning groups (see also H.Gardner).

Innumerable amounts of questionnaires for self-evaluation and external evaluation are provided and used by teacher training centres and universities.

(Examples from the workshop are available at: www.science-on-stage.de.)

In the course of the workshop, the method based on *Ned Herrmann* – less well-known in teacher circles – was introduced in more detail.

The aforementioned tools to evaluate one's own science teaching – with the aim to further its quality – are interdependent. Deriving a model of "good teaching practice" is already a process creating a consensus between individuals who cooperate more or less – those who "wear glasses" as it were. Ideally, a successful outcome of this process is achieved through multi-level regress. In reality, the process is often shortened through settings influenced by educational policies – quite frequently bypassed by teachers' individual approaches in the classroom.

It seems consistent that the application of methods (including checklists) and evaluations lead to a greater – if not the decisive – benefit for our own actions, if we are aware of our own preferences in terms of thinking and acting. The method of self-perception introduced in the workshop is described in a few words. Subsequently, we think that the reader is better prepared to relate the described "learning environments" and "models" to his/her own script for his/her teaching.

2

Self-perception

Brain dominance model – Ned Herrmann

Thinking styles in schools

The following text refers to a small programme which enables simple and fast access to our own thinking preferences as based on Ned Herrmann's brain dominance model. You can access it at:

www.mic-net.de (Button: Denk-Stil-Test).

Classroom teaching is pure communication between me (the teacher) and my pupils. Yet do we have the same access to the facts I want to convey? Do all the pupils understand my personal teaching style? A certain amount of doubt is appropriate in this context. Sometimes I notice that I cannot reach a particular pupil with my way of teaching, yet he/she would actually like to learn something. We 'tick' differently – I in terms of my presentation and he/she in terms of the reception.

The following instructions can contribute to a better understanding between teacher and learners by enabling them to adjust to their respective styles of thinking, acting, teaching and learning to one another.

How can we achieve this? The "Herrmann Dominance Model" helps everybody to achieve a better understanding of the self and to be sensitive to the receptiveness of the individual pupil, because 'communicating' as the basic requirement for pedagogic effectiveness normally presupposes that I know how I 'tick' and that I have a sense of how the 'recipient' of my teaching ticks.



Ned Herrmann

In the 1970s, Ned Herrmann, an US American of German origin who was head of personnel at General Electric at the time, developed an analysis system that enabled him to assign employees jobs that were suited to them, achieving a high level of contentment with the job among the staff as well as optimum productivity for the group.

He was successful and nowadays, his concept is used globally and in many different areas.

Ned Herrmann based his model on research results in brain physiology available at the time. The brain model applied by him, which is described in a very shortened version here, is so easily applicable to everyday life that it has proven to be very 'handy' for many different areas where thinking, acting, communicating, intuition and of course learning and thus teaching are concerned.

The basic concept of this model, and one which is still in use worldwide today, is the allocation of the many functions of our brain to four different classes called A,B,C and D and colour-coded as follows

A: blue

B: green

C: red

D: yellow

Many other models allow us to arrange our brain functions physiologically and psychologically. Ned Herrmann's dominance model seems to us to be the simplest and most practical approach. It does not provide any information about the "Truth about your brain", etc. Yet it facilitates an impulse to think about the self and our forms of interaction with others which has frequently been tried and tested successfully.

Details:

A („blue“):

Thinks analytically, does not engage with anything that is not "explainable". A relies on figures and facts. On this basis, A feels secure to act. A generally perceives "psychobabble" as negative, but accepts it if based on unequivocal research results.

"Hang on ... ?!", A would reply if confronted with moods or opinions rather than facts. As a rule, A would then ask for figures and key data to provide orientation for his/her decision-making.

B („green“):

Security and order are important for B, who therefore avoids risks. B is cautious and puts quite a lot of effort into achieving clarity about a particular situation. "Yes, and what is the point of all that ...?" B would ask, or "... how is this going to be funded?"

C („red“):

C is communicative! C cultivates friendships, might play music with others, likes going out, enjoys meeting new people and signs contracts because the sales representative is nice – yet not before having consulted with friends. "Oh, we can do that ..." says C and at a party, C is an absolute hit.

D („yellow“):

D constantly has fascinating ideas, which are pursued without shying away from any risks – yet D is less concerned with the implementation in everyday life. D tends to follow spontaneous associations rather than formal logic. When shopping, D follows his/her creative impulse. As a project manager, we can hear D say "...great, we can do that!" or "...that will definitely work!"

Now which of these four thinking styles is mine? The answer: **All four!** According to this model, as human beings we can access a mix of all four “quadrants” in our brain, which are consequently also all active in our thoughts, actions, learning and teaching. But: The “dominance” of these four quadrants varies, which means that some of us think more in B-terms, others are more determined by the D-quadrant, etc..

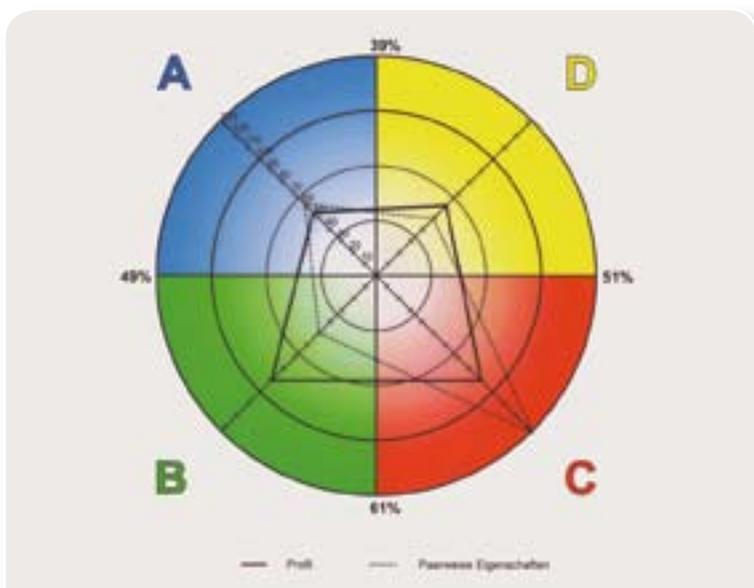
It is exciting to observe how people with different “dominances” interact. This is a particular challenge and opportunity for pedagogues as it is their goal to reach young people. If a pupil is an A-type how do I, a D-type, reach this human being?

In adult education, this question of addressing differently dominated types is essential for the transfer of knowledge, ability and will.

The answer to the question of whether I have an A, B, C or D dominance may set important priorities in my teaching style.

The test on www.mic-net.de can give you an idea about your own “dominance – whether it is A, B, C or D. Yet the test result is only a rough “profile” of your thinking, acting or teaching. A professional analysis – internationally tried and tested in thousands of cases – is available from HERRMANN INTERNATIONAL DEUTSCHLAND, www.hbdi.de.

Example of a professional HBDI Profile



One aspect is very important in this context: Your dominances (more A, more B, more C, more D) reveal to you that your teaching is 'dominant' in a way that might have direct appeal for some of your pupils, yet reaches others with greater difficulty. You are sending on one 'channel', while the recipient might expect a very different frequency: You send 'blue' – your pupil receives on 'yellow'. – As pedagogues, we ought to be sensitive to this kind of our sending and the recipient condition – often full of expectation – of the learner entrusted to us.

Self-evaluation and developing our sensitivity for the receptiveness of learners is the aim of the test.

→ Short instructions for the “Thinking Styles Test“:

For different situations, four responses in line with the basic positions according to Herrmann are available, illustrated in the respective colours. With your scoring (between 0 and 40) you decide to what extent you can identify with the individual descriptions.

10 sets of questions with four responses are available. You decide which ones are most important for you and skip the others. However, you should evaluate at least eight groups of questions. You can 'cheat' as much as you like – while you may have some superficial fun, you will not gain any really interesting insights.

In order to be able to do the test, the Java plug-in of your internet browser has to be installed and Java has to be activated. If your browser tries to prevent the test window from opening with the pop-up blocker, you can deactivate it for the duration of the test. Once you have extracted hints about your profile of thinking, acting and teaching from the 'target', a particular 'dominance might be apparent. In the light of your personal test result, please treat yourself to reading the distinctive features of the four 'quadrants. Subsequently, you may want to think about a possible profile of one of your pupils.

The test can be considered successful if another aspect of communication between you and your pupils has made you an even more sensitive teacher.

Learning environments and research assignment

3

A typical learning group can be outlined as follows:

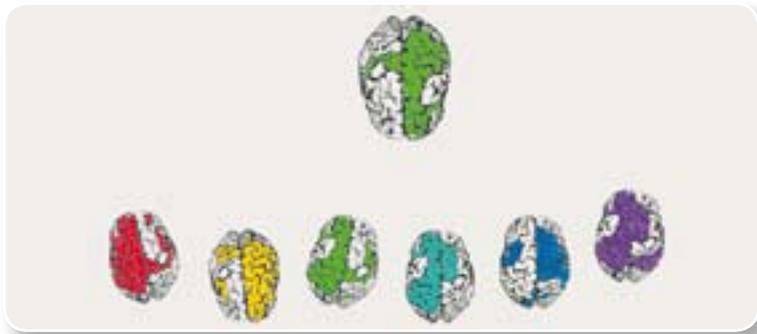
A completely normal classroom situation:

- Richard Feynman
- Colin Powell
- Stefan Effenberg
- Karol Woytila
- Nena
- Richard v. Weizsäcker
- Jane Goodall
- Wolfgang Welz
- J.K. Rowling



Imagine the teacher talking with great enthusiasm about the Law of Free Fall or experimenting with the Law of the Lever.

In a slightly abstract representation, the "thinking machines" of the teaching- and learning groups may present the following image:



Every teacher knows the situation:

The learners' brains are all active, but – in a symbolic representation – only one actively "follows", whereas the others are busy with different ideas – more or less close to the topic presented by the teacher.

Statistically speaking, the teacher only reaches a few of the learners with his / her topic in a standard classroom situation. Those pupils are

the few who might also turn towards science later in life. Unfortunately, this establishes a very undesirable effect: The learner depicted as following the teacher corresponds with the teacher's way of thinking. Should he / she become a teacher in the future, this experience will dominate his / her behaviour – "the way I think is right". The others – undoubtedly also intelligent individuals – are often shaped by experiencing a feeling of incompetence, because their access to the world was not adequately presented to them. Many studies have confirmed this perception.

It is important to break down this form of passing on knowledge. Above all, each of the brains assembled in the classroom requires an appropriate access to different subjects. The keyword "individualisation of learning" describes this mission all European education systems are currently pursuing.

Theoretically, it would be possible now to compile a profile of each pupil's thinking preference, which would require an enormous effort and would only provide very rough guidelines for the preparation of learning matters. It seems more efficient to involve the learners themselves in the process of the individual selection of their learning path.

One elegant method is a broad formulation of classroom topics in the format of **research assignments**. A "letter from a Pharaoh" for example, which still needs to be translated, reaches the learning group with the request to help building the pyramids. All questions of mechanics still need to be clarified – from arranging transport without a wheel in sand to the advantages of using levers, inclined planes and pulleys. The issue of remuneration (work, performance) or identifying how hundreds of workers can shift an ashlar by adjusting their movements to the rhythms of a song are other questions that might come up.

You can find this and other very motivating examples – all tried and tested in the classroom – on the website www.science-on-stage.de.

First and foremost, we need to be aware that it is essential to ensure that a learning group gifted with multiple intelligences is provided with as many learning paths and access opportunities as possible.

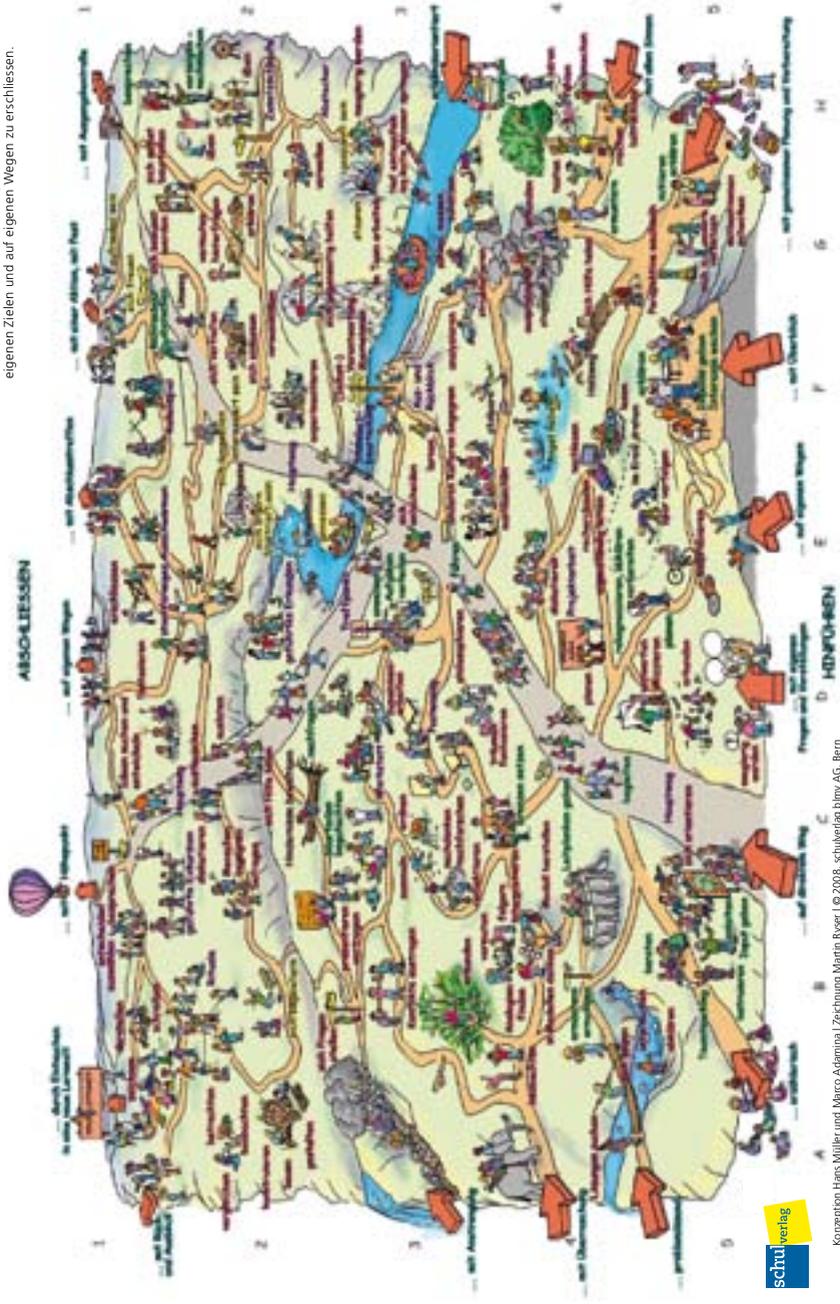
A poster of the *Berner Lehrmittel- und Medienverlag* (see following page) is inspiring and helpful. It can be downloaded from www.nmm.ch

LERNEN UND LEHREN

Element des Grundlagenbuchs «Lernwelten Natur-Mensch-Mitwelt»

Lernen heisst: Zugang finden zu verschiedenen (thematischen) Lernwelten, auf verschiedenen Wegen Bekanntem begegnen, Neues erkunden und entdecken, sich in diesen Welten orientieren.

Lehren heisst: Lernwege in diese Welten vorbereiten, die Lernenden auf ihren Wegen begleiten, sie instruieren und anleiten, aber auch ermutigen, andere Welten mit eigenen Zielen und auf eigenen Wegen zu erschliessen.



Konzeption Hans Müller und Marco Adamina | Zeichnung Martin Ryser | © 2008, schulverlag bmv AG, Bern

schulverlag

4

Models for good practice in science teaching



Subject teachers undoubtedly play a central role in the further development of teaching science in Europe. The following questions are of interest in this context:

- What is the professional competence of the teachers?
- What are their goals in subject teaching?
- Which of these goals can be realised and which methods are used to achieve the goals?
- Which contents ultimately reach the pupils?

Can we make any concrete practical recommendations for science teachers, enabling them to enhance their professional approach and thus the quality of their teaching approach?

There are gaps in the systematically obtained "knowledge about science teachers". General studies from a pedagogical point of view exist, yet in Europe only few empirical data about a necessary or at least ideal *professional competence of science teachers* exist.

The Swiss pedagogue *Hans Aebli* spoke of teaching as an art: "To observe a good teacher at work is as beautiful as watching a violin maker". When asked what makes a good teacher, pupils often reply with the following: "He/She is fair", "explains well, in an understandable manner and with a lot of patience", "can take a joke and has a sense of humour", "enjoys his/her subject", "can admit to own mistakes", "shows interest in our problems", "is a good listener" or "demonstrates the benefits of specialist knowledge of a subject".

It seems to be so easy – yet in practice only very few teachers achieve this.

Hilbert Meyer listed the following 10 "aspects of good teaching practice", which can be very useful for planning and realising your teaching in the classroom:

- 1. Clear structuring of the teaching process:** Clarity about processes, goals and content; clarity of roles, agreement of rules, rituals and personal spaces
- 2. High level of real learning time:** Achieved through efficient time management, punctuality, outsourcing of organisational aspects; rhythmisation of the daily routine
- 3. Creation of an environment conducive to learning:** Through mutual respect, reliable observation of rules, adoption of responsibility, fairness and care
- 4. Clarity of content:** Through clear formulation of tasks, monitoring of the learning process, plausibility of thematic developments, clear and binding formats to secure results
- 5. Meaningful communication:** Through involvement in the planning process, a culture of discussion, conferences for pupils, learning diaries and learner feedback
- 6. Diversity of methods:** Diverse "stage-management"; diverse activity patterns; variability of progress and balancing of teaching formats
- 7. Individual support:** Through personal spaces, patience and time, internal differentiation and integration; through individual analyses of skill levels and co-ordinated learning support plans, special support for pupils from risk groups
- 8. Intelligent exercises:** Through conscious use of learning strategies, accurate fit of exercises, variation of methods and references to practical applications
- 9. Clear performance expectations:** Through adaptation and transparency, clear feedback (fair and timely)
- 10. Appropriately prepared environment:** Reliable order, skilful arrangement of the classroom, space for movements and aesthetics of interior design

Beyond all these general, subject-independent key qualifications, additional competences in terms of subject didactics are required which can be of parti-

cular significance for science teachers, enabling long-term professional success and satisfaction (according to A. Müller):

The professional science teaching expert in practice is characterised by the following:

When imparting knowledge in the scientific subject

- Highlights fundamental questions and concepts of the subject.
- Incorporates concepts of history and the philosophy of science.
- Is informed about new research methods and technologies.
- Establishes references from the respective subject contents to higher-ranking aspects of education, for example to views of the world, references to everyday life, to the environment, social impacts, etc.
- Establishes references between the respective subject contents to their technical application and to their social impact.
- Perceives the qualitative interpretation of scientific contents as a major element of his / her teaching.
- Ensures the correct use of specialist terminology when necessary.
- Looks for links with other disciplines when teaching subject topics.

When teaching scientific methods of cognition and work methods

- Incorporates fundamental theoretic approaches and methods of the subject, for example induction, deduction, idealisation, approximation, and error analysis, formulation of hypotheses, analogies and models into his / her teaching.
- Points out the role of mathematical description as an essential "formal terminology of the subject" and demonstrates the benefits of an abstract, formalised description of natural and technical phenomena through examples.
- Incorporates fundamental empirical approaches and methods of the subject, for example observation, experimentation, classification, assessments, measurements, storage, description and interpretation of data, development and verification of hypotheses and models.



- Competently uses his / her knowledge and skills in experimentation and the operation of media, always observing safety regulations.
- Clarifies the interplay of theory and experiment through suitable examples.
- Independently sources and uses information and literature related to the subject.

Uses his / her didactical expertise in a subject by

- Planning his / her teaching according to one (or several) didactical model(s) appropriate for the subject.
- Focusing on specific topics, enabling him / her to allocate more time to these topics than envisaged in the curriculum.
- Considering the pupils' ideas and already formed knowledge structures, difficulties in understanding and typical sources of errors.
- Using topic-specific, suitable strategies to motivate the pupils and awaken their interest, for example by relating his / her teaching to the pupils' reality, through experiments and autonomous tasks.
- Considering gender-specific differences in the pupils' interests.
- Incorporating research results in didactics and the psychology of learning relevant to his / her subject.
- Using didactic literature and internet sources relevant to his / her subject.

When planning and designing scientific learning processes:

- Finds a suitable language to describe subject contents.
- Uses didactical reduction, elementarisation and visualisation for complex and abstract facts – suitable for the respective age groups.
- Uses media to activate and build on the pupils' previous experience and knowledge.
- Introduces new learning contents through background stories or problems from everyday life.
- Raises awareness among the pupils that they can experience science with their own bodies.

- Plans structured teaching at an adequate level of specialisation, with the emphasis on cumulation and sustainability.
- Plans and designs learning environments for self-directed learning in the subject, e.g. projects, learning stations, individualised learning, etc.
- Adequately uses specialist media, for example teaching materials, presentation media, information systems, etc. Includes extracurricular learning sites in the planning process.
- Encourages the use of specialist terminology, for example by working with authentic texts and by creating opportunities for using in the specialist terminology in the classroom.

When experimenting

- Selects experiments suitable for specific learning objectives and targeted towards the different pupils' learning needs.
- Ensures that demonstration experiments are set up clearly.
- Sets up experiments efficiently and in a targeted manner
- Finds sources of errors in the experiment and overcomes practical difficulties quickly.
- Adequately evaluates and secures results.
- Uses experiments developed by the pupils.
- Uses freehand experiments – including "everyday objects" – and develops impressive settings.
- Gives experiments or tasks related to school experiments as homework.
- Uses standard measuring methods of basic scientific variables.
- Includes pupils in demonstration experiments, for example by using them as assistants or through discussions in class.
- Observes the laboratory- and safety regulations
- Incorporates computer-aided experiments, for example capturing measured data, processing and visualisation, simulation or modelling systems.
- Uses relevant literature and internet sources for experiments.

- Uses experiments for different specialist functions, for example to formulate hypotheses and to verify them qualitatively, semiquantitatively and quantitatively and for data collection.
- Uses experiments with various didactical functions – for example motivation, visualisation, development of a physical law, confirmation, practical application, etc.



To foster a task culture

Tasks are used

- To overcome typical perceptions of pupils, difficulties in understanding and errors.
- To secure basic knowledge.
- To build up routines.
- To build up vertical links, for example through repetition in a new context, widening of the terminology.
- To establish horizontal links, for example through interdisciplinary applications.
- To support girls and boys in their learning.
- To foster cooperation between female and male pupils.
- To foster independent and responsible learning.
- To foster the ability to solve problems and the pupils' creativity
- To encourage pupils to work on open assignments or projects.
- To foster the ability to observe.
- To encourage the application in everyday situations.
- To establish references to professional life.
- To practise scientific ways of thinking and working.
- To practise independent problem analysis and planning of possible solutions.
- To select, comprehend, evaluate and process information from various media.
- To develop hypotheses or prognoses as well as experiments for their verification.
- To practise specialist argument patterns in the subject, for example through scientific concepts and principles.
- In combination with experiments that will be marked.

The professional science teaching expert shows his / her convictions and views in practice as follows:



Handles the complexity of teaching situations by

- Using a broad range of teaching methods.
- Using and also combining different presentation formats, for example real, linguistic, graphic or mathematical.
- Reacting with flexibility to different situations, relating to the different levels of subject knowledge and the different experiences, perceptions and views of the pupils.
- Being sufficiently responsive to subject-related questions from pupils.
- Asking for subject-specific reasoning from the pupils.
- Finding appropriate explanations and answers when balancing between formal correctness in the subject and relative simplification for the benefit of the pupils in teaching situations.
- Showing a didactically and personally adequate approach to dealing with mistakes.
- Realising a discussion format that fosters learning and gradually developing the necessary specialist terminology from common language.

Achieves sustainable and independent learning by

- Requesting a high level of autonomy and own initiative from the pupils (particularly for their own experiments) in his / her teaching.
- Clarifying the importance of specialist knowledge for the pupils through real-life situations.
- Creating meaningful opportunities to secure and deepen knowledge – for example through repetition and practice, structuring and networking, transfer and application.
- Incorporating opportunities to acquire and practise subject-related learning strategies.

Uses subject-specific diagnosis- and evaluation techniques and

- Uncovers difficulties in understanding and wrong perceptions of pupils and is able to react to them.
- Creates opportunities to learn from mistakes in the subject.

- Uses diagnosis- and feedback techniques to support the pupils and to enhance the quality of teaching.
- Uses subject-specific forms of performance measurement and evaluation.
- Uses different task formats for a targeted and differentiated support of the pupils' learning process.

To develop his/her role as a subject teacher, he/she

- Uses various opportunities for further training in the specialist subject and in subject didactics.
- Points out the meaningfulness and significance of science education – also at a personal level – e.g. through examples in class, personal commitment and noticeable identification with the subject.
- Points out the enrichment of other disciplines through this particular discipline.
- Reflects his/her own professional actions in a constructive and self-critical manner.
- Personally expresses commitment and identification in a way that is appropriate for the subject matter and the respective situation to spark the pupils' interest in the subject.
- Spends sufficient time outside of the classroom to minimise the distance between the pupils and natural sciences.
- Demonstrates that natural sciences can be fun.

Emphasises the following eight individual attitudes as the basis for the development of a "general scientific attitude" in his pupils (G. Schäfer):

- Honesty (sincerity, truthfulness)
- Accuracy (precision)
- Amazement (admiration, respect for and love of nature)
- Inquisitiveness (with regard to nature)
- Rationality (reasonable behaviour)
- Objectivity (factual approach)
- Judgement based on facts (empirical approach)
- Propensity for abstraction (inclination to formalise)

LITERATURE:

Meyer, H.: "Was ist guter Unterricht?" Cornelsen Verlag Scriptor GmbH & Co. KG, Berlin 2004
 Müller, A.: "Instrument NaWiKomp", Koblenz University, Landau, 2006
 Schaefer, G. (Editor): "Allgemeinbildung durch Naturwissenschaften", Memorandum of the GDNÄ-Bildungskommission 2002 + Amendment 2007, Aulis Verlag Deubner 2007

Overview of activities

Project events

2006

22nd–24th September

Kick off meeting at the Science Center “phaeno” in Wolfsburg (Germany)

2007

02nd–06th April

Follow-up meeting within the European festival “Science on Stage” in Grenoble (France)

14th–16th September

Follow-up meeting within the education conference “EduNetwork 07” at the Hasso-Plattner-Institut in Potsdam (Germany)

2008

23rd–26th October

Presentation on the national Science on Stage festival in the Urania in Berlin (Germany)



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Overview of activities:
Project events
Participants

Feedback Questionnaire



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Annex

Participants

Working groups – topics:

A = Science in Kindergarten and Primary School,

B = Interdisciplinary Teaching,

C = Self-Perception and Self-Evaluation

| | NAME | FIRST NAME | COUNTRY | TOPIC |
|----|-------------------------|--------------|-------------|---------------|
| Ms | Alemany | Miralpeix | Spain | A |
| Ms | Asmussen | Corinna | Germany | A |
| Mr | Bach | Holger | Germany | B |
| Ms | Barthel | Hannelore | Germany | B |
| Ms | Baumgardt | Eva-Maria | Germany | A |
| Mr | Bechert | Jan | Germany | A |
| Ms | Beer | Mareike | Germany | A |
| Ms | Bernard Garcés | Elisa | Spain | B |
| Mr | Birkhahn | Jörn | Germany | A |
| Ms | Blasco | Gloria | Spain | A |
| Mr | Brozzo | Walter | Germany | A |
| Mr | Brzezinka | Grzegorz | Poland | A |
| Ms | Chicinas | Luminita | Romania | C |
| Mr | Chicinas | René | Netherlands | C |
| Mr | Chydzinski | Marcin | Poland | A |
| Mr | Constantinescu | Dragos | Romania | A |
| Mr | Constantinos | Constantinou | Cyprus | A |
| Mr | Cunningham | Noel | Ireland | C |
| Ms | Curtis | Amanda | UK | A |
| Mr | Daman | Pascal | Luxembourg | B Coordinator |
| Ms | De Masi | Ernesta | Italy | B |
| Mr | De Sanctis | Adolfo | Italy | B |
| Ms | Dobkowska | Maria | Poland | B |
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