



ENGLISH



Teaching Science in Europe 3

*What European teachers
can learn from each other*

SCIENCE  ON STAGE
GERMANY

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Teaching Science in Europe 3

What European teachers can learn from each other

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





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Opportunities for all temperaments and talents



It has been ten years since the great kick-off in Geneva in 2000 to a series of five big European symposia of science teaching and learning. Yet the debate

about the problems of teaching and the search for pioneering solutions in didactics and methods still remains high on the agenda of the European teachers from 27 European countries, who have been meeting since (and continue to do so) on the Science on Stage platform.

In their exchange of good practice examples, they focus on the construction of learning landscapes (see picture). This is a concept that allows teachers and learners of all temperaments and talents an enriching learning experience and successful teaching, while it also enhances as well as sustains the quality of the lessons and their results.

At the Science on Stage festival in Berlin in the autumn of 2008, workshops on three central topics took centre stage:

- Science in kindergarten and primary school
- Benefits of non-formal education initiatives
- Moderation of learning science.



Learning landscapes, multiple ways of learning for multiple intelligences.

Taken from the project: Focus on Teachers – Flow in science teaching, Authors: Jutta Felten, Wolfgang Welz; see also: www.mic-campus.de (keyword: CaTT)

With this report, the 55 participants from 12 countries – having attended a total of four Science on Stage meetings within one year – are now drawing provisional conclusions from their intense research and discussions [See attachment for dates and participants].

“Provisional” means that this work – as all educational processes in general – is not finished. Therefore the presented results partly resemble minutes or interim reports. Different views and strategies, especially those rooted in cultural differences, were to be analysed and assessed with regard to their potential to help solving problems experienced when teaching. The focus on the process itself was to help participants to benefit not only by collecting material but also by experiencing right and wrong tracks at the meta level. The participants of the workshops are the protagonists who spread the ideas and concepts in their own countries and within their own teaching structures.

Two questions are asked occasionally: “What is Science on Stage and what does it do?” and “Does the non-profit organisation Science on Stage Deutschland e.V. achieve its own goals?”

Dr. Eleanor Hayes, editor in chief of the magazine “Science in School” (published throughout Europe), enlightens us on the first question by

taking a look at Science on Stage and its development as an outside observer.

The second question is answered in an external evaluation, which Tanja Tajmel from the Humboldt University of Berlin conducted at the Science on Stage festival 2008 in Berlin. A summary of the results of this evaluation will be presented here – the full version in German can be downloaded from the website of Science on Stage Deutschland e.V.

To offer sustainable opportunities for all temperaments and talents is the joint aim of all European actors on the Science on Stage platform. However, sustainability is no self-preserving state. Sustainability is – as the origin of the term in forestry implies – a process that has to be fostered. And this is hard work!

The organiser would particularly like to thank all participants for their high level of commitment and wishes all teachers a lot of joy, fulfilment and success in their work.

We would also like to encourage our readers to take part in the continual dialogue by using the feedback form in the appendix of this book.

The events and the dissemination of the results would not have been possible without the generous support of the Robert Bosch Foundation, the Siemens Foundation and THINK ING., an initiative of the German association of metal and electrical industry employers. All participants and the organiser are extremely grateful for this support!

DR. WOLFGANG WELZ

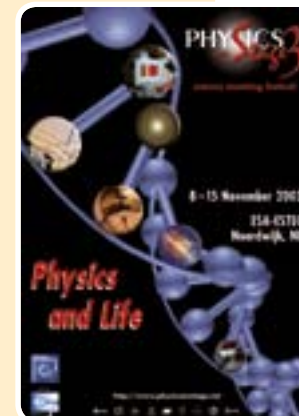
Chair Science on Stage Deutschland e.V.

Chair Executive Board Science on Stage Europe

Science on Stage: heading for a country near you

How better to inspire thousands of schoolchildren across Europe than by motivating and educating their teachers? As **ELEANOR HAYES** explains, that is the idea behind Science on Stage – a network of local, national and international events for teachers.

Initially launched in 1999 as Physics on Stage, it was the brainchild of EIROforum (w1), the publisher of *Science in School*, and received financial support from the European Commission. In 2005, the initiative was broadened to cover all sciences and renamed Science on Stage, but the format remained essentially unchanged. National representatives organised competitions, science fairs and festivals, to identify innovative teachers and teaching activities, encourage the improvement of national education systems and establish a European community of science teachers keen to share and exchange their best teaching ideas. The size of the national activities varied – some were quite small, while the Spanish Ciencia en Acción event (w2) involved several thousand people. A number of lucky teachers from each country were then selected to attend the international festival hosted by one of the EIROforum organisations – a chance to exchange teaching ideas with 500 colleagues from more than 27 countries, attend lectures by leading scientists, take part in workshops, visit world-class research facilities and enjoy the on-stage science shows.



Most importantly, participants from the international festival then took the ideas and experience back to their own countries to share with their colleagues – sending ripples of inspiration across Europe. One of the collaborations that emerged was between the UK and



Malta: chemistry teacher Tim Harrison has made several trips to this Mediterranean archipelago to perform dramatic chemistry shows in front of thousands of school students and their teachers. Didier

Robbes from the University of Caen, France, found Italian partners to set up an education company based on his electromagnetism project. And there has been much activity at the national level too: Science on Stage Belgium and Science on Stage Austria e.V., for example, have presented their activities at a range of conferences and events, both for teachers and the general public (see Furtado & Rau, 2009).

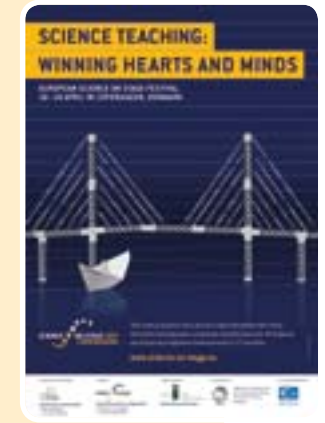


In 2008, the contract with the European Commission – and thus the financial support – ran out, but the enthusiasm and commitment of the national organisers continued. In some countries, the national events had gained so much momentum that it was clear they would continue, even without the lure of an international festival. Nonetheless, it was recognised that the international festival – with the chance to swap ideas and experience with teachers from across Europe – was an intrinsic part of Science on Stage.

The German national organisers (w3) took the initiative, therefore, to plan an international Science on Stage festival in October 2008, with substantial sponsorship from THINK ING (w4). Two hundred and fifty European teachers flocked to Berlin to share their teaching projects and experiments, discuss innovative methods in workshops and round tables, attend scientific talks and stage performances, and visit Berlin's research institutes. Thus was born the idea that the national organisers should pass the Science on Stage flame from one to the other, competing to host the international festival every two years.

With this in mind, representatives from 18 European countries met on 22–23 October 2009 in Berlin to establish Science on Stage Europe

(w5), and to decide which country should have the honour – and the responsibility – of hosting the next international festival. The national organisers from Austria, Malta and Poland made excellent bids, but the final vote went to Denmark. With generous financial support from the Danish Education Ministry, the fourth Science on Stage international festival will take place on 16–19 April 2011 in Copenhagen.



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WEB REFERENCES

- w1 – EIROforum – the publisher of *Science in School* – is a partnership of seven European inter-governmental research organisations. For more information, see: www.euroforum.org
- w2 – Ciencia en Acción is the Spanish Science on Stage organisation. See: www.cienciaenaccion.org
- w3 – To learn more about Science on Stage Germany, see: www.science-on-stage.de
- w4 – THINK ING is an initiative of the German Association of Metal and Electrical Industry Employers. To learn more, see: www.think-ing.de
- w5 – To learn more about Science on Stage and find your national contact, see the Science on Stage Europe website: www.science-on-stage.eu

RESOURCES

Teaching materials, photographs and much more information about previous festivals is available here: www.science-on-stage.net





For more information about previous Science on Stage activities, see the following *Science in School* articles:

Capellas M (2007) Science teaching flies high at Science on Stage 2. *Science in School* 5: 10–11. www.scienceinschool.org/2007/issue5/sos

Furtado S (2009) Science on Stage: recent international events. *Science in School* 11: 11–14.

www.scienceinschool.org/2009/issue11/sos

Hayes E (2007) Awards, rewards – and onwards! *Science in School* 5: 12–14.

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Hayes E (2008) Science on Stage: recent activities. *Science in School* 10: 4–7.

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Dr. Eleanor Hayes is the Editor-in-Chief of *Science in School*.

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Hayes E (2009) Science on Stage: heading for a country near you. *Science in School* 13: 2–3. www.scienceinschool.org/2009/issue13/sos.

To learn more about the journal, read articles online in many languages or subscribe to the free print journal, visit:

www.scienceinschool.org.

Summary of the evaluation of the Science on Stage Festival 2008 in Berlin

THE EVALUATION WAS PREPARED BY MS. TANJA TAJMEL,
HUMBOLDT UNIVERSITY BERLIN

The evaluation shows that Science on Stage has great strengths in the exchange between teachers. Teachers who take part in Science on Stage can be characterised as follows:

- They develop own ideas to improve their lessons.
- They are highly motivated to present, to discuss and to distribute these ideas.
- They are looking for new teaching ideas that they want to adopt for their lessons.

For the teachers, the opportunity to appear as experts presenting their own ideas is the greatest strength of Science on Stage. This is – as the post-test proves – the highest aspect of motivation to participate. It has been stated by the participants as a fundamental difference to other teacher trainings. Science on Stage covers the teachers' need for this kind of exchange and discussion to a very high degree. Accordingly, there is a distinctive wish to have enough space to present the projects and to have enough time to visit the fair.

The key aspect of Science on Stage can be found in the category "person teacher". Science on Stage highly supports and strengthens the self-conception of the teachers, the identification with their own profession and the subject and the enjoyment of the profession. It can be supposed that this could impact positively on the quality of the lesson.

The main question for the evaluation has been if there are certain key aspects and to what degree the key aspects can be found in the analysis. Against this background, Science on Stage can be evaluated as very successful since it covers one of three key aspects almost





entirely (categories: improvement of lesson, improvement of knowledge and “person teacher”).

It is less important for the participants to be involved in a competition and to win a prize. For the participants, the festival is not a competitive event but firstly an opportunity for exchange.

Strengths and weaknesses of Science on Stage can be summarised as follows:

Strengths	Weaknesses (or little importance)
<ul style="list-style-type: none"> → New experiments and new teaching topics → Teaching in other countries → Fun and enjoyment in the lessons 	<ul style="list-style-type: none"> → Context of everyday life → Science as part of the culture
<p>SPECIAL STRENGTHS:</p> <ul style="list-style-type: none"> → Opportunity to share experiences with colleagues → Identification with one's profession → Opportunity to present a project → Exchange of knowledge among teachers in Europe → Ideas for hands-on experiments 	<p>LITTLE IMPORTANCE:</p> <ul style="list-style-type: none"> → Assessment methods → Teaching and learning methods → Competition and the possibility to win a prize → Opportunity to be on stage

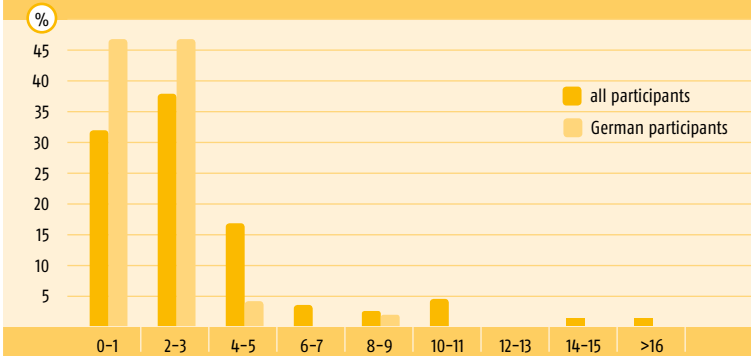
International aspect

About 38% of all Science on Stage participants (respectively 46% of all German Science on Stage participants) have made 2–3 international contacts and want to maintain this contact.

In line with the fact that the German participants represented the largest group (56%), most of the participants named one German project as one of the three most favourite projects. German participants in particular chose German projects, while non-German participants chose more different countries. One reason could be language: Non-German participants are prepared to speak English in a foreign country. But German participants can get along well without being forced to speak English by staying in the “German corner”.



Teachers you met at the festival, with whom you will stay in further contact: How many international contacts are amongst these?



Conclusion

Science on Stage successfully pursues its targets, raising the students' interest in science in the key aspect “person teacher”.

The importance of the international component was mainly revealed in the post-test two weeks after the festival. The results of the quantitative analysis of the international exchange showed that even with a very disproportionate allocation of nationalities and one dominant group/nationality, there is a valuable international exchange of ideas.

Science in Kindergarten and Primary School

A

Science in Kindergarten and Primary School

16

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A

A

Science in Kindergarten and Primary School

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N

Natural sciences are currently finding their way into everyday life of kindergartens and primary schools. This is due to the insight that children are not overextended by exploring natural scientific everyday phenomena, as has been assumed for a long time. A requirement for this is that natural scientific topics are not being prepared as 'appropriate for children'. Instead, children should get the opportunity to grasp the respective topics and tasks through activity-based learning. In the two previous publications of this booklet series (*Teaching Science in Europe* and *Teaching Science in Europe 2*), examples are given of how to implement this approach in practice.

Whereas natural scientists themselves initially took scientific experimentation into kindergartens and primary schools, many pedagogues now take part in the discussion about appropriate methodology for early scientific education as well. Furthermore, valuable input is given by neurobiologists, who analyse the learning process. According to Petra Evanschitzky of the Transfer Centre for Neuroscience and Learning (ZNL) in Ulm, Germany, it is important to define the aims for working on scientific topics with children first and adapt a methodology to suit these aims afterwards. Is the aim to arouse curiosity or to provide a possibility for an in-depth examination of phenomena?

The more natural sciences are established in kindergartens and primary schools, the more the insight grows that they should not only be implemented for the sake of scientific contents. Scientific experimentation additionally promotes other competencies that ought to be developed and strengthened according to modern educational curricula. How sciences can be applied to language promotion is shown in the first contribution to this chapter – “Science and Language”.

In the second contribution, the example “Shadow – not just a natural phenomenon” shows how didactic aims and methodologies can be brought into agreement with each other.

1. Science as a way to improve language skills in kindergarten and primary schools

The following contribution is divided into three parts. First, Yves Quéré, a member of the French Academy of Sciences, explains why science and language are intricately linked with each other. In the second part, it is briefly highlighted why literacy is essential for modern Europe, using the German city of Berlin as an example. The third part, led by Stuart Naylor, gives practical advice on how science education not only improves science literacy, but also language skills.

1.1. Science and Language

The relationship between science and language is not accidental: In fact, it is present, as a consubstantial linkage – these two kindred spirits that were born exactly at the same time out of the same need.

1.1.1. Common history of science and language

There was, indeed, a day – one could describe it symbolically as such – when, for the first time, a living being pronounced an articulate sound – for us, a noun – in order to denote a *something*, an object (a tree...) or a phenomenon (the wind...), incorporated in her/his environment. That day, language was born, allowing humans to exchange impressions or feelings or information about this particular ‘something’; but that day, science was also born, in that in the beginning, these words were none other than our communication about Nature, our attempt to put

it in order. Therefore, each year we continue to create hundreds of words to name minerals, pharmaceutical molecules, insects... as a taxonomy which is assuredly a part of our scientific activity.

After the nouns came the verbs, describing actions (to sleep, to run ...), then the adjectives and adverbs – the auxiliaries of our science in just the same way as those of our language, since they allow us to specify our perception of objects (the tree is big or it is small) and of actions (I run quickly or I run slowly). In this way, the birth of language is also the birth of a science of comparisons, as taught initially to children in nursery school, when we ask them to rank objects by increasing sizes or by hardness or by identical colours, etc.

The capacity for building sentences followed soon. And with the immense number that an elementary combination allows to create with only several dozens of words, it was quickly necessary to observe that the majority of them only had a fleeting and local usage. Therefore, the sentence, “I am leaving for the buffalo hunt, keep the fire in the cave burning,” is only of interest at a particular point in time and for a specific tribe. In contrast, if I say, “Released, the stone falls,” I speak an eternal (my grandfather said the identical thing) and universal truth (in all tribes, people have said the same thing). Unlike the previous one, this sentence is a typical sentence of science. It reveals to me such an absolute fragment of the truth of the world that I believe it will be true tomorrow as well: And for myself, I create this foolish tense in my language that is the *future*, which only the accumulation of thousands of repeated observations – that is to say science – justifies. Also, while nothing proves that this will really be, I allow myself to say wisely, “Tomorrow, the stone *will fall*” whereas “Tomorrow, I shall give a lecture” is somewhat foolish since I know nothing about what tomorrow will be like.

1.1.2. The How? and Why?

Next comes the *How?* before the *Why?* How does the stone fall? I answer without doubt, “The stone falls quickly,” or even, “The stone falls vertically,” introducing to my language an element of geometry here, making my description of this phenomenon more precise. Until Aristotle took hold of this question so that the *why* gave an answer that we called

theory by way of a single line of reasoning: The stone falls because it is "of a terrestrial essence." It falls because it came from the Earth and it must therefore return to it, and a large stone falls more quickly than a small one.

It was Galileo who adopted these questions and responded to them using an experimental method: It is up to Nature to answer the questions we ask about her, and not to Galileo himself, nor to the Pope, nor to the Nobel Prize Committee, nor to the Prince, nor... to respond to them, but to Nature herself, inviting us to engage in a dialogue. The experiment is then a kind of conventionalised conversation (that we maintain) with Nature.

In the present case her response, contradicting Aristotle, is that "A large stone falls at the same speed as a small one," a sentence that we can say in German, in French, etc. and also that "They fall with the same acceleration." Galileo would imagine this last sentence to be pronounced in the mathematical language: $h = t^2$, where h indicates the height of the fall and t the time of the fall. And science from now on will continue to express itself in this way, either in the mathematical language (this is frequently the case in physics) or in the ordinary language (such as, for example, for botany or for the theory of evolution).

This property of language and science to be like twin sisters must be transparent in our teaching of science. Terminology must be precise right from the start and we must ask this precision from the child. If, in poetry, one can say "the tree," in science one must be precise: the fir, the larch, the cedar, etc. Also, and more importantly, the syntax must reflect a constructed thought, clarified by reason. For instance, in the example sentence, the cause precedes the effect in such a way as to teach an elementary logic. In this way, the children will write in their notebook, "When I warm the ice, it melts," and not "I warm the ice when it melts."

1.1.3. Conclusion

In these various ways, the teaching of science appears to be a powerful ally of language. If we consider the latter as undoubtedly the most important aspect for the future of the child, we must introduce science to

the school with this double perspective. By all means do teach the children known facts relative to the world that surrounds them, but moreover open their spirit to curiosity, to precision and above all to reason; all these contribute to the quality of expression of their thoughts and therefore to their language.

YVES QUÉRÉ

1.2. Reasons to improve language skills using science

1.2.1. Literacy is essential for everyone in a modern society

Scientific developments and use of advanced technology products in daily life demand a basic literacy of the whole population. However, research conducted by the OECD (Organization for Economic Co-operation and Development, 2000, *Literacy in the Information Age: Final report of the international adult literacy survey*. Paris) has shown that in 14 out of 20 participating countries, at least 15% of all adults have only the most rudimentary literacy skills, making it difficult for them to cope with the increasing demands of the information age. Among countries with large numbers of citizens at the lowest levels of literacy are: Belgium, Czech Republic, Hungary, Ireland, Poland, Portugal, Slovenia, Switzerland and the United Kingdom. Even in the best performing countries (including Denmark, Finland, Germany, Netherlands, Norway and Sweden), 8% of the adult population are impaired by severe literacy deficits in everyday life and at work. Low literacy is not only found in marginalised groups, but throughout the adult population in all surveyed countries. And even in the most economically advanced societies, between one-quarter and three-quarters of all adults fail to attain minimum literacy levels which experts consider to be necessary for coping with the demands of modern life and work.

1.2.2. Berlin as a European example: Increasing numbers of children with low literacy skills – both in connection with an immigrant population and with children with German as their native language

In the city of Berlin, children from families with a migration background will make up almost half of the children starting school in the near future and many of these children will have literacy problems. In order to assess the language competency of the children entering school, the Berlin Senate for Education developed a language assessment tool called "Bärenstark" ("strong as a bear"). In 2003, a total of 26.720 children in

388 schools were tested and the results clearly show that language deficits are highly dependent on the children's ethnic and social background (Senatsverwaltung für Schule Jugend und Sport (Hg.), 2003, Bärenstark. Berliner Sprachstandserhebung und Materialien zur Sprachförderung für Kinder in der Schuleingangsphase. Berlin).

In a Berlin school district with a high percentage of migrants (27.9%), the "Bärenstark" test was also performed in 2007 with 2176 pupils from 34 schools. It continued to show a high dependency on children's ethnic and social background and that more than half of the children have language deficiencies. Children that have attended preschool were found to have better language skills than children who did not. In this district, both children with a migration background and children without benefited from attending a preschool.

A report of the chamber of industry and commerce Ulm (IHK Ulm: Bildungsreport 2008, 24.09.2009) shows that language skill deficits are also rising in areas with low unemployment rates indicating economic wealth. This suggests that language skill deficits affect a large number of children throughout Germany. **GOSTINCAR BLAGOTINŠEK, YILMAZ, DANIELSON**

1.3. Ways to improve language skills through science

There are several general principles that teachers can adopt to create an effective learning environment that will support language development. These principles include aspects of classroom organisation as well as pedagogy. For example:

- Give your class more questions and problems instead of information and instructions.
- Make sure that there is always a clear sense of purpose for every activity (this means a sense of purpose for the learner, not just for the teacher).
- Promote collaborative working most of the time, in pairs or small groups, so that learners have somebody to share language with. When something needs to be written down, organise the writing so that learners do this collaboratively rather than individually ①.
- Enable talk to happen, by providing time and organising the space and furniture to promote talk in the classroom.



Young engineers discussing in their team how to construct a propeller-driven car. The children are from the Anna-Lindh-Grundschule in Berlin, which participated in the European project Pollen.

- Value the learners' ideas and (at least in the early stages of conversation) suspend judgement about their ideas.
- Use a small number of simple rules to support talk (e.g. When you have said something, listen to what other people have to say).
- Suggest that learners can take on different roles when they are working collaboratively (e.g. co-ordinator, resource manager, data recorder).
- Make good use of stimulating resources that will engage learners and promote communication.
- Try to use activities where there are plausible alternative viewpoints, rather than a single right answer.
- Provide explicit support for language where possible (e.g. through word banks ②, vocabulary cards, displays and dictionaries) and people support from peers, older learners in the school, parents and teaching assistants.



A word wall. Objects used in science lessons are continually present – bagging and labelling them helps learners to remember the words and their correct spellings (modified from a slide of M.P Klentschy used in a workshop about "Science and Language" as part of the teacher training programme in Berlin, one of the *Seed Cities* of the European programme Pollen. A German word wall will be provided for the German version).

These principles apply especially to oral language development. Most of them apply to written language development, too.

A clear purpose for written language is vital if learners are to engage with it in a serious way. Unfortunately, a lot of writing in science tends to lack both value and purpose, emphasising 'What we did' instead of 'What we learnt'.

Value and purpose can be created through presenting the outcomes of scientific activities to an audience. Learners can use posters, diaries, class books, PowerPoint slides, emails, letters, assemblies, conferences and a wide range of other possibilities to present their ideas in a meaningful way. What about a mini *Science on Stage* for children?

There are teaching and learning strategies that promote language development and scientific concept development at the same time. Most of these are effective in other curriculum areas as well as science. It is not possible to provide a comprehensive list, but some examples are given as illustrations.

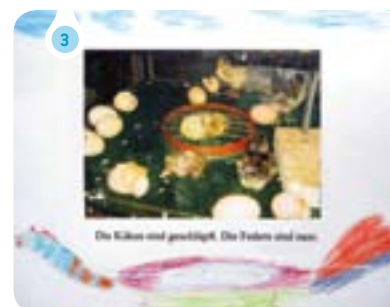
- Use stories that present scientific problems. Learners of every age enjoy stories – including adult learners. Stories help to create a context and a focus for a scientific problem, and this provides a reason for learners to solve the problem. For example, a group of friends might want to rescue the princess who is locked up in a tower. They want to bring a ladder to rescue her, but they don't know how big the tower is. One of them suggests that they could measure the shadow of the tower to find out how big the tower is and this leads to a discussion about whether this would work.
- Support the learners to write a science notebook. By thinking about what to write, the learners reflect their ideas. It also creates ownership. Learners can be supported by giving them sentence stems (see table).
- In order to help learners to master new vocabulary, teachers can create a word wall in their classroom ②. New objects or pictures (animals, plants and some other objects will not be suitable for bagging) are put into bags that will be labelled. The word wall reinforces the concepts and the learners can refer to it in discussions or while writing in their notebooks.

Useful sentence starter for the different phases of scientific enquiry.

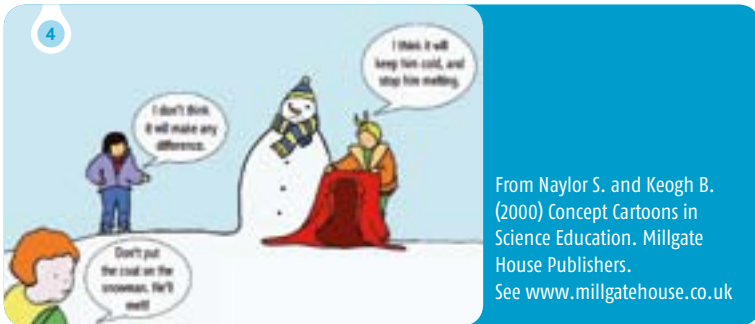
Modified after a workshop from M. P. Klentschy on "Science and Language" performed for teachers in Berlin who take part in the European Pollen programme.

Phases in scientific enquiry	Useful sentence stems
Prediction	→ If ... then ... will happen because.... → I think ... will happen because
Data	→ I noticed that.... → I have observed that → When I did happened.
Claims and evidence	→ I claim that → I know this because
Conclusion	→ My prediction was accurate because.... → I wish to revise my prediction because.... → Today I learned → In conclusion,
Reflection	→ What really surprised me about this investigation was → A new question I have now is.... → I want to know more about → I am confused about

- Another way is to encourage the children to make scientific picture books themselves, covering scientific topics, which include photos, drawings and short written texts ③. These books become valuable additions to the class or school library. Experience shows that the books will often be looked at or read.
- Use surprising observations that intrigue learners and make them curious to find out more. Surprising observations can be based on



Page from a picture book on the development of chickens made by children from the "Schule an der Schwalm – Förderschule Lernen", a school in Germany supporting learning impaired children (Translation of the text in the picture: The chickens are hatched. The feathers are wet).



the intuitive (but often incorrect) ideas about the world that learners bring with them to science lessons. For example, young learners typically believe that heavy things fall faster than light things, and that air makes things lighter. Teachers can use these to engage learners and create a purpose for finding out more.

- Use Concept Cartoons to offer alternative viewpoints about a problem. Concept Cartoons have very little text and they invite learners to join in with the conversation. They are highly effective at encouraging communication, since learners can agree or disagree with the characters without appearing to put their own ideas forward 4.
- Use systematic ways of getting learners to share their ideas. These can include card sorting, matching activities, true-false statements and so on. Sharing their ideas through discussion helps learners to clarify their thinking and identify where they need to find out more about the science. At the same time, it helps to develop their language skills.
- Use technological challenges, such as making a wind velocity indicator or a 30-seconds timer. These challenges require from learners to find out about the science in order to produce a technological solution to the problem. The sense of purpose is obvious, as is the value of applying scientific ideas to help to solve a problem.
- Use real-world problems that learners can identify with. For example, which is the best material to use for an umbrella? What is the best

way to grow beans for the vegetable show? What is the best way to insulate your bedroom if you have a very noisy neighbour? These problems have an obvious sense of purpose, with no pre-defined correct answer and they encourage learners to explore and investigate different possibilities.

- Divide up bigger topics into mini-projects, so that each small group of learners develops into mini-experts for their project. This automatically gives them a purpose to find out about their area of study and a purpose for presenting their findings to the rest of their class or to an outside audience. Sometimes, mini-projects can be micro-projects that last no more than 15 or 20 minutes, but the principle is still the same. **NAYLOR, BREUER-KÜPPERS, CURTIS, DANIELSON, PREM-VOGT, SKIEBE-CORRETTE**

Pollen und FIBONACCI

Five of the nine contributors of this chapter have been partners of the European project Pollen and are now partners in the European project FIBONACCI.

Pollen was launched in January 2006 and ran over a period of three-and-a-half years. The focus of Pollen was the creation of 12 Seed Cities for science throughout the European Union, where science education in primary schools and kindergarten was improved by introducing and supporting enquiry-based science education. Part of creating a Seed City was developing a commitment of stakeholders within the whole community to support primary science education. In each Seed City, Pollen provided material and methodological and pedagogical support compatible with the framework of the local curriculum. All of the materials produced as part of Pollen as well as further information about the project can be accessed free of charge through the Pollen website: www.pollen-europa.net.

Within FIBONACCI, project lessons learned from Pollen and the German Sinus-Transfer programme will be disseminated by 12 Reference Centres to 24 Twin Centres, based on quality and global approach. This will be done through the pairing of the experienced Twin Centres 1, many of which are former Pollen partners, with 12 Twin Centres 2. These will receive training and tutoring for 2 years in order to become Reference Centres in turn and start disseminating, thus improving both science and maths education within Europe.

2. Shadow – not just a natural phenomenon

In this contribution, the phenomenon “shadow” will be pursued spirally with experiments in four steps and a possible enhancement will be sketched.

2.1. Experiments to wet one’s appetite for the subject

In this phase, the children explore and ascertain the phenomenon “shadow”. Explanations should be given sparingly.

1

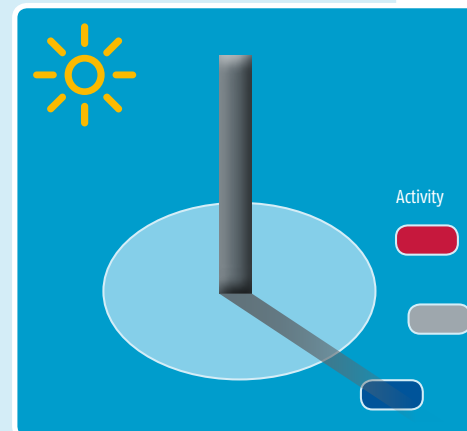
Observing or ‘playing’ shadow formations on an open-air ground

MATERIAL:

- sunny day
- sand-pit
- wooden pole, 1,50 m length

ACTIVITIES:

The children observe the shadowing of the pole. At this point, some assumptions on how the shadow image occurs can be expressed. The check mark of the initial position of the shadow and the observation at a later point in time shows that the shadow image wanders around. The game “shadow bouncing” also succeeds to amaze. Especially difficult: Each of the participants places one foot on the opposing shadow.



2 Experiment: "Guessing shadows"

MATERIAL:

- lamp
- bed sheet
- little figures (car, astronaut, clothes-peg, animals), cup
- big figures
- hands

ACTIVITIES:

The small figures are positioned closely to the lamp, so that the large-size shadow image can be seen on a bed sheet which is further away. The children watch the different shadows and guess, which object is shown here. In the second experiment, similar objects of different sizes are positioned in such a way that the shadow of the larger figure appears smaller. Every child cuts out one dwarf and one giant from cardboard at the end of the experiment. This generates a great surprise – even dwarfs can turn into giants.



3 Shadow quiz: "A sleepless night"

MATERIAL:

- pocket or table lamp
- figure: "little moth" / "fly"
- light wall

STORY:

A story is narrated and amplified dramatically. The content is a child's experience at night, with sudden shadows inducing panic reactions. Objects such as a "little moth" or a "fly" spread fear and trepidation.

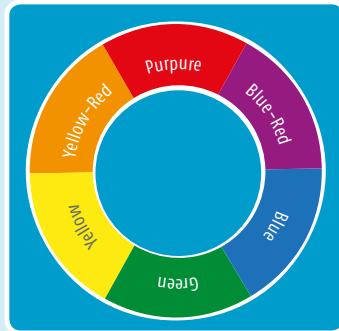
4 Experiment: Coloured shadows

MATERIAL:

- 3 desk lamps (red, green, blue)
- 3 pocket lamps (red, green, blue)
- white wall / bed sheet
- slightly shaded room

ACTIVITIES:

The three different lamps are positioned next to each other at breast height – with a distance of 30–50 cm between them. The distance to the white wall should be approx. 2–3 m. The children place themselves between lamp and wall. Coloured lamps induce coloured shadows. Although only three light sources exist, more than three shadow colours can be counted, which even change when the children move.



What happens if one or even two lamps are turned off?

Advice: To generate a shadow with sharper contours, one has to stand very closely to the wall. In a shaded room, the variety of colours is reduced.

Explanation: If green, red and blue are projected onto the same screen, the spot where all three colours converge appears in white. The spot at which only two sources of light converge appears in a mixed colour due to the principle of subtractive colour mixing. If, for example, red and green merge on the screen, yellow will come up. If you then hold a figure that casts a shadow in the optical path, a dark umbra appears that is superimposed by parts of the light beams in the shadow span – and that is why they appear coloured. There is a greater variety of colours in the slightly shaded room than in a completely darkened room as light superimposes itself, which includes numerous colours.



2.2. First advanced study phase

Alongside with the self-dependent trial, the focus is on explaining the observed phenomena at this point.

5

Experiment: How do shadows emerge?

MATERIAL:

- thick silhouette paper
- small wooden poles
- cup, water glass, mug, acrylic glass pane
- tracing paper
- scissors
- sticky tape
- desk or pocket lamp / overhead projector
- white wall / screen / white fabric

ACTIVITIES:

In the first phase, the children cut out silhouettes from paper, which they then fix onto the wooden poles using sticky tape. Light up the screen and hold the silhouette in between screen and light source; the silhouette will cast a shadow onto the screen. The tracing paper blocks the light only partly, so that the wall is lit up slightly where the shadow appears. Light can get through the holes in the cardboard box and the water glass. Dark areas do not let the light pass. One can perceive the dark areas on the wall; they are called shadow images. Only opaque objects cast shadows.



6 Creating shadow images of a head



MATERIAL:

- desk lamp
- thick light silhouette paper

ACTIVITIES:

Outline the shadow images of the children's heads on the screen with a pen. Subsequently, these can be cut out and glued onto cardboard.

lead to an exemplary build-up. A small drawing of the sun by one of the students could mark the lamp as such. The wandering of the shadow can be imitated by relocating the lamp. The construction and the repeated presentation and explanation of the experiment by the children form a cornerstone for the further development of successful experimenters.



2.3. Second advanced study phase: Modelling

7 Experiment: Exemplary depiction of the formation of shadows in experiment 1

MATERIAL:

- rainy or cloudy day
- desk lamp as 'sun model'
- baking tray with sand
- little wooden pole
- building bricks for fixing the shadow impact

ACTIVITIES AND INTENTION:

A reproduction of the 1st experiment is prepared in the "experimentation lab" and to be presented at a parent-teacher conference or an open day. Share considerations with the students which then

8 Day and night

MATERIAL:

- globe
- pocket or halogen lamp as sun
- yellow cardboard sun
- tokens/figures with sun glasses
- tokens/figures in bed
- modelling clay for fixing the tokens/figures
- sun glasses

ACTIVITY:

The room is darkened and the globe illuminated. The children fix both tokens onto the globe. Only one part of the globe is illumi-



nated, the other part remains darkened – no matter how much it is being rotated. Children know that we need light to be able to see and that there is darkness where no light appears – namely night. Children in Japan are wide awake at the same time as children in Germany sleep soundly.

The globe is now being rotated from West to East, with children in Germany waking up while those in America are still asleep. Thus, first steps of orientation are integrated in this concept. If the children seem to be overstrained, the movement of the sun (or the lamp) can be stopped. To promote the learning effect, “Good morning” and “Good night” in different languages can be introduced and short song sequences can be practised – to be sung whilst following the earth’s rotation. Migrant children and their parents are skilfully integrated this way.

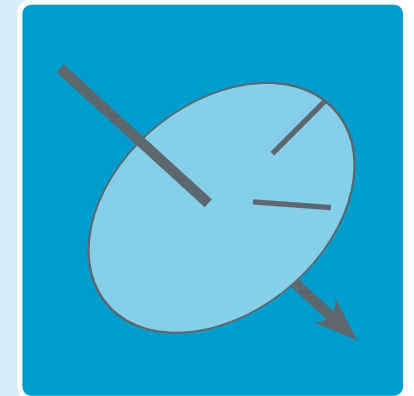
Time management and time of day Experiment: Construction of a sundial

MATERIAL:

- cardboard pane
- little wooden pole/pencil
- coloured pencil

ACTIVITIES:

Every child creates its own sundial. For that purpose, they stick the wooden pole through a little hole in the centre of the cardboard pane. Subsequently, they stick the shorter bit of the wooden pole into the soil in the playground and mark the location of the shadow cast by the pole every solid hour. Small prepared labels can be glued onto the cardboard in place of value figures.



2.4. Third advanced study phase

Shadow theatre

ACTIVITIES:

The children write their own story and create figures for the theatre play in teamwork. By adding background music to the theatre, this project turns into a magnificent example for interdisciplinary work. A presentation of the play in a kindergarten can be seen as a further challenge. This enables school children and those in a kindergarten to make contact at an early stage – and school becomes fun.

It is exactly such a shadow play that can raise the motivation of children in a kindergarten and the other way round to deal with the topic more closely.



2.5. Suggestions for enhancement topics

- Why does the temperature differ in the various places on earth?
- Lunar or solar eclipse

SAUER, G. STETZENBACH, W. STETZENBACH

More information on science in kindergarten and primary school is available on www.science-on-stage.de, category "teaching material".

Benefits of Non-formal Education Initiatives

B

Benefits of Non-formal Education Initiatives

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B

S

Introduction

Science education is an important component of education. It does not only comprise cognitive aspects, but also an interest in science, the scientific way of thinking and a scientific orientation – in other words what we call scientific literacy. Students nowadays have to acquire competencies that enable them to solve fundamental problems in the future. To us, it seems to enhance the students' understanding of global problems relating to the environment, such as climate change, water, energy, health and limited resources, and to equip them with solutions to address these challenges. This is one important reason why more and more groups and organisations have become active in non-formal education initiatives in order to support scientific learning.

Definition of Non-formal Science Education

Non-formal learning means learning by chance, occurring without any conscious education or teaching, outside of organised learning situations, mostly in everyday situations. In this case, neither formal education nor informal educational initiatives are necessary.

We understand formal education as the formation provided by special organisations representing the school system from pre-school to university. In this case, teaching and learning is compulsory and fixed by a curriculum. Non-formal education implies education that occurs in a great variety of educational learning sites. These sites are rather different from each other and pursue different aims, yet all of them attribute non-formal educational aspects to the education at school.

B

Benefits of Non-formal Education Initiatives

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As non-formal educational initiatives are so diversified, it is difficult to provide a short definition. Instead, we collected attributes that determine non-formal educational initiatives. A non-formal educational initiative

- is outside school,
- is outside school classes,
- is organised,
- is not compulsory,
- is flexible,
- has flexible schedules,
- is interesting,
- triggers interest in science,
- is motivational,
- is based on interactivity,
- involves external experts at school.

Non-formal educational initiatives are characterised by learning situations outside of the classroom or outside school. This does not mean any everyday learning, but an organised institution or site aiming to promote science themes and to develop the pupils' competencies. The learning contexts are not compulsory and do not end with a certification. In contrast to curricular directions at school, contents are not established by adhering to the curriculum. They are closely linked with the specific nature and the aims of the non-formal initiative. Aims may be the transfer of spatial knowledge to a general public as well as the professional orientation towards science or the field experience of nature and so on. Based on individual learning goals, the schedules are usually more flexible than at school.

Non-formal science initiatives are important to show how fascinating science is. Their activities are supposed to stimulate interest in natural science questions and to motivate pupils for further science learning. Non-formal initiatives offer more interactivity than traditional classroom learning. Hands-on activities play an important role in most of the initiatives.

We include the visit of external experts at schools and their communication with pupils about up-to-date information in the non-formal educational initiatives described above as well as interactive websites.

Types of Non-formal Scientific Education

SCIENCE MUSEUMS are considered as the first non-formal educational initiatives. In former times, when technical progress was moderate, science museums showed long-term technology development. A visitor could see and learn what had happened in the past and what had just been invented. The locomotive principle for example was used more than a hundred years after its invention. There are only a few options for interactive learning in science museums.

SCIENCE CENTERS demonstrate basic scientific phenomena. The visitor can handle exhibits, change displays and examine again and again. Thus, one gets a first impression about what happens, but does not acquire in-depth knowledge. On the other hand, everybody can get in whenever he or she wants as a Science Center is open for everyone without advance registration.

SCIENCE FESTIVALS offer similar contents and activities as Science Centers, but are often more spectacular. They are open for a short time. Nevertheless, they may increase curiosity for science and technology.

A new approach to raise curiosity for science is organised by universities. Lectures with attractive demonstrations for children at the beginning of a semester are the main activity in this context. These events are called **CHILDREN'S UNIVERSITIES**. They facilitate a first insight into the world of science.

Really effective learning is offered in a **LEARNING LAB**. Such laboratories are founded by research labs, universities, museums, Science Centers and industry. The main focus is on experimentation. Multiple learning activities in a well-equipped lab environment are addressed to all kinds of students of different age groups and school types. They are usually accompanied by their teachers and get to know new scientific methods, newest research findings and committed scientists. In addition, learning labs show teachers how to conduct new experiments.

A lot of other non-formal activities include **FIELD DAYS** outside the school as well as **TRAVELLING EXHIBITIONS** and **SCIENCE TRUCKS** temporarily parked on the schoolyard.

An exceptional non-formal event are the spectacular experiments in the ISS space station, which can be watched and compared with similar experiments on earth over the Internet.

Benefits of Non-formal Education Initiatives

At present, benefits of non-formal education initiatives are controversially discussed. Some evaluations found out that their motivational effects are very promising. Other findings say that the effects are rather imperceptible, especially the curricular-related learning outcome. Based on their experience, the participants of this workshop established the following list of effects promoted by non-formal education initiatives. They:

- motivate pupils and teachers,
- are fun,
- improve curiosity,
- stop stagnation and boredom,
- boost interest in science,
- are situated at another place with another atmosphere,
- are perceived more strongly as 'real life',
- provide a change in the learning environment,
- offer an authentic learning environment,
- extend curricula,
- provide professional orientation,
- transfer awareness of the outside world,
- initiate communication between teachers and experts from other institutions,
- offer an exchange between experts and pupils,
- make available expert knowledge,
- give cognitive input for normal school lessons.

Diverse groups take advantage of such a cooperation between schools and non-formal education initiatives. Especially, there are:

- school-related groups
- experts (scientists)
- school teachers
- pupils
- general public

beneficial for:	experts	teachers	students	society
motivation	Experts at non-formal education initiatives... acquire funding get in contact with young people can talk about their work	Non-formal education initiatives... offer professional development for teachers promote motivation boost interest in science boost curiosity are fun offer a change in learning environment	Non-formal education initiatives... promote motivation boost interest in science boost curiosity are fun offer a change in learning environment promote a positive attitude towards science and technology	Non-formal education initiatives boost interest in science
knowledge	Experts at non-formal education initiatives provide teachers and students with additional input to normal school lessons	Non-formal education initiatives... instruct teachers and students extend curricula offer a parallel way to formal education increase awareness of the world of science	Non-formal education initiatives... impart knowledge about STEM eliminate misconceptions about science extend curricula offer an addition to formal education increase awareness of the world of science offer professional orientation in science	Non-formal education initiatives increase awareness of the world of science
scientific methods	Experts at non-formal education initiatives... support projects connect with the workforce of the future	Non-formal education initiatives... offer educational material give inspiration for new experimental and educational methods	Non-formal education initiatives offer laboratory activities with new tools	Non-formal education initiatives broaden scientific perspective of the world
communication	Experts at non-formal education initiatives... raise awareness of their own working process learn to communicate with non-experts	Non-formal education initiatives... promote communication between teachers and experts offer workshops for teachers break down the barriers between experts and teachers	Non-formal education initiatives... promote communication between experts and pupils break down the barriers between experts and students	Non-formal education initiatives... promote science communication in the public build bridges between experts and the public
evaluation	Experts at non-formal education initiatives get feedback on their own work	Non-formal education initiatives promote reflection on own lessons	Students... perceive to be closer to real life are provided with orientation for a judgement of scientific topics	Non-formal education initiatives provide orientation for a judgement of scientific topics

Hence, the matrix is divided into benefits for students, teachers and the general public, as we are convinced that they are the main target groups of those initiatives.

Conclusion

All in all, there are multiple initiatives that aim to foster scientific competencies. The educational benefits of non-formal education initiatives are based on multiple interactions between all partners. They are filling gaps of science learning that cannot be covered by schools, for example using the latest scientific methods or showing the results of top research. They supplement school science and make science enjoyable as the predominant use of hands-on and enquiry-based activities develops teamwork, critical thinking and problem-solving skills. Non-formal education initiatives have the potential to help young and adult people to develop scientific knowledge along with attitudes, values, skills and critical thinking. The latter are indispensable means for a successful life in a rapidly evolving society as they are not fixed by strict curricular rules.

A close interaction and strong links between the school system and non-formal initiatives have been established, but should still be extended. On the one hand, schools ought to come up with ideas, hands-on methods and laboratory work themselves. Schools are supposed to express their needs for support clearly and could recur more often to initiatives outside school and look for a co-operation. On the other hand, non-formal initiatives are required to respect the curricular restraints dominating school life. They benefit in terms of transporting their knowledge and their commitments. An increasing interlacement between school and society contributes to a development of competencies in pupils. This is seen as an important step forward to cope with the huge environmental challenges evolving in our future.

The following tables give a short overview over the diversified non-formal educational contributions in Europe. Five good practice examples coming from different European countries are exemplarily presented in this booklet. They may spread all over Europe into more initiatives.

The following table gives an overview about the presented non-formal initiatives.

2 Good Practice of Non-formal Initiatives			
name of participant	non-formal initiative	type of initiative	country
Peter Jann	Life Science Zürich	Learning lab	Switzerland
Shamim Hartevelt	ESA	Complex network with Internet platform	Netherlands
Rudolf Pausenberger	towerofsenses, Turm der Sinne	Mobile exhibition	Germany
Antonio Serrano	COSMOCAIXA	Science museum	Spain
Miroslav Los	Natural Science and Physics Experiments Competition	Science competition	Poland

EXAMPLE

1

A Science Learning Center

name of the institution

Life Science Zurich Learning Center, University of Zurich & Federal Institute of Technology Zurich

address

Winterthurerstrasse 190 · CH-8057 Zurich · Switzerland

website

www.lifescience-learningcenter.ch

nationality

A	CH ★	D	E	GR	I	NL	P	PL
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type of the non-formal educational initiative

school lab ★	Science Center	travelling exhibition	science festival	field work	children's university ★	expert at school	other ★
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target groups

pupils ★	teachers ★	head teachers	teacher trainees ★	parents	general public ★
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age of pupils

4-6	6-10	10-13 ★	14-16 ★	17-20 ★	21-25	other
-----	------	------------	------------	------------	-------	-------

disciplines

biology ★	chemistry [★]	mathematics	physics	technology	astronomy
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activities

Experimentation

competencies to be learned

Disciplinary competencies

knowledge ★	scientific methods ★	communication	judgement ★
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Cross-curricular competencies

cooperation ★	self-direction	networked thinking	application of knowledge ★
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Description: The Life Science Zurich – Learning Center (LSLC) creates a nexus between secondary schools, the general public, life sciences and educational sciences. It aims to improve scientific literacy in general and to support teaching modern life sciences at schools. Furthermore, the LSLC wants to raise the curiosity and comprehension for this fascinating field. The LSLC is an example of an institutional REC that integrates a high school teacher education programme, continuing education for high school teachers and lab activities for all school levels and the general public. Recently, a research study in science education has been initiated that investigates the impact of lab courses on secondary school students.

Secondary school classes, individual students, teachers or specific professional groups and other interested persons are invited to conduct their own experiments in a cutting-edge research environment, to experience the fascination of life sciences, and to critically discuss the impact of the latest findings on society with the scientists involved. The LSLC applies a unique model of cooperation between researchers from life sciences (biology) and from educational sciences when these collaboratively supervise teacher trainees developing school lab activities or teaching units for the LSLC or for the research institutes. Key concepts used in teacher education are "Didactic Reconstruction" and "Cultural Border Crossing".

Whenever possible, teachers, scientists from the respective research areas and science education researchers are actively involved in the development and testing of new lab courses and services. Furthermore, Ph.D. students from natural sciences are employed as instructors for lab courses, acting as science mediators and possibly serving as role models for secondary school students.

Special benefits for learning at school: The LSLC provides a virtual and physical platform where a steady flow of expertise and know-how among all persons involved contributes to a continuous improvement of teaching and learning activities at the LSLC and at school.

EXAMPLE 2 A Web-based Learning Platform

name of the institution							
European Space Agency, ESA/ESTEC							
address							
Keplerlaan 1 · 2200AG · Noordwijk · The Netherlands · phone: +31 (0)7156559 · fax: +31(0)71565232							
website							
www.esa.int/SPECIALS/Education							
nationality							
A	CH	D	E	GR	I	NL ★	PL
type of the non-formal educational initiative							
school lab	Science Center	travelling exhibition	science festival	field work	children's university	expert at school	other ★
target groups							
pupils ★	teachers ★	head teachers	teacher trainees	parents	general public ★		
age of pupils							
4-6	6-10 ★	10-13 ★	14-16	17-20	21-25	other	
disciplines							
biology ★	chemistry ★	mathematics ★	physics ★	technology ★	astronomy ★		
activities							
Production of printed, digital and web-based educational material · Competitions based on space missions							
competencies to be learned							
<i>Disciplinary competencies</i>							
knowledge ★	scientific methods ★	communication ★	judgement				
<i>Cross-curricular competencies</i>							
cooperation ★	self-direction ★	networked thinking ★	application of knowledge ★				



Photo: Hanne Nijhuis for NEMO Amsterdam. Image taken at the Space Expo, Noordwijk, The Netherlands, during an ARISS-contact

Description: The Delta Researcher School Project was started in 2004 at the time when the Delta Mission of ESA astronaut André Kuipers from the Netherlands was scheduled to fly to the International Space Station. This presented an opportunity to engage a personality of nationwide standing to involve young children in the journey to outer space.

The Department of Research and Science Policy in the Netherlands recognised that such a mission provided a unique chance to give a much needed boost to the level of science education in primary schools. A co-operation between the Ministry of Education, the European Space Agency and the National Aeronautics and Space Administration of the United States of America started in order to form the Delta Researcher Schools Program. These three organisations got together to take informal space knowledge directly into the classroom.

The astronauts who live and work in the unique microgravity environment are also seen as ambassadors of their respective countries. These missions serve as an opportunity to demonstrate many physical and biological phenomena that can take the students out of their classroom laboratory into the space environment. This thematic approach, where human spaceflight and the International Space Station are used in the pedagogical cycle is, by its very nature, exciting and inspiring for students in the classroom. The Delta Researcher School Project together with the European Space Agency helps to organise teacher workshops and events for school children, for example competitions where winners get a chance to speak live to an astronaut (ARISS contact). It brings in expert speakers and education materials to inspire and increase the knowledge base of teachers. Teachers in turn are encouraged to develop their own lesson materials from what they have learned and share them with all teachers who can access them from the delta website. This pilot programme can be used as a model for all countries, supported and endorsed by the Ministries of Education.

Special benefits for learning at school: Reach children at an early age and involve them in human spaceflight activities to inspire enthusiasm for science and technology.

EXAMPLE 3 A Travelling Exhibition

name of the institution								
towerofsenses – Museum (turmdersinne – Museum) tourofsenses – Mobile Exhibition (tourdersinne – Wanderausstellung)								
address								
Spittlertorgraben 45 · 90429 Nürnberg								
website								
www.turmdersinne.de								
nationality								
A	CH	D ★	E	GR	I	NL	P	PL
type of the non-formal educational initiative								
school lab	Science Center ★	travelling exhibition	science festival	field work	children's university	expert at school	other	
target groups								
pupils ★	teachers	head teachers	teacher trainees	parents	general public ★			
age of pupils								
4–6	6–10	10–13 ★	14–16 ★	17–20 ★	21–25 ★	other		
disciplines								
biology ★	chemistry	mathematics	physics	technology	astronomy			
activities								
Hands-on experiments for perception and deception								
competencies to be learned								
<i>Disciplinary competencies</i>								
knowledge ★	scientific methods ★	communication	judgement ★					
<i>Cross-curricular competencies</i>								
cooperation	self-direction ★	networked thinking	application of knowledge ★					



Description: The towerofsenses invites pupils and adults to the phenomenal world of perception. It focuses on the question in what way our senses provide reliable information as a basis for scientific understanding. Investigating cognitive phenomena is a playful path of learning. The basic idea of the hands-on museum is to experience, to marvel and to grasp knowledge. Thus, the towerofsenses is related to the subjects of biology and psychology. But it is even more: Due to its special didactic concept, it aims to be a museum that encourages critical thinking and a philosophical approach to science: When and why can we be deceived? Can we still achieve reliable knowledge?

The instructions are designed to enable different visitors to select their specific depth of understanding and ensure their selected level of learning.

The latest branch of the towerofsenses is a mobile exhibition which can be rented by schools as well as for business events.

Special benefits for learning at school: Pupils and students achieve awareness of the basics, the possibilities and the methods of grasping knowledge – both in terms of their own perception in particular and of the outside world in general.

EXAMPLE

4

A Science Museum



Description: In order for secondary pupils to grasp a particular physical concept, namely “physics and music”, this proposal is to visit one science museum, specifically CosmoCaixa, in Barcelona. The aim is simple. It increases their poor knowledge about one branch of physics – namely sound. A few days before the visit, the teacher performs classroom activities with the pupils, for example key words, Socratic questioning and so on, always working with emotion, success and first and foremost surprise in order to get the students truly interested in the trip. At the museum and after a short general descriptive introduction, teacher and pupils go directly to the exhibition Physics & Music. The pupils look at several modules, devices, gadgets, etc., manipulating and touching as much as possible and taking notes of their impressions and opinions in a special notebook. Afterwards, back at the school, the visit will be discussed, including the doubts and questions raised during the visit.

Special benefits for learning at school: At that age, the visit per se increases the love for science in general.

In terms of sound, pupils realise that all music has a physical foundation and explanation, which astonishes the sensitive student.

name of the institution							
COSMOCAIXA							
address							
Carrer Teodor Roviralta 47-51 · Barcelona							
website							
http://www.fundacio.lacaixa.es/nuestroscentros/cosmoaixabarcelona/cosmoaixabarcelona_es.html							
nationality							
A	CH	D	E ★	GR	I	NL	PL
type of the non-formal educational initiative							
school lab	Science Center ★	travelling exhibition	science festival	field work	children's university	expert at school	other
target groups							
pupils ★	teachers ★	head teachers	teacher trainees	parents	general public ★		
age of pupils							
4-6	6-10	10-13 ★	14-16 ★	17-20 ★	21-25	other	
disciplines							
biology ★	chemistry	mathematics ★	physics ★	technology	astronomy ★		
activities							
Interactive exploration							
competencies to be learned							
<i>Disciplinary competencies</i>							
knowledge ★	scientific methods ★	communication	judgement				
<i>Cross-curricular competencies</i>							
cooperation ★	self-direction	networked thinking	application of knowledge				

EXAMPLE 5 A Science Competition

name of the institution							
Zespół Szkół Publicznych							
address							
Czastkow Mazowiecki 55 · 05-152 Czosnow · Poland							
website							
http://www.zspczastkow.prohost.pl							
nationality							
A	CH	D	E	GR	I	NL	PL ★
type of the non-formal educational initiative							
school lab	Science Center	travelling exhibition	science festival ★	field work	children's university	expert at school	other ★
target groups							
pupils ★	teachers ★	head teachers	teacher trainees	parents ★	general public ★		
age of pupils							
4-6	6-10	10-13 ★	14-16 ★	17-20	21-25	other	
disciplines							
biology ★	chemistry ★	mathematics	physics ★	technology	astronomy ★		
activities							
Hands-on experiments prepared and presented by students							
competencies to be learned							
<i>Disciplinary competencies</i>							
knowledge ★	scientific methods ★	communication ★	judgement ★				
<i>Cross-curricular competencies</i>							
cooperation ★	self-direction ★	networked thinking	application of knowledge ★				



Description: Since 2001, the Natural Science and Physics Experiments Competition has been organised in two stages every year: The first is the school stage (school preliminaries) led by teachers of the school. The second is the district stage (for pupils, winners of the school stage from all schools of the administrative district), led by the teacher trainer of Miroslaw Los in the Complex of Public Schools in Czastkow Mazowiecki (Poland).

During the Natural Science and Physics Experiments Competition in the Complex of Public Schools in Czastkow Mazowiecki (Poland), pupils present and talk about their own experiments (prepared independently). There are two categories: Primary School (elementary science – age 10–13) and Lower Secondary School (physics – age 14–16). At the end, pupils have to answer the questions of the Competition Committee and the public.

The competition exhibition is open to the public of the commune and administrative district. The Competitive Committee of the district stage consists of independent experts, academic teachers and scientists from outside the administrative district. The competition takes place in a friendly atmosphere. All participants of the competition are awarded because of their interest in physics and other natural sciences.

Special benefits for learning at school: This type of activity is supposed to be a fascinating fire-work, stimulating imagination and engaging all senses, forcing every participant to reflect. The competition motivates pupils to carry out science experiments and in the end to activate them and to get them involved in research work during the lessons.

Moderation of Learning Science

C

Moderation of Learning Science

58

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A

1. Introductory remarks

At the international Science on Stage festival 2008 in Berlin, quite a number of European colleagues followed the invitation of Science on Stage Germany

to mutually introduce and discuss their teaching methods and examples of lessons in symposia and workshops. Our workshop dealt with the role of the teacher in the area of tension between moderating the process of learning and mere instruction. The teachers who had worked together in previous Science on Stage workshops, reflecting upon the topic "learning types and teachers' behaviour", with outcomes published in "Teaching Science in Europe 2" in chapter C: *Self-perception and self-evaluation*, were consequently integrated into our workshop.

At the first symposium, during the preparation time for the ensuing workshops and in the process of these workshops, very different appraisals of the moderation process in learning situations already came into being. The concept of moderation implies a permanent reflection of the traditional teacher's role, which has not been evident and is still under discussion up to the time of editing this published issue. However, consensus exists among all partners that teaching should do justice to the process outlined here:

- The teacher should withdraw from the role of the mere instructor to be able to function as an accompanying "expert of the process/pre-cognition" during the learning process,
- for the students – depending on their previous knowledge – a learning process is set in motion which enables the internalisation of new experiences through self-directed and active work, including the exchange between the students and offering the chance of formulating problems in sensible contexts.

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Moderation of Learning Science

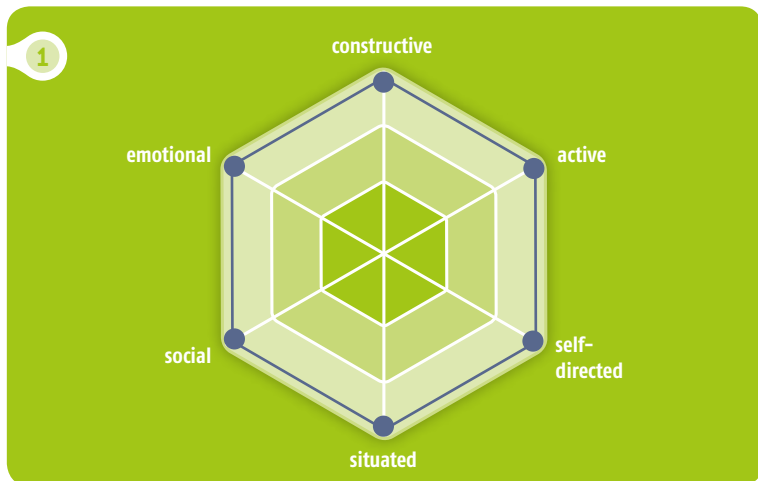
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- A “conceptual reconstruction” – if necessary a change in thinking and consistent action – takes place for the individual learner,
- which should facilitate the learning progress of the students and enter into their long-term memory.

Since the Sputnik shock suffered by the USA, international learning research in the high-tech nations of the Western world has developed experiences in analysing (ideal) learning progress into a theory subsumed under the term “constructivism” (cf. section 3).

In the course of a shortened summary of these workshops organised by Science on Stage Germany and the resulting suggestions for classroom teaching (see section 4), the authors provide a more in-depth explanation of the core concepts of this theory (see section 3) here – to the extent deemed necessary during the workshops. Those with an expert knowledge of the theory may of course skip the chapter.

In the following, we introduce an evaluation template called “hexagon”. As a graphic display of the theory, it enables “constructivist” analyses of any kind of teaching situation ¹. Several case studies demonstrating good teaching practise were devised by colleagues to present the hexagon’s use as a tool for reflection.



2. The “hexagon” of constructivist quality assurance

From everyday experience, a Physics teacher is very familiar with the case where – for learning e.g. about the topic “sound” – an emotionally striking hearing impression is coupled with a measuring process involving students who find out the speed of wave propagation in different media (air; solid material; water) through sensory perceptions. The student on the way home from school who can then explain the Doppler effect of the alarm siren of an ambulance to her/his friend, experiences that “knowledge” is useful as well.

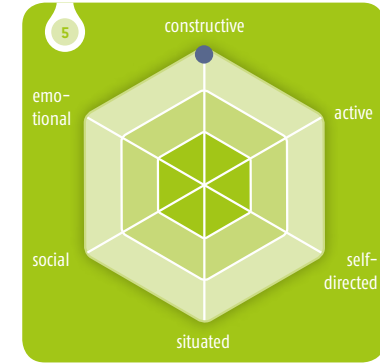
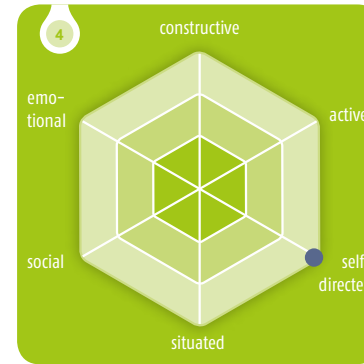
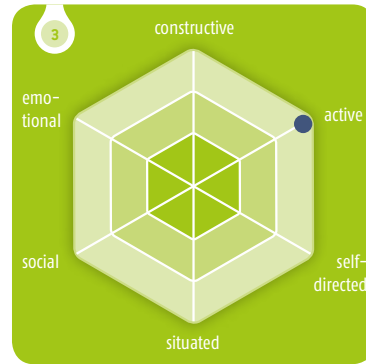
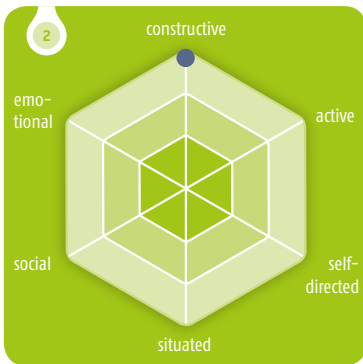
Evaluating and reflecting upon such a learning situation by means of a diagram of constructivist core concepts, one can easily recognise to what extent the learning process (traditionally called a lasting change in behaviour) was based on constructivism.

The positioned points at the external end of the axes of the hexagon represent a science lesson where parameters of constructivist learning situations are carried out.

3. Abstract: Constructivist learning theory

Learning will be understood, for the purposes of a pragmatic, moderate constructivism, as a construction process of the learner. It represents a process of knowledge acquisition in which knowledge that has to be learnt cannot simply be adopted. It must be based constructively and independently on one’s already available imagination about the topic. Consequently, the existing imagination of the learners plays a determining role in the learning process and must take a central position in the development of actual teaching attempts.

In constructivism, it is assumed that a human being is incapable of perceiving (vs. sensing) any external reality directly. Therefore, any person’s recognition is bound to the (internal) perspective of the observer. Such a paradigm does not deny the existence of a reality, yet nevertheless stresses that all knowledge about this reality is a construction of the individual human being. From this position, a view about the learning theory called **MODERATE CONSTRUCTIVISM** has been derived. This deals



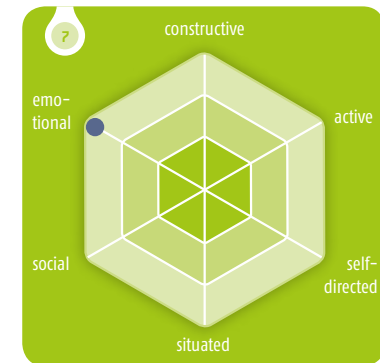
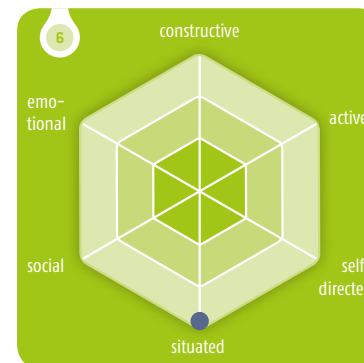
with the question how emerging or acquired experiences (knowledge) change individually.

The learner and the learning process are in the centre of moderate constructivism. The following characteristics apply:

- Learning is a **CONSTRUCTIVE** process: While learning, the learner is (re)constructing already available experiences, imagination and convictions. Besides, the meaning of new bits of information are not adopted from external sources and integrated according to the instructor's desire. They are constructed actively, on the basis of (pre)existing imaginations and suppositions. Because every individual interprets an object in different ways, different learning results occur. **2**
- Learning is an **ACTIVE** process: Effective learning is only possible if the learners participate actively. Therefore, it is learning-productive when the learners take an active role in the teaching/learning process. Thus learning means physical work. **3**
- Learning is a **SELF-DIRECTED** process: It helps the learner if she/he can be responsible for steering and controlling these processes. The learning process cannot be directed and controlled from outside. The surroundings / settings can merely initiate and stimulate the learning process. **4**
- Learning is an **EMOTIONAL** process: Learning processes are always bound to the individual cognitive systems of the learners. In cogni-

tion, emotional aspects like interest, emphasis and motivation also play an important role. **5**

- Learning is a **SOCIAL** process: Although learning processes are bound to the cognitive systems of the respective individuals, they are also linked to social components. Learning takes place within social interactions, where ideas and suppositions, among others, are communicated, negotiated, tested and shared with others. Learning should therefore allow interactive events. **6**
- Learning is a **SITUATED** process: Learning takes place in contextual situations, i.e. the knowledge is connected with the content and social experiences of the learning situation. Specific contexts represent a background of interpretation during learning. Bits of information only become meaningful for the individual if they are embedded in relevant contexts. **7**



Constructivist attempts lead to a reflection of the (traditional) role of the teacher. Thus it is obvious – if the above-mentioned aspects are to be considered in the lessons – that teachers need to teach less instructionally and support the learning process individually in open learning environments.

The following examples demonstrate that one will not always be successful in designing constructivist learning situations where all parameters have the utmost impact. Such attempts may in some ways even hamper learning. Sometimes it is hard to evaluate a specific parameter, then the parameter's axis is (intentionally) left blank. Nevertheless, wherever possible, all planning and preparation of lessons where students shall be supported in their learning shall aim to evaluate these (most) parameters at the outermost positions of the hexagon.

4. Teaching models and examples

Throughout the following examples of selected teaching subjects and units, we offer opportunities to the interested reader to get to know and to carry out an assessment and reflection with the help of the hexagon. Materials in the form of handouts and worksheets accompanying the examples are available to download from the Science on Stage Germany homepage.

4.1. The Physics teachers Christine Trautwein and Günter Niehues (Germany), Christine Reinholtz (Denmark) and Maria Serra (Italy) compile with their 7th form students (teaching unit **ELECTRICAL ENGINEERING**) the

basic everyday usage of different electrical switching circuits (under observance of the security regulations):

- installation of a switching circuit between battery and electric light bulb;
- serial circuit and parallel circuit (e.g. the floor-bell circuit);
- alternating circuits (i.e. hall lighting circuits)
- construction and function of an extension lead / cord.

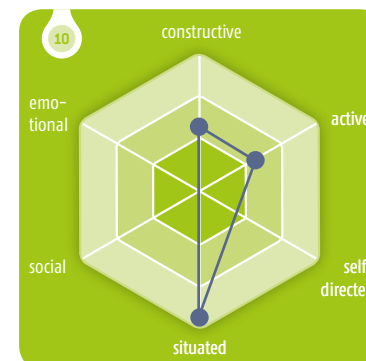
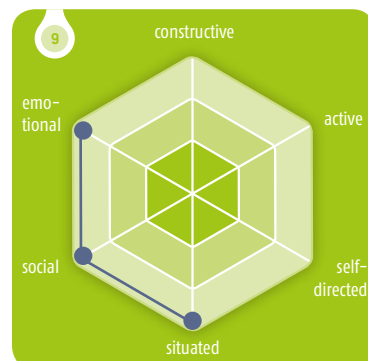
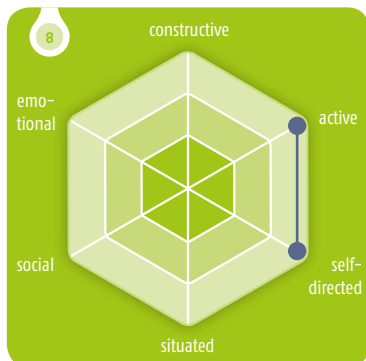
The individual steps, carried out by the students either in single work or in teamwork in small groups, are briefly outlined as follows:

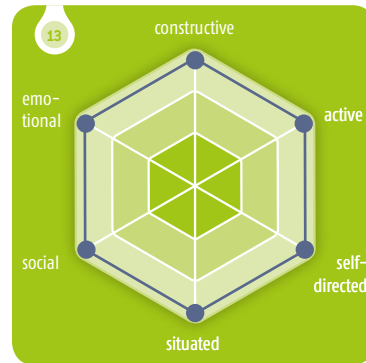
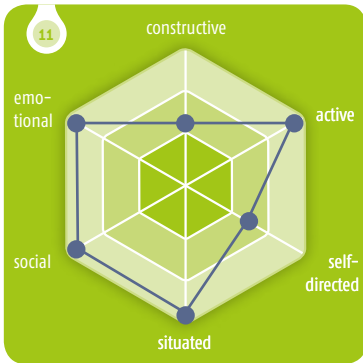
A: The teaching unit begins with the setup of a **SINGLE (SIMPLE) SWITCHING CIRCUIT** and the plotting of a circuit diagram. The students learn to make use of (the) symbols, to experience the importance of circuit diagrams / plots in the course of the next task. First, the students draw their built-up switching circuit. A high degree of active self-direction is guaranteed here, because every student decides about the individual building and plotting design. ⁸

B: The successful circuits are discussed with regard to **FUNCTION AND EVERYDAY SUITABILITY** and the appropriate circuit diagrams are compared (with the example in the textbook). The social, emotional and context-related parameters are in the foreground, when the discussion leads to a constructive clarification of aspects that matter. ⁹

C: Thereafter, the **MODELLING OF SPECIFIC RULES AND REGULATIONS OF ELECTRICITY** will follow for the purpose of a "theory of electric current" (if necessary with the suitable equations) through the interpretation of the

different circuits and their usage in everyday life. The amount of a student's activity and constructive (possibly self-discovering) learning depends on how much time and intensity is available or required during this phase. According to the student's successful work the teacher can summarise the necessary theoretical aspects. ¹⁰



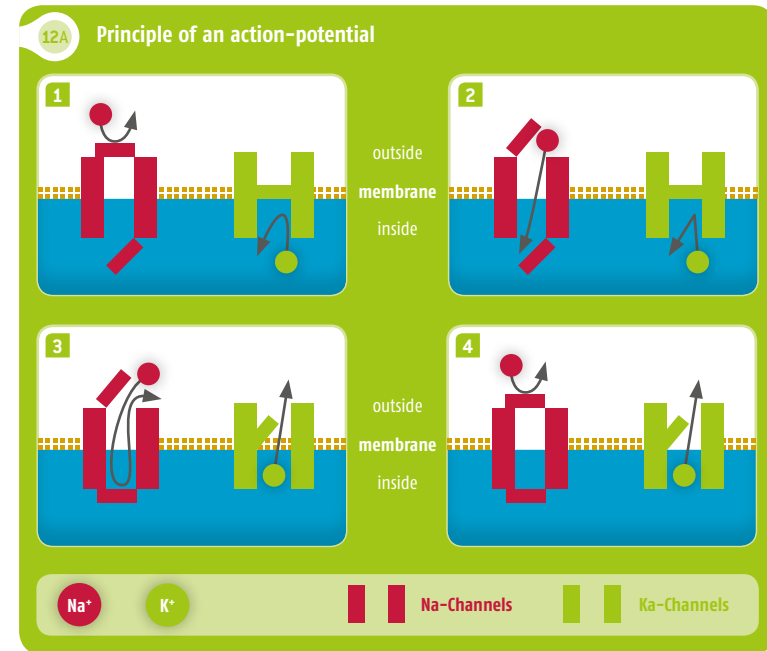


D: As “a diploma piece”, the student teams disassemble an extension lead/cord, make a functional sketch and screw the individual parts together again. After examination by the teacher, the practical trial occurs by connecting the cord with an electric consumer. All single aspects of constructivist teaching and learning take effect as well as the handling of safety regulations. ¹¹

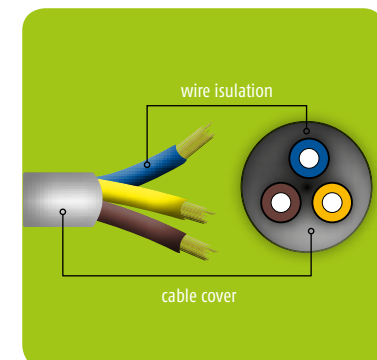
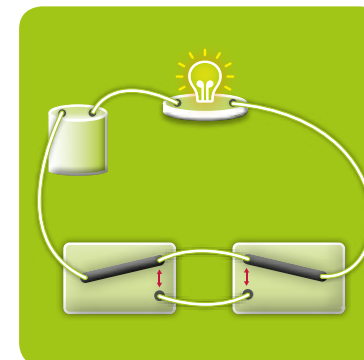
4.2. The German Biology teacher Lutz Wendel challenges his class at the end of the teaching unit “NEUROPHYSIOLOGY – ACTION POTENTIALS IN THE NEURON” with a compilation of a functioning model with easy materials and symbolic processes. Modelling is – not only in the natural sciences – one of the basic intellectual abilities of humans. Based on observations of the natural system or alternatively learned from sources of textual information, thought models are originated which come close to the real system, however – according to the task or question – reduced to essential points of interest. At the same time, the understanding of the process is strengthened during the development of the model and can be verified – not only by the judging and grading teacher.

A: The students (level 13) are tasked to build a model of the propagation of ACTION-POTENTIALS IN AN AXON in 45 minutes (of a lesson). They are allowed to freely organise suitable material (also sourced beyond the school area).

B: During the implementation of the given task, the students exchange their biological knowledge and its usage relevant for everyday life or

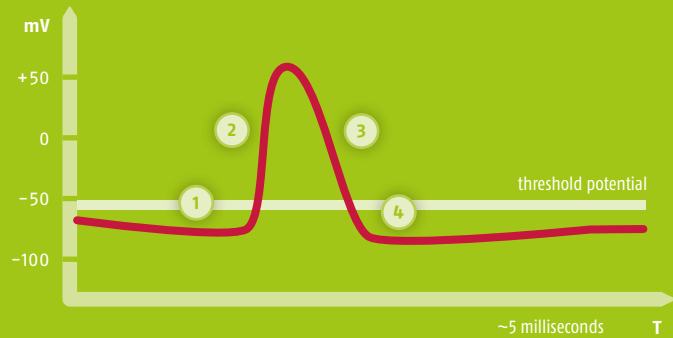


relevant for society. Furthermore, they make adequate use of the technical language and representations in the field of neurophysiology. They plan, structure, communicate and reflect their work. As a result, they illustrate or explain biological facts and procedures using a subject-related language and with the help of suitable models and representations. These core competences are strengthened with the task of modelling in a constructivist manner and with it contribute to the student’s higher level of remembrance and knowledge. ¹³



12B

Phases of an action-potential in axons



C: Then, in the **PRESENTATION PHASE** of the models, the students' creativity appears: In Lutz Wendel's case, a group had stocked up on cardboard shoe boxes in a neighbouring shoe store. They were intended to show the parts of an axon, cotton pads of different size and colour showed the types of ions involved. Now the expiry of the action potential was shown – rather laboriously – by transporting the cotton pads either into the cardboard box or by taking them out.

Another group could not agree on any approach for a longer time, until they had found – aware of the time pressure – an easy and accordingly sensuous solution: The students of this group used the fact that the Biology classroom is on the ground floor and has numerous windows. The windows were assigned to the respective ion channels (Na/K-channels, see illustration), classmates (in an appropriate colour code) were converted into types of ion. To show the expiry and the reproduction of the action potential, now the students had to climb through the windows in a suitable place. This also led to a learning effect with students who had already introduced another model, but now wanted to “take part” once again.

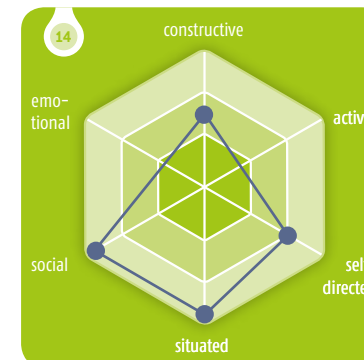
4.3. “Terraforming via Moodle” (Facebook/ any Internet platform)

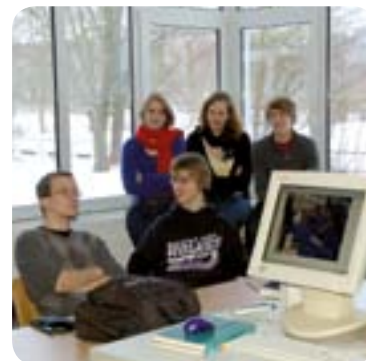
In the following teaching model, the idea and the practical experience of the Finnish colleague Merja Kuisma (Geography and Biology) is adapted to science-orientated interdisciplinary Biology lessons. Terraforming is a specialisation of astrobiology where the conditions and necessary requirements for human life, e.g. on a planet like Mars, are calculated and planned.¹⁴

The teaching model offers students – on the basis of their individual IT experience, for example by applying chats such as “moodle” or “facebook” – a discussion and analysis of:

- the precious property of the Earth's atmosphere (everyday topic);
- the specific ingredients of a gas of vital importance as an important component of any biosphere (specialised knowledge);
- communicative competence in teams (social interaction);
- self-directed educational progress / development of scientific issues and topics (interdisciplinary activities);
- the processing of experiences and knowledge towards a presentation (publication);
- a critical analysis of human determination (science versus fiction).

The everyday infiltration of youthful thinking with fictional motives – above all by media influences – should be used in this teaching model to enhance science orientation creatively and sensibly. The moderation by the teacher, i.e. the moderation of learning scientific contents, happens





virtually "online" (possibly with the help of external experts / organisations like ESA) in a defined learning group. The teacher can directly comment and correct (if necessary) the Internet-based progress of the lessons.

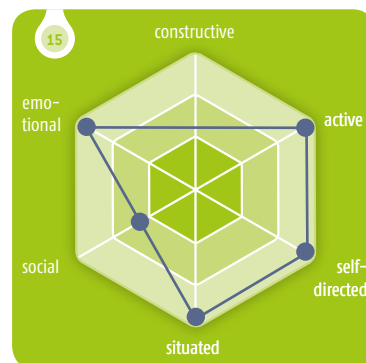
INDIVIDUAL STEPS:

A: Merja Kuisma suggests approaching the topic with the task of developing a **LIST OF QUESTIONS** in teamwork (2-3) which should be answered systematically by means of available online/offline sources of information, e.g. ESA/NASA websites, specialist papers from textbooks and illustrations. Examples:

- "How is life defined then, actually?"
- "Mars has no water, or does it?"
- "What does the 'habitable zone' have to do with the Sun?", etc.

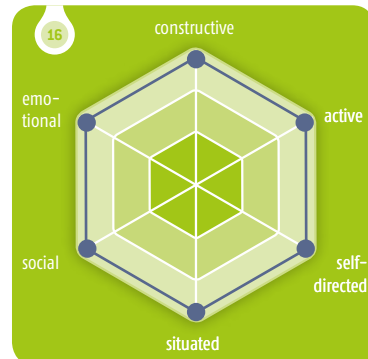
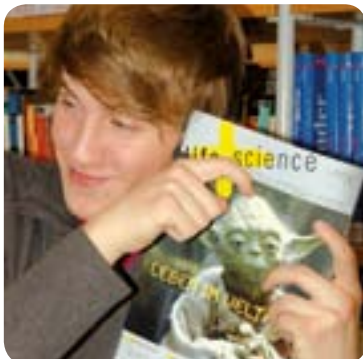
B: During the following Internet search or the search in a traditional library to answer one's own questions as well as interesting questions of others, different individual interests (e.g. Chemistry / Social Sciences / journalism) and strategies (e.g. visual learning type with a greater need for illustrations that support imagination) come into being. These own interests will, on the one hand, adapt to the interests in the learning group, or can, on the other hand, be steered by the moderating teacher for the purposes of using specialised terms and scientific language: e.g. "Attention: your preferential website www.xy.com is Geography for dummies! No uniform graduation / Questionable weighting of economic interests / etc." or: "Watch out: faulty terms!"

According to the objective and its intended level of quality to be achieved by the individual student, a discussion of the topic at different levels of intensity and complexity is needed. Merja Kuisma stresses the advantage of the open working form (e.g. in moodle) concerning the confidence-building measures between teacher and students in longer working phases. On the one hand, students want to impress the teacher with their tempo of the procurement of information and processing, on the other hand, the teacher shows her / his far-sighted education approach thanks to her / his experiences and can offer tips about the quality of the used sources. This often shows impact on the learning progress of the students' education. Therefore, the more or less self-directed initiative of the learner receives the greatest possible elbowroom, limited only by the factors time and infrastructure (Internet-working desks / library rooms / other study places).¹⁵





C: In such a teaching sequence, special value must be attached to the final **PRESENTATION OF THE LEARNING PROGRESS AND THE RESULTS**. First the students should compare their own lists of questions of the 1st lesson to realise the magnitude of the knowledge increase. Then every working group decides whether it would rather like to examine the progress of the other groups or to introduce their own results. This results in a specific grouping into “experts” and “journalists”: The experts present their findings and discuss their results in the form of a “professional congress”, whereas the journalists report about the event and ask critical questions. The teacher takes down necessary marks and grades in the course of the presentation event or later judges the achievement of the journalists, mostly in the form of a newspaper report or school-TV report. An invitation of other school audiences, an exhibition of graphic learning contents or the (compulsory) production of an instructional film for the Internet platform are obvious possibilities to present the findings. ¹⁶



4.4. The excursion in science lessons

In the following remarks of the German colleague **MICHAEL LENSKI** (Berlin), the teacher-student interaction during an excursion is in the focus. The example refers to the methodology in such a way that it can be helpful for all fields of natural sciences. The excursion (of several hours or even days) is always a “touchy” and critical method. It “disturbs” the experienced teaching schedule of the days concerned and is therefore subjected to critical questions concerning efficiency and long-lasting effects. Ideally, the students involved are also moved by the problem, because the change of the learning place goes together with non-everyday expenditure. Therefore, an excursion which is effective in terms of learning is surely a lasting impression for the students.

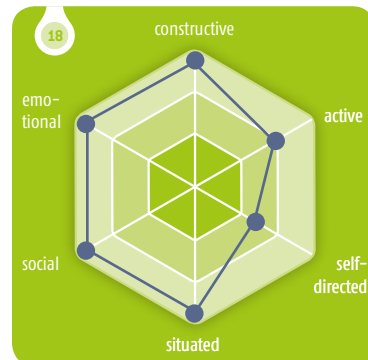
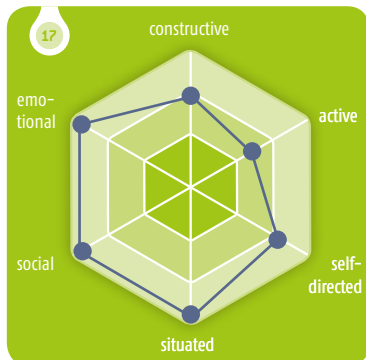
Michael Lenski practises as a biologist in a big city under complicated conditions – when nature (in this case “touched” by people) is questioned; when the students’ talent for observing human behaviour shall be trained, the big city will be the proverbial “playground” then.

A: He stresses the value of a conventional **INSTRUCTION PHASE**, in the form of the teacher directly pointing out the phenomena to be observed. One analytic method for the treatment of the respective question will be provided immediately, for example:



- detection of plants/insects/birds and their registration in catalogues;
- demonstration of measurements of the ph-value of fluids;
- use of measuring instruments for aerial tests/traffic noise;
- registration of measured values in given computer programmes;
- advice for documentations by means of sketches and photos.¹⁷

B: The success of the following **STUDENT TEAMWORK** is, even at a high degree of own initiative, linearly depending on the skilful conversion of the teacher demonstration. Then, only nature itself “is in the way” of the creative potential of the student teams, so that the students’ conceptual reconstruction of “nature” can be experienced “in vivo” according to the central setting of tasks. Particularly with excursions that last a whole day (or even longer), the importance of **SOCIAL INTERACTIONS** throughout the learning process increases, if the teacher limits her/his moderation to the technical minimum. The organisational course of the

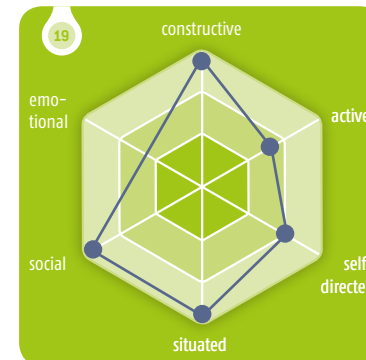


excursion (esp. in terms of food, lodging, transportation) can be the students’ responsibility. The excursion then resembles an expedition, which contributes to the lasting impression on the students and the teacher. Hence, Michael Lenski reminds of excursions as a learning-intensive and at the same time successful teaching experience.¹⁸

C: The final **PRESENTATION OF THE LEARNERS’ RESULTS** of the respective teams at the same time contains a new component of *reconstruction*: In brief, subject-related answers and results of the respective questions must be formulated and presented.¹⁹ Hence, the “classical” excursion report on the part of the students should give way to a “lecture” by the team. Often, there is an opportunity to provide an insight into the results of their work for an external group of schoolmates, their parallel class, parents, etc. The evaluation of the excursion hours and the teacher’s (official) judgement/grading meet here – forming a sensible relation to the learning process.

Michael Lenski thus confirms the “lively realism” of the accumulated experiences, while he points out that basic experiences at the same time form the basis of constructivist methods.

In both teaching examples below, a technical-media component takes effect in the students’ activity. The students produce technically advanced images with their (private) digital cameras during the learning process. Intentionally, the production is confronted here with the more frequently carried out (more passive) reception of digital media.



4.5. Spectral analysis – “light”

Martin Falk (Germany) introduces a proposal for an advanced discussion of **SPECTRAL ANALYSIS IN PHYSICS AND CHEMISTRY** from his experience with astronomical study groups. Technically, the main focus refers to the higher levels of secondary school.

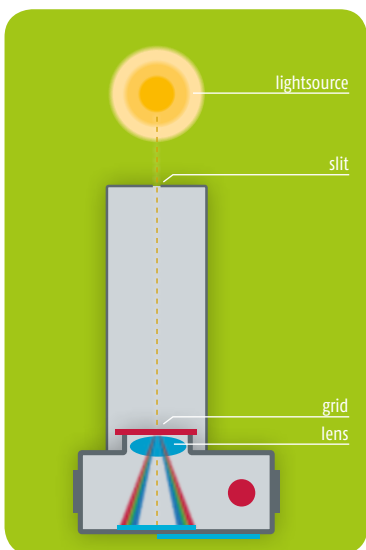
The common “pocket spectrometer” can be copied in an inexpensive and relatively easy way as an adapter for modern digital cameras so that the observed spectrum can easily be documented. Thus photographing produces an image which can be edited and analysed with the help of free Internet software. The quality is comparable with spectra from schoolbooks.

With the digital camera and the software, a practical aid is available to the student/teacher to document common experiments and observations on the subject “spectral analysis” of the respective lessons. The visual impression can thereby be measured qualitatively and quantitatively. The constructivist component arises from the students’ higher level of practical activity and thus motivates enhanced learning.

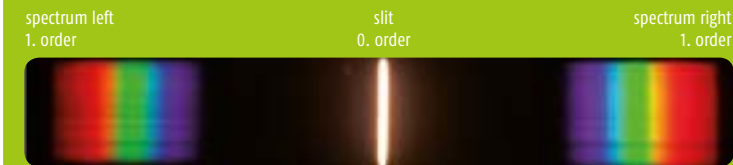
SINGLE WORKING STEPS AND TECHNICAL INFORMATION:

A: The “do-it-yourself construction” spectrometer is ready for use with low expenditure in about 20 minutes. Merely the handling and setting of the camera close to the source of light which is to be photographed must be practised (by means of trial and error). It resembles the use of optical devices like microscopes, as well as suitable experimental setups (optics, flame colouring, etc.). This promotes psychomotoric skills and technical practice with specific devices and can be learnt well in small groups.

A holographic **TRANSMISSION GRID FOIL WITH 500 LINES/MM** – e.g. of the company Edmund-Optics (as a stripe of the piece – alternatively in the version of a slide frame – costs: ~15€ for a classroom set) diffracts



Original spectrum of halogen lamp



the light of any source as a continuum or emission/absorption spectrum if the foil is held accordingly before the eyes. Instead of the short visual impression the camera offers, thanks to the high sensitivity of modern picture sensors, a photo of the spectra “from the (skilled) hand” is obtained. The “slit” necessary for the spectral analysis represents a tiny slit in the wall of a small box (edge length approx. 10 cm) opposite to the camera lens which is mounted or fixed on the camera. The lens is (manually) focused in the mode “close-up” on the slit (see technical drawing).

B: (Ir)respective of the background knowledge of the students about spectral analysis (2–4 students grouped according to age) after the preparation of the available camera, the teams are busy with the documentation of the spectra of (many) different sources of light placed before the slit. This takes up approximately one lesson, according to experience, intensity and number of sources. Typical sources of light are the neon tubes of the room lighting, flames of candles or gas-burners,

Magnified photo-cuts of slit and spectra

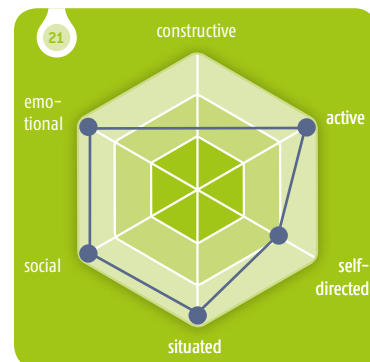
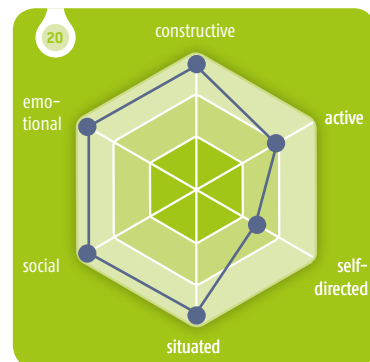


TFT screens, coloured LEDs and not least the (direct or reflected) sunlight. Visually impressive spectra are guaranteed by the careful preparation of the camera and skilful handling when they appear on the monitor of the computer workstation in the next stage.²⁰

C: The "rainbow colours" at first sight already hint to the spectral energy distribution (according to their relative brightness) and now should be evaluated with software available over the Internet (e.g. "IRIS" by www.astrosurf.com/buil). The extensive literature of the Internet regarding spectral analysis up to the spectral classes of the stars offers a wide field of work for different student interests and objectives as well as resources for detailed knowledge building, acquired in a well-balanced combination of theory and practice.

The next task is the labelling (by means of picture software such as *Photoshop*, etc.) of the single spectrum pictures with the name of the source of light and assorting according to the types (continuum, emission/absorption and possible line strength). Then the special IRIS-software (after a short tutorial on the website) offers the opportunity to compare the results of the students' teamwork with professional school-book spectra concerning resolution and wavelength of prominent lines.

D: The (ppt) **PRESENTATIONS** of the respective working groups form the end of the unit with explanatory comments on the spectral phenomena, from the spectrum of a neon lamp up to the attempt to take a photo of a star spectrum.



The last step is a (relatively easy, thematically, however, demanding) practical student experiment in the astronomy lessons, applying the knowledge acquired in the lessons "at night and outdoors". The camera is lying on the back (now only with the foil fixed in front of the lens and focused on "infinity") and "spectral-analyses" the brightest stars in approx. 10 seconds long exposures through the transmission grid foil.²¹

4.6. "Genes go Hollywood"

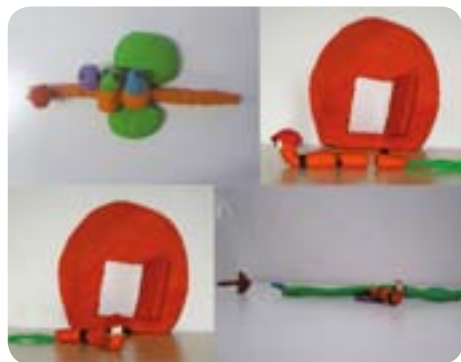
Lutz Wendel (see section 4.2.) consistently comes to an end of the cognitive model education in the learning process with a **STUDENT PRODUCTION OF AN INSTRUCTIONAL MOVIE/VIDEO**.

In parallel sessions of the **BIOLOGY TEACHING UNIT "PROTEIN BIOSYNTHESIS"**, the upper level (12/13) students summarise their acquired knowledge by means of digital media in such a way that the self-provided animation stimulates the necessary recapitulation of complicated processes (e.g. for the Abitur/graduation/exams). However, as "a by-product", a "self-made" video (on the homepage of the school) also stimulates the motivation of younger students to identify with the contents of the subject Biology. A shortcut of the film is available as a download from the Science on Stage Germany homepage.

SINGLE WORKING STEPS:

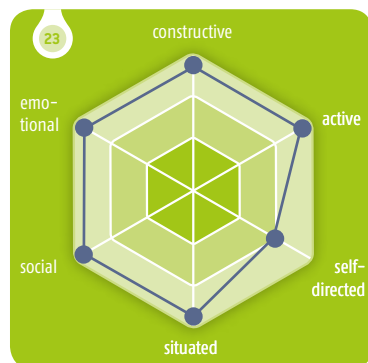
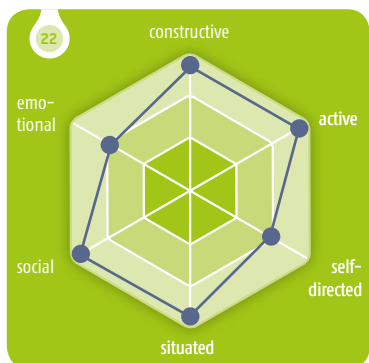
A: The teacher sets the task to find a suitable model representation for a dynamic system. As static models easily hit the limits of comprehension,





the students consistently develop the idea of providing a cartoon/an animation. Thus the **PROCESS OF THE SYNTHESIS** is photographed picture by picture with **HANDMADE SYMBOLS OF PLASTICINE** and afterwards compiled into a movie by means of the software "iMovie", "Moviemaker", etc. (see also "Slowmation" on the Internet). A side effect arises for several students with the opportunity to introduce already acquired practical skills in dealing with picture media and to speed up the group work. ²²

B: A permanent **COMPARISON OF THE EXPERTISES WITH THE TEXTBOOKS** parallel to the modelling phase is necessary in order to avoid subject-related mistakes. With the creativity of the single working groups, an age-appropriate "fun factor" comes along stylistically. On the one hand, it appears to be simplifying, on the other hand, it emphasises the constructivist component "emotion". An intermediate solution would be an expert GIF animation by students with special background knowledge.



However, the complicated processes and the difficult modelling are rarely perfect in practice, which is in itself a new opportunity to improve one's knowledge during the final "public viewing" of the results of work.

C: Because the protein biosynthesis is dividable into three bigger segments (transcription, maturation of RNA, translation), the students should work using an appropriate division of labour. It turns out that it is difficult for the students to commit themselves to a common symbolism and to stick to a pre-planned schedule and flow chart for the relatively long time (possibly 6 lessons). Besides, the processes of group dynamics (choice of a project manager, contacts with experts, solutions for infra-structural / media problems) give insights and experiences in professional working practice and lab practice, even if a playful component still pre-dominates.

D: For the role of the "moderator", a certain liberty arises, depending on whether she/he should merely be accessible as an adviser, take part in active modelling or steer weaker working groups with good advice. She / he may found a jury for the "film festival" or be in charge of public relations (press, regional competitions) of the school's Biology department.

The idea of Lutz Wendel and the results of his students are at the same time a sensible proposal to use self-made videos/movies as a modern "infotainment" for students' mobile phones. ²³

5. Concluding remarks

The co-ordinators of the "moderation workshop" had to shorten the teaching ideas and proposals of the co-operating colleagues significantly. Besides, the interested reader should not miss the fact that – albeit in a short form – innovative teaching sequences or teaching units are introduced here:

- where motivating activations of the students can succeed in science lessons,
- which require intensive cooperation and exchange between the students,
- which allow the students to try out own ideas in the lessons and to go their own ways,

- which are embedded in true-to-life contexts and permitting the students' imaginations to relate to them,
- which are demanding, they should provide curriculum-based contents and
- are therefore more than proposals for "exotic teaching lessons".

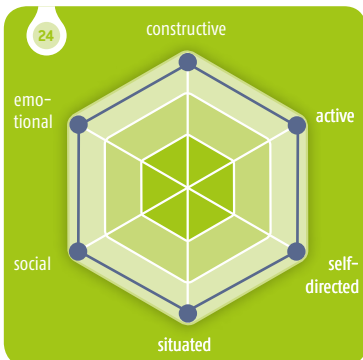
With these examples, teaching situations should be created nurturing a positive learning atmosphere. Besides, the teacher faces the challenge to maintain the structural terms of learning with all its freedom within the defined frame (no anarchic lessons), to support groups of students which need aid and instructions to pay attention to actual usage of learning-time and to provide information which of course can be used in alternative ways. The benefit of the moderation lies in the fact that the "energy" of the teacher is not distributed indiscriminately in all directions, but applied directly where individual support is required.

More detailed handouts about the ideas introduced here are available on the homepage of Science on Stage Germany. From summer, 2010 work will go on in improving them in the workshops related to the release of this issue.

We are looking forward to e-mails via Science on Stage Germany to share your experiences, comments, criticism and ongoing communication of ideas.

We cordially thank the co-operating colleagues of our workshops for their commitment and the devotion to spreading positive emotional learning experiences in science lessons.

MARTIN FALK, DIRK KRÜGER AND WOLFGANG WELZ



Overview of activities

Project events

2008

23rd–26th October

Kick-off workshop during the Science on Stage festival in Berlin (Germany)

2009

30th–31st January

Coordinator meeting in Berlin

19th–21st June

Follow-up workshop at Gläsernes Labor Berlin-Buch (Germany)

25th September

Coordinator meeting during the EduNetwork 09 in Saarbrücken (Germany)

13th–14th November

Workshop "Science and Language" (Subgroup of "Science in kindergarten and primary school")

2010

11th–12th June

Presentation of the publication at the final meeting at Gläsernes Labor in Berlin (Germany)

Participants

Working Groups – topics:

- A** Science in Kindergarten and Primary School
- B** Benefits of Non-formal Education Initiatives
- C** Moderation of Learning Science

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Ms.	Brücher	Ilka	Germany	A
Ms.	Curtis	Amanda	UK	A
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Mr.	Scherer	André	Germany	A
Ms.	Serra	Maria	Italy	C
Mr.	Serrano	Antonio	Spain	B
Ms.	Skiebe-Corrette	Petra	Germany	A
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Ms.	Tomczyk	Alexandra	Germany	C
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Ms.	Yilmaz	Nese	Germany	A

Feedback Questionnaire

Publication „Teaching Science in Europe 3“

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| <input type="radio"/> Other: | | |

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Which question(s) or which topic(s) would you like to work on in a European teachers' workshop?

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„Teaching Science in Europe 1“

with the topics:

- Science in primary school
- The interdisciplinary approach of teaching science in Europe
- The role of the experiment in teaching Science on Stage
- Astronomy in the classroom

„Teaching Science in Europe 2“

with the topics:

- Science in kindergarten and primary school
- Self-evaluation of teachers
- Interdisciplinary teaching

in German in English

to the following address:

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The booklet is free of charge, we kindly ask you to recompense the postage.

Introduction to Science on Stage Deutschland

The non-profit organisation Science on Stage Deutschland (SonSD) establishes a network for German science teachers, promoting exchange with pedagogues from other European countries.

It organises workshops and training programmes to disseminate interesting experiments and new teaching concepts from all over Europe in Germany.

The organisation promotes scientific and technical education in Germany and in Europe.

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