

The following lecture was given by Barbara Winter to participants of the international colloquium “Trends in Science Education and scientific culture in Europe and Asia” in Macao, 17-18 June 1999

Promotion of key skills in science education

A concept for upper secondary schools

1 The school / general conditions

I am teaching at an upper secondary school in Bremen, Germany with about 2400 students, 150 teachers and 50 master craftsmen with teaching positions. The school consists of four departments. One of them leads the students to the certificate named „Abitur“, the advanced level exam qualifying for university studies.

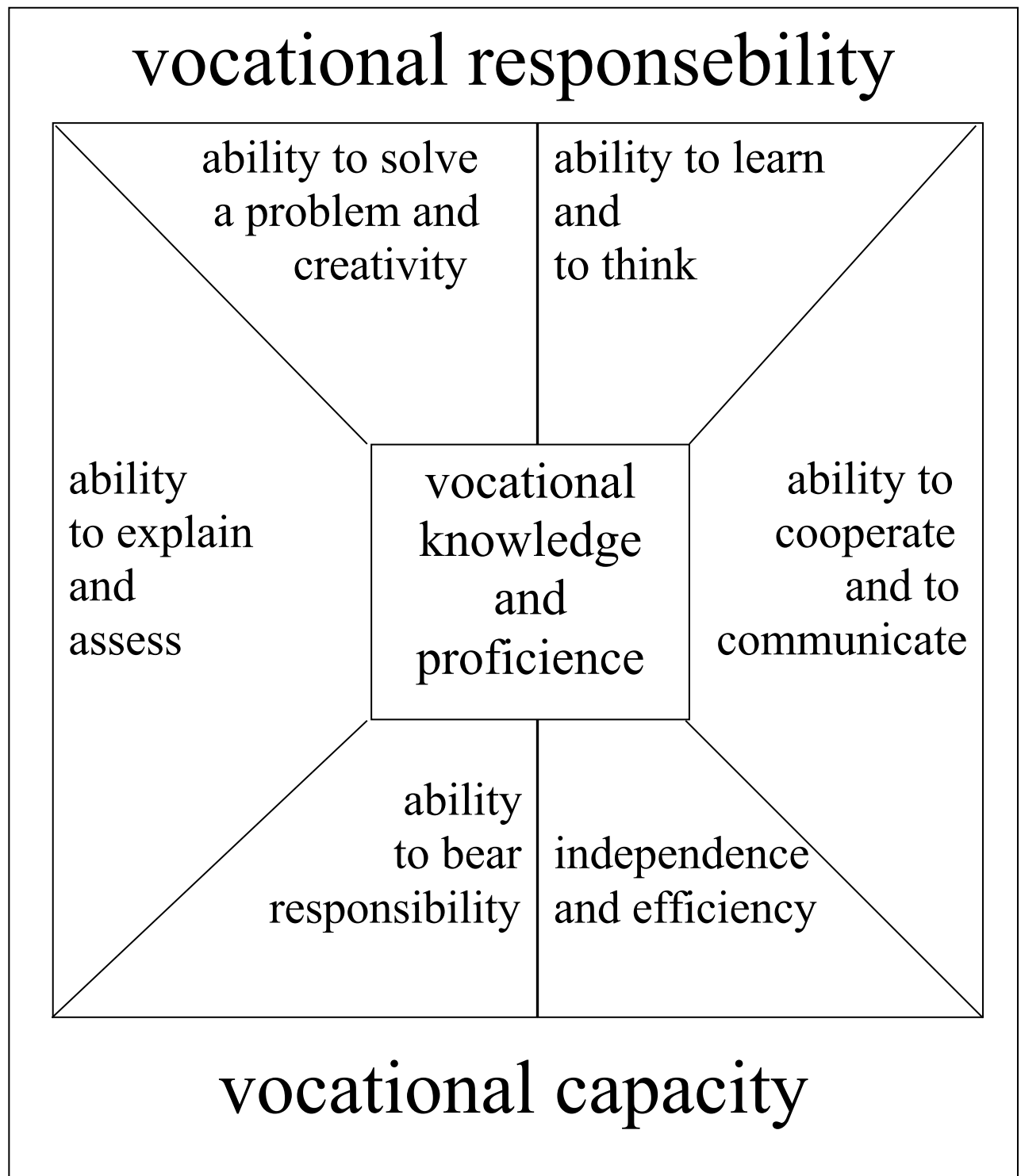
About 300 students in our courses stay three years at this school in grades 11 to 13. Teaching is not organised in classes but in a course system. Each student enrolls in two special subjects (advanced courses) and seven basic courses. Science is regarded as a difficult subject and not so many students take these courses in comparison to languages. But I’m sure we all think science must be part of a sustainable education.

2 Promotion of key skills in school

Vocational success is based not only on academic or technical qualifications. Social competence and knowledge in methods are as important. The students do not only have to learn facts, they must be trained in teamwork as well as in a lot of other soft qualifications named "key skills".

What are key skills?

Vocational responsibility and vocational capacity are generic terms, key skills are assigned to them.



Key skills assigned to „vocational responsebility“ and to „vocational capacity“ based on a description of „Brassard, et al: Wege zur beruflichen Mündigkeit, Weinheim 1992, Deutscher Studien Verlag“.

Key skills are not only connected to special activities, to specific jobs. Not just people in executive functions must be qualified in key skills. In companies work often is organised in projects, a form of organisation to work on and solve complex problems, carrying out extensive tasks. Employees have to work in teams, which requires qualifications in a lot of the named key skills. Individuals who are well-trained in key skills are better prepared for later challenges in a changing world (life-long learning).

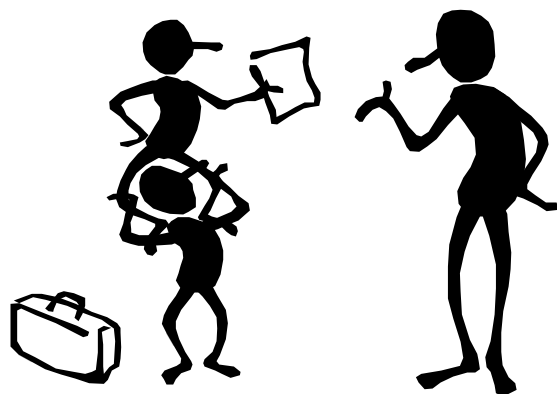
What can we do especially in school to develop qualifications like key skills for our students?

We have to arrange situations in education with challenges comparable to reality. Not only specialised knowledge in subjects like chemistry, biology or physics are to be aimed at. Complex questions have to be presented to our students, questions which cannot be answered by simple facts from the point of view of one specific discipline. Thus young people have to work in a team, discussing all aspects of the situation, throwing light from all sides.

3 Which key skills did we select?

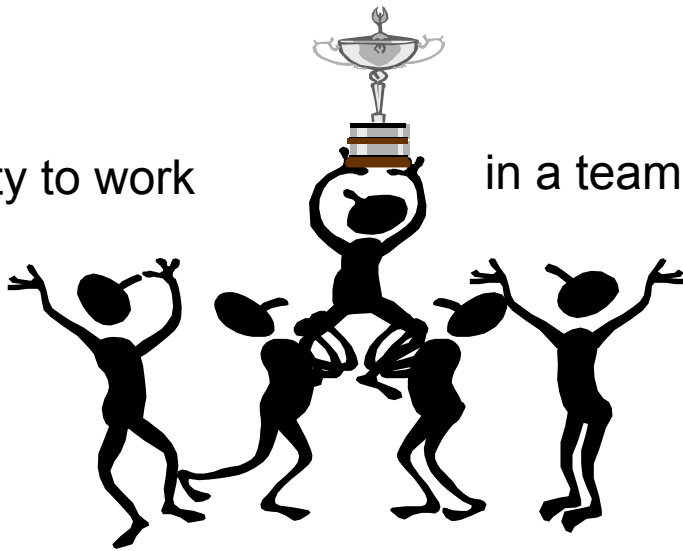
More than 600 key skills are named in an investigation by the German „Institut für Bildungsforschung“ in Bonn. The most important key skills are

ability to communicate
and to cooperate



ability to work

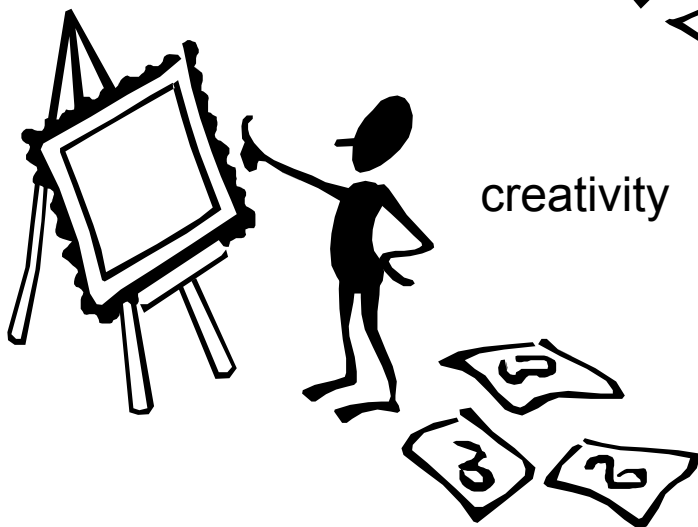
in a team



ability to solve a
problem



creativity



ability to present the
results of work

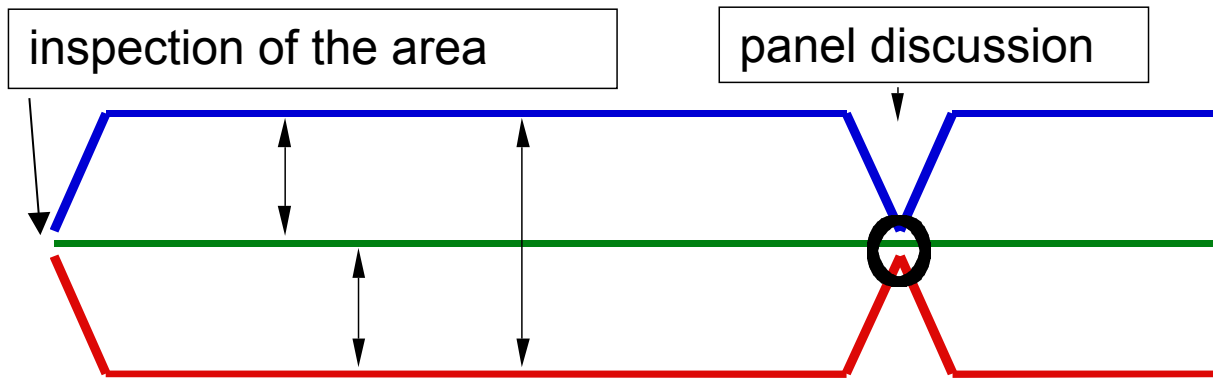


Each school subject somehow supports the development of key skills. But we - that is our team of biology, chemistry and physics teachers - missed the description of a specific contribution from science education. Soft skills cannot be learned in a few lessons, a program is necessary. The students must be in training like a sportsman. Therefore we arranged a program for 6 semesters. The topics were worked out in team sessions between the teachers from all the science courses. They form the knowledge basis for a common activity in the later part of the semester where students from different courses and subjects work together e.g. in preparing a science exhibition in their school. But let us have a look on the six semesters.

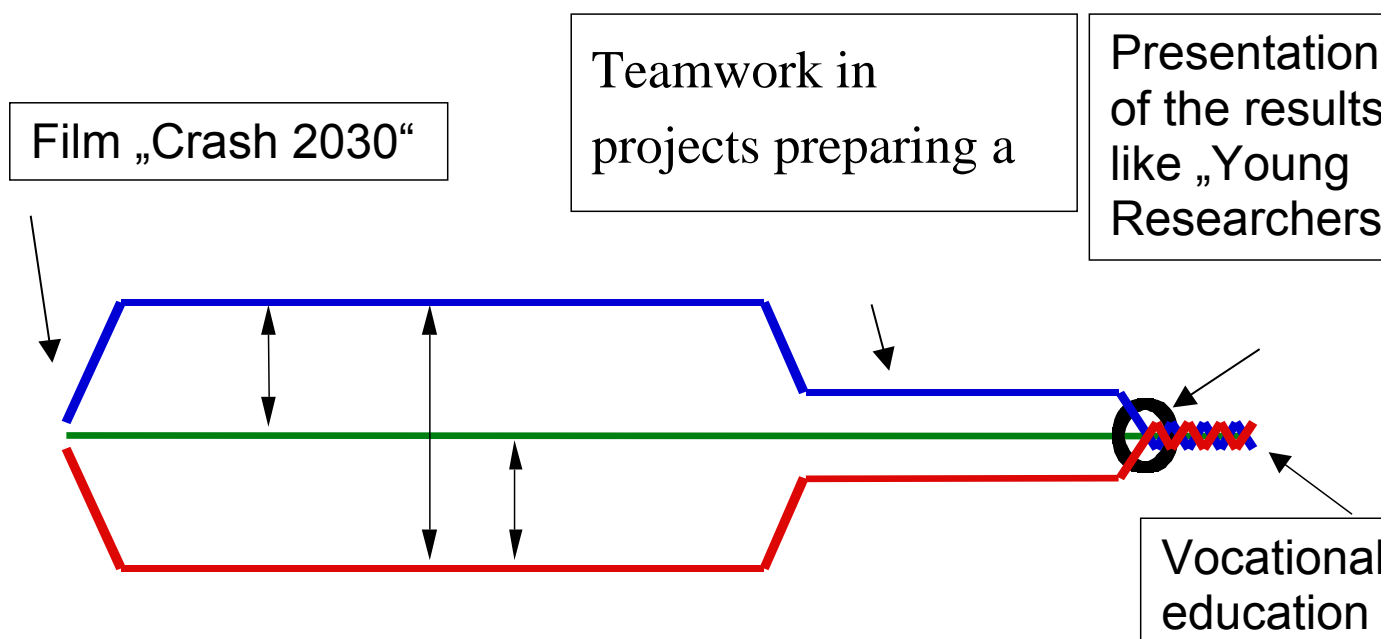
4 Concept for six semesters

Teachers and students from five courses in biology, chemistry and physics cooperate with each other. The teachers laid down the common structure, valid for all semesters. The following graphics show the course of the first three semesters. Each line symbolises one subject. Are these lines close together, the students cooperate closely.

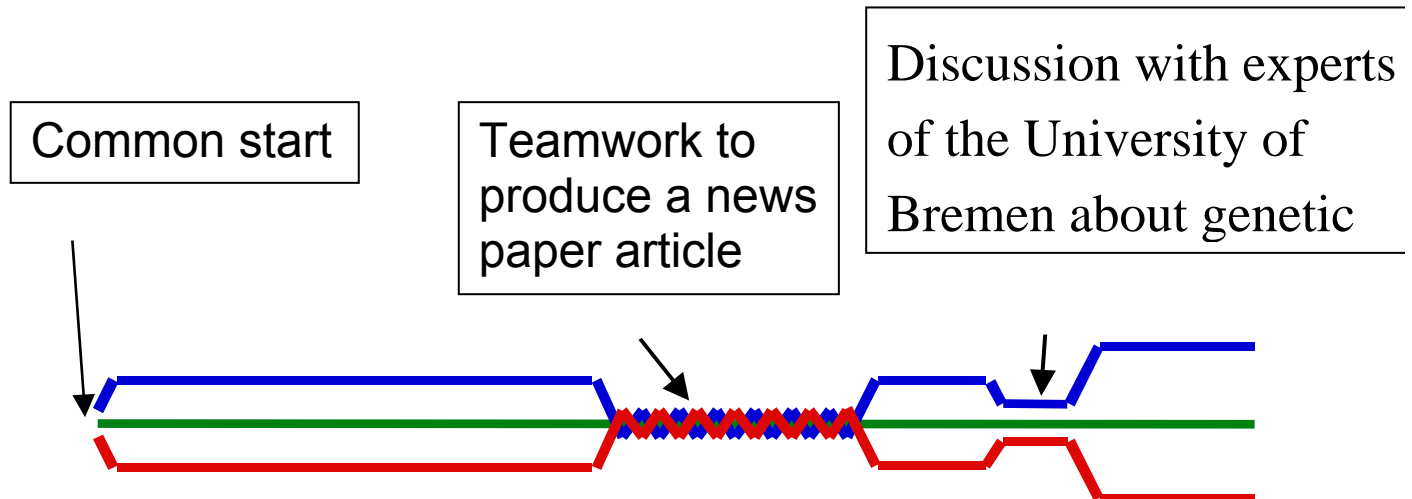
1. Semester: Investigation of a lake



2. Semester: Atmosphere of the earth – greenhouse effect



3. Semester: Genetic engineering



Teaching starts with a common starter for each course involved. This can be a film about the subject, a newspaper article or a special event like a "path of experience" (about optics phenomena). So we stimulate the students' motivation for their coming work. For the later projects the students must be prepared to be experts in their chosen discipline. They need well-founded know-how to explain topics from their special fields to their peers in the following teamwork sessions. All the members of the group have to communicate with and to learn from each other. So in the first about 8 weeks we teach them specific knowledge from their chosen subjects (biology, physics, chemistry).

One high-light of the semester is the phase of project work, lasting 4 to 6 weeks. In this time the borderlines between the subjects are dissolved. The students form teams with members from the courses in biology, chemistry and physics and work more or less independent. They go to the library, search for literature, produce illustrative material, produce a radio feature etc. The teacher is an adviser and observer, every time responsive. He/She is no longer in the centre of teaching, no longer the organiser of everything concerning the lesson. The aim of this phase of project work is to make a

product, e.g. the preparation for a panel discussion about a specified subject (e.g. "Is chocolate a drug?"), planning and realisation of posters and objects for a scientific exhibition ("Young Researchers") or a science centre, writing a reader about a medical theme etc. The teachers communicate their opinions about these products and assess them. Each team gets a mark for their working process and their products.

Finally the students go back to their courses and exchange experiences, criticise their own work, the teacher's support and so on. Sometime we had good reviews, sometimes the students gave us good suggestions for improvement.

The demands on the students rise from semester to semester. Starting with a simple task that can be realised with their friends from a single course, the students learned step by step to organise their work, to communicate and to co-operate with members from other courses on more complex problems.

For a better understanding let's look at two semesters in detail.

5 Semester "Genetic engineering"

Start:



„Are these Products made by using naturally grown substance?“

„How can we recognise genetically manipulated food?“

„How does genetic engineering work?“

As an entry into the common work the teachers presented the students with food like intensively red tomatoes, maize, special sweets containing soybean flour and a lot more accompanied by the question: "Are these products made by using naturally grown substance?" or "Would you like to eat it?". The students discussed the questions, tried to remember the situation of gene food in Europe (Is it allowed or not?) and "How can we

recognise genetically manipulated food?”. Other questions like “How does genetic engineering work?” and “Are there other example for the use of genetic engineering?” followed. The necessity to learn about methods of genetic engineering became clear.

2. Phase: Teaching lessons in biology, chemistry and physics, just as the students choose them, becoming experts in their special subjects.

In the following phase the students were taught in their courses, divided into biology, chemistry and physics according to their school subject choices. Everybody had to become an expert in his special subject. So e.g. in biology the young people worked on chromosomes, DNA and genes, in chemistry on amino acids, proteins and a special electric field method named electric phorese, in physics on the electric field and the movement of ions in electric fields. After 10 weeks full of instruction there were a lot of specialists in aspects of genetics, each from the special point of view of one subject. The acquired knowledge had to be exchanged between the students. Therefore we created a special situation in the following phase of project work.

3. Phase: Teamwork to produce a newspaper article about the scientific background of a story like



- Murder in the town green
- Martina N. – a child suffering from Aids
- Meat scandal in the harbour

The students of all the courses in the three science subjects were regrouped into teams of five persons - two students from biology, two from chemistry and one student from physics. These teams had to work together during the following five weeks. We did it in this way, because we intended to have a

situation similar to a company, where people have to work together even if they are not friends. So we, the teachers, decided who became member of which team. These groups had to choose a specially constructed problem, which we prepared around genetic engineering. They were:

Murder in the town green

Martina N. – a child suffering from Aids

Meat scandal in the harbour

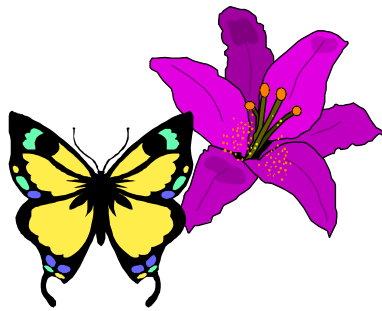
Each problem consists of a story in the form of a newspaper article. For example the story of the murder in the town green describes an excursion of six brothers with a carriage. In the evening the driver of the carriage is found in the town green - he was murdered. A trail of blood is considered to be a indication of the murderer. Only one of the six brothers can be the criminal. Genetic methods must be used, because the suspects are related in their blood types. The students are only given the story, enriched with catchwords of forensic methods. Their task is to write an article for the science pages of a newspaper, which explains the methods used in the investigations. The article is to be aimed at the general public, i.e. the interested layman, the newspaper reader.

To solve this task the students have to work out the central issues, to communicate with experts from other subjects, to co-operate, to work well in a team, to organise their working process, to choose a proper language, and to present the results of the work in an attractive form. Thus, they have to practise a lot of key skills.

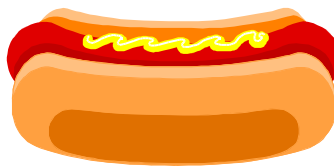
4. Phase: Completion of the specialized knowledge in science

6 Semester “Light and colour”

Start: “Path of experience” about optics phenomena
50 exhibits for example

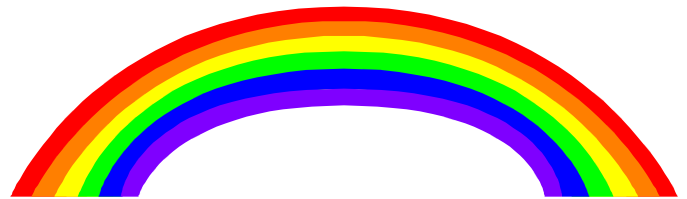


Colour in nature
Optical illusion



Colour in food

Colour and light



In the fourth semester the theme is “Light and Colour”. We start with a special event - a "path of experience". The young people had to walk through five rooms and look at various experiments all around light and colour. We want them to be inspired and to have good ideas for the coming scientific museum (science centre) to be made by themselves.

2. Phase: Teaching lessons in biology, chemistry and physics, just as the students choose them, becoming experts in their special subjects.

But before the museum can be opened for the project phase, several weeks of hard work must be done. First the students develop ideas and limit them to something that can realistically be achieved. In the mean time in each course the students are taught basic subject-bound knowledge. A few weeks before the team work starts, the teachers meet and group all the

students' ideas under headings. In our first trial the scientific museum was organised in seven departments:

1. Light and lamps
2. Pictures and copying
3. Winning and analysing colours
4. Colours in food and clothes
5. Colours and style
6. Colours in the animal kingdom
7. Perception of colours

Each department has a head leader, one of the teachers, and three student-teams working on different themes under the generic term, organising themselves in the same way as in the semester before. Creativity and exact time management were the main key skills except for ability to work in a team. After five weeks we got round about 20 subject areas with a lot more exhibits. The exhibition could be opened to the school public. Teachers, peers and parents were invited to the event.

7 Results

Students

- cooperate better than before.
- can organise their work better than before.
- profit from the methods they learned like mind mapping, brainstorming, etc..
- used this methods intensive to prepare themselves for the exams.
- can present themselves and their results of work better than before.
- got better jobs after finishing school.

Last not least:

- Teachers learned the same things too.