Bildung und Kultur

Sokrates

science-live!

TEACHER- SCIENTIST-PARTNERSHIPS

129289-CP-1-2006-1-DE-COMENIUS-C21

Geschwister-Scholl-Realschule Mannheim

hochschule mannheim

Institut für Energie- und Umwelttechnik

Pädagogische Hochschule Heidelberg

1 Preconditions

1.1 Geschwister-Scholl-Realschule

The Geschwister-Scholl-Realschule in Mannheim (http://www.gsr-mannheim.de/) is a full-time school for lower secondary education with an obligatory program for the students. There are 43 teachers currently teaching 480 students in 18 classes at the school. More than 20 % of the students have a migration background. Both, the headmaster Wilfried Manes as well as the deputy headmaster Hendrik Tzschaschel are directly involved in the TSP-project.

Quite recently, the school has formulated its concept which was presented at a public event:

- "Following the ideals of Hans and Sophie Scholl[1], we further freedom of opinion, sense of responsibility, and mutual respect at our full-time school.
- Our school has the courage to try out new approaches for teaching and learning.
- We define ourselves as a school community in which the strong points and the talents of each individual are encouraged to grow and are nurtured with respect to independence and self-responsibility.
- In our everyday school-life, phases of concentrated working, relaxation, and physical exercise take alternate turns.
- In our understanding, school is an inviting place to learn and live within. Mutual consideration, observing the agreed upon rules as well as respect towards people and objects are important to us.
- Due to our co-operation partners and external connections, we open new environments for learning and living.
- At our school, teachers, parents, and students are acting as one team which designs and develops its school life in confidential co-operation."

Due to the new formal curriculum several work groups have been established for some years: further development of science teaching, encouraging and supporting the self-directed learning of the students, school development – bringing rhythm into the full-time running (of the school), development of a special support program for students with migration backgrounds, realization of a support program for “reading and language proficiency”.

Science teaching is a priority within the profile of the Geschwister-Scholl-Realschule. The science teachers (the “NWA-Fachschaft”) of the Geschwister-Scholl-Realschule has developed a new approach to teaching science at a high level. At an early stage, students are working out topic areas within the framework of the project program independently and in self-responsibility.

The school curriculum of integrated science teaching includes a close co-operation with the topic “project oriented technical working” (grade 6) and the subject “technology” (grades 7 to 10). The science training workshop of grade 8 supports talented students in science classes. Both, teachers and students are responsible for defining the syllabus. Within the scope of this project the school is involved in the special event "Explore Science" in co-operation with the Thoraxklinik Heidelberg.

The Geschwister-Scholl-Realschule is working with scientific institutes in the field of climate research and cooperates with the University of Education. The latter is responsible for the

[1] Hans and Sophie Scholl were members of a group of students active against the Hitler regime during second world war. They were sentenced to death in 1943 and killed by guillotine. “Geschwister-Scholl-Schule” is a name most often chosen for schools in Germany.

education of teachers in order to optimize the concept of science teaching. Students are introduced to authentic scientific research within the scope of a climate research project. Scientific personnel of a research institute research work together with the students at an open problem in the field of increasing CO_2 concentration in the atmosphere. At school, scientific personnel are integrated as experts in project classes.

From the participation in the TSP project, the school expects support for its science teaching, well-directed assistance from experts from university and University of Education, and in this context a willingness for communication from all partners.

1.2 Hochschule Mannheim

The Hochschule Mannheim (www.hs-mannheim.de) consists of nine faculties. It has a staff of 160 professors, 160 other academic staff members, and 55 non-scientific staff members. At present, there are 4,300 students, including 800 from abroad, enrolled in 27 different bachelor and master programs. The co-operation partner, Prof. Dr. Wolfgang Kohl, is the head of the Institute of Energy Management and Environmental Technologies (Institut für Energie- und Umwelttechnik) (www.che.hs-mannheim.de/iuwm/). This institute is part of the field of "process and chemical engineering" and is engaged in environmental monitoring and measuring technologies, energy management and energy economics, as well as renewable and economic energy systems. In connection with the project work, the institute provided the external learning environment for the students of the Geschwister-Scholl-Realschule. The main task was the calibration of carbon dioxide measuring sensors. The students were introduced to theory and practice of the calibration of measuring sensors. In addition, the institute has of a mobile environmental measuring station which could be used at the Geschwister-Scholl-Realschule for their lessons and project work. Also, the institute provided the further training courses for the teachers of the Geschwister-Scholl-Realschule.

1.3 University of Education in Heidelberg

The University of Education Heidelberg (www.ph-heidelberg.de) is responsible for the education of teachers for primary schools, lower secondary schools and special schools in the federal state Baden-Württemberg. The university comprises 180 staff members and 4,000 students which are taught in the content knowledge of sciences, methodology and subject specific didactics. Quite recently, in co-operation with Hochschule Mannheim, there has been established a master's program for engineering pedagogy which leads to teaching at vocational schools.

The University of Education is running an institute for further education (“Institut für Weiterbildung http://www.weiterbildung-ph.de/content/index_ger.html) which is devoted to further education and offers courses for in-service teacher education. The programs are decided upon in a concerted commission with the federal state school authority for each semester.

One of the main foci of the University of Education is devoted to natural sciences. The activities for the TSP-project took place within the department of chemistry which is part of the faculty for natural sciences and social sciences, and the Science-Technology-Society Institute which is devoted to interdisciplinary studies. Therefore a well-suited home for the TSP-activities has been available.

The department of chemistry hosts a special learning environment for local schools: The student laboratory *science-live!* (www.science-live-heidelberg.de) in which visiting classes are able to perform experiments within the context of the general topic "Climate and Energy" together with their teachers. At the same time, the student laboratory *science-live!* serves as a training environment for pre-service science teachers which are involved as tutors supporting the experimentation of the students. The pedagogical overall concept is based on

the ideal of self-directed learning. The activities in the student laboratory *science-live!* are constantly evaluated by means of an integrated research design.

Within the scope of the TSP-activities, the student laboratory *science-live!* was, at the beginning, used to prepare the students of the Geschwister-Scholl-Realschule. Special preparatory classes were also used to give an introduction into the problem of measuring the carbon dioxide concentration and the analysis of mixtures of gases. Low cost and routine gas chromatographs as well as carbon dioxide measuring sensors with varying accuracy have been available for this task.

Parallel to the operations in the area of student activities and teacher initial training activities the student laboratory *science-live!* is also used for further education courses for in-service teachers.

2 Results

Parallel to the beginning of the TSP-project, the Geschwister-Scholl-Realschule has developed a suitable school curriculum which provided the requirements to realize the demanding objectives which are connected with the TSP-project in the specific project work of students in grade 10. The curriculum is stretching over the entire time of schooling from grade 5 to grade 10. It provides the possibilities for an efficient work in the project and a stepwise approach to prepare the students. The curriculum contains all the learning methods for efficient working, the different possibilities of documentation of learning and learning results, as well as the respective ways and means of communication in order to enable an efficient presentation of project results for a third party.

2.1 School curriculum for scientific working

curriculum of methods of the Geschwister-Scholl-Realschule	**grade**	**Integrated Science / project-oriented topics**
learning and working techniques; training of general methods • highlighting • writing protocols • looking up facts • keeping records • filing	5	collecting and structuring data • measuring, observing, comparing data • doing experiments and taking notes • searching for evidence • documentation of results → My best liked pet
learning and working techniques; special days • workplan for a week • teamwork • mind-mapping	6	finding characteristics discussing results → making a diary in science → recording changes in a biotope
ways for presentation • poster • short lecture • presentations with media • use of models • films/videos • demonstrations	7	draw up hypotheses and plan experiments • use of models for explaining • use of software for search of information, rearrangement and presentation → from raw materials to products

ways for documentation • project diary • portfolio • reports	8	structuring complex matter • evaluation of experiments by means of specific language, diagrams, … • models and concepts for explaining and defining connections • analysing and learning from shortcomings and mistakes • reflecting and assessing results → one project: students' choice, but emphasis on biology
training of communication • lecture • steering a conversation • interview • moderation techniques	9	combining and unifying partial problems • assessing and applying when indicated insights gained • planning model experiments and simulations → two projects: students' choice: 1. emphasis on chemistry 2. emphasis on physics
project-oriented work • examination of competencies	10	realizing complex connections between science and technology in society → two projects: topics from the curriculum (teachers' choice)

Schools in Baden-Württemberg are able to split up the total amount of hours of instruction flexibly between the different grades. The general teachers' conference and the school conference (consisting of teachers, parents and students) have to support this decision. The following shows how the hours of instruction are arranged at the Geschwister-Scholl-Realschule in the integrated science teaching:

2.2 Table of hours of instruction for scientific working

grade	hours	remarks
5	3	integrated science (one teacher only)
6	3	integrated science (one teacher only)
7	3	integrated science (one teacher only)
8	4	integrated science (one teacher only) - curriculum of methods: documentation
9	6	4 hrs. (regular classroom work): 1 hr. per section physics and chemistry; 2 hrs. for section biology 2 hrs. project sequence (regular classroom work): with 2 project phases
10	5	3 hrs. (regular classroom work)): respectively 1 hr. per section 2 hrs. project sequence (working in separate teams): with 2 project phases
	24	total amount of hours of instruction

The following items give an outline of the organization of the project work in grades 9 and 10:

2.3 Organization model of the Geschwister-Scholl-Realschule for grade 9

In grade 9, six hours of scientific working will be offered starting school year 2009/10. The Geschwister-Scholl-Realschule offers 2 hours in physics, chemistry and biology respectively. Within the modules physics and chemistry, the students are working project oriented in two phases.

2.4 Organization model of the Geschwister-Scholl-Realschule for grade 10

In grade 10, there are 5 hours of instruction: physics, chemistry, and biology one hour each plus 2 hours project oriented classes. The project sequence is divided into two phases. During these two phases, the class is divided up into several teams which choose their respective project from the offered topics.

3 Project work at school

The work for the TSP-project at this school took place in two phases during the school year. The students were working in small teams normally consisting of four people. Project phase 1 was completed with a documentation of the students, whereas project phase 2 was completed with a public presentation on the occasion of a school festivity.

3.1 Performance assessment / evaluation of learning at grade 10

<table>
<tr><td>modules
→ 3 written tests during the term</td><td rowspan="2">further achievements like
oral participation,
short presentations,
tests, lectures, etc.</td><td></td></tr>
<tr><td>project phase 1
→ one subject specific practical test</td><td></td></tr>
<tr><td>→ written achievements: 50 %</td><td>→ other achievements: 50 %</td><td>2/3 of the marks</td></tr>
<tr><td colspan="2">project phase 2
→ subject specific testing</td><td>1/3 of the marks</td></tr>
</table>

The students could choose freely which of the projects they wanted to join. The following four projects were available:

project	**topic**
1	"The Sun as a Source of Energy" Renewable Energy – Solar Cell / Hydrogen Cell
2	“Consequences of the Green House Effect and the Air Pollution for Living Creatures”
3	“Steering and Controlling” – Construction of Lego Robots in the Scientific Scope
4	“Genetic Finger Printing” Biotechnology/Genetic Engineering

projects in school year 2007/08:

project	topic
1	"Alternative Energy" – Solar Cell / Hydrogen Cell
2	“Global Warming and Carbon Dioxide in the Atmosphere”
3	“Senses and Information Technolog”
4	“Genetic Finger Printing”
5	“Saving Energy”

projects in school year 2008/09

4 Overview of the work in the TSP-project Heidelberg/Mannheim

activity	time frame
Preparation and conceptualization with regards to content for the start-up conference for the TSP-project with all project partners at Heidelberg, practical organization	January 2007
Holding and assessing the start-up conference	12 – 13 Jan. 2007
Local meeting at the Geschwister-Scholl-Realschule in Mannheim with the project partners Prof. Kohl (Hochschule Mannheim) and the participating teachers of the school. Agreement upon the necessary activities as well as responsibilities and obligations at school and universities	6 Feb. 2007
Conceiving and setting-up of a platform for the exchange of documents within the project ("BSCW-Server")	February 2007
Local workshop at the University of Groningen / Netherlands: adjusting the work program / getting to know the institution / participating in a course of further education for teachers with Dutch science teachers	23 Mar. 2007
Local workshop at the University of Uppsala / Sweden: finalizing the work program of the Swedish work group / getting to know the project members / adjusting the possible experiments	29 Mar. 2007
Project meeting at the University of Education, planning the involvement of *science-live!* in the project activities	22 June 2007
Developing a form for the schools participating in the TSP-project ("self-disclosure")	Mai / June 2007
Workshop in the *science-live!* laboratory for participating teachers from Mannheim	22 June 2007
Drafting the workplan Heidelberg-Mannheim: Meeting at the Geschwister-Scholl-Realschule in Mannheim. Discussing the project activities for the students, the involvement oft assisting tutors from the ranks of the pre-service teachers enrolled at the University of Education	20 July 2007
Local workshop at the IBIMET institute in Florence with project partners from Italy / conferring with the partner school / discussing the work program	18 Oct. 2007

Local workshop at the agricultural school in Benevento with the local science teachers and Antonio Raschi of IBIMET institute / discussing possible co-operations	19 Oct. 2007
Presenting the TSP-project at scientific conventions: annual meeting of the GDCh (German Chemical Society, unit on chemistry education) annual meeting of the GDCP (society for didactics of chemistry and physics) meeting on EC-education programs hosted by the federal ministry of education of Baden-Württemberg at the "Haus der Wirtschaft"	17 Sept. 2007, Ulm 18 – 20 Sept. 2007, Essen 13 Nov. 2007
Conceptually preparing the continuous CO_2-measuring with sensors at Heidelberg and Mannheim as well as a presentation on the web	November 2007
Project management / drawing up partnership agreements / reports to the EC	January to December 2007
Joint workshop TSP and carboschools+	09.03 – 10.03.08 Norwich
Preparing and conceiving the contents for the project presentation on the annual meeting of the "International Conference on Chemical Education", 3 to 8 August 2007, Mauritius	July 2008
Assessment of the TSP-project results in school year 2007/08 ("1st cycle")	June – August 2008
Maintaining the website www.teacher-scientist-partnerships.eu and integrating the weather station	May to December 2008
Local meetings at the University of Education Heidelberg with the project partners from the Geschwister-Scholl-Realschule in Mannheim and the Hochschule Mannheim. Preparing, conceiving and agreeing upon the contents of the activities as well as responsibilities and obligations at school and universities. Holding project afternoons in the student laboratory *science-live!* for participating students of the Geschwister-Scholl-Realschule Mannheim	July to October 2008
Conceptual work on the continuous CO_2-measuring with sensors at Heidelberg and Mannheim. Installing a measuring sensor at the Geschwister-Scholl-Realschule Mannheim	Aug. to Dec. 2008
Preparing the concept for the final conference in Florence in spring 2009; defining the modules; drafting the agenda; co-ordination with project "Carboschools+"	Oct. to Dec. 2008
Assessment of the TSP-project results in the school year 2008/09 ("2nd cycle")	Jan. to Apr. 2009
Preparing and conceiving the contents for the project presentation on the IOSTE-conference (International Organization for Science and Technology Education) at the Siauliai University, Faculty of Education, Natural Science Education Research Centre, Lithuania 14 to 18 June 2009	April 2009

Maintaining the website www.teacher-scientist-partnerships.eu and integrating the weather station	Jan. to Apr. 2009
Local meetings with the project partners from the Geschwister-Scholl-Realschule Mannheim at the Hochschule Mannheim. Preparing, conceiving and agreeing upon the contents of the activities as well as responsibilities and obligations at school and universities as well as the presentations for the final conference at Pistoia / Italy	Jan. to Apr. 2009
Preparing, planning and holding of project afternoons in the student laboratory *science-live!* for participating students from the Geschwister-Scholl-Realschule Mannheim ("instrumental analysis ")	March 2009
Conceptual working on the continuous CO_2-measuring with sensors at Heidelberg and Mannheim.	January to April 2009
Holding one project afternoon at the Hochschule Mannheim for participating students of the Geschwister-Scholl-Realschule Mannheim ("calibration")	March 2009
Holding one project afternoon in the student laboratory *science-live!* Heidelberg for participating students of the Geschwister-Scholl-Realschule Mannheim ("instrumental analysis ")	March 2009
Visiting the Institute of Environmental Physics of the University of Heidelberg with Prof. Levin for participating students of the Geschwister-Scholl-Realschule Mannheim ("analysis of the CO_2 concentration in the atmosphere")	March 2009
Public presentation of the students' project results on the occasion of the school festivity of the Geschwister-Scholl-Realschule Mannheim	4 April 2009
Final papers of the students, assessment of the students' efforts	April 2009
Further education for teachers: "Developing Understanding for Science" at the “Institut für Weiterbildung”	21 April 2009
Preparation and holding of the final conference in Pistoia. Defining the final papers. Co-ordination with the EC-project "Carboschools+"	24 to 27 April 2009
Further education for teachers: "Teachers – Students – Researchers are starting to network" at the “Institut für Weiterbildung”	5 May 2009

5 Results of the students' work in the TSP-project

The realization at school took place in the school years 2007/08 and 2008/09 within the scope of the project work of grade 10 foreseen in the formal curriculum. Both school years were separated into two project phases respectively.

The students were working in small teams of three to five people. In every project phase, the students were obliged to document and present their work (e.g. also by means of a public presentation on the occasion of a school festivity).

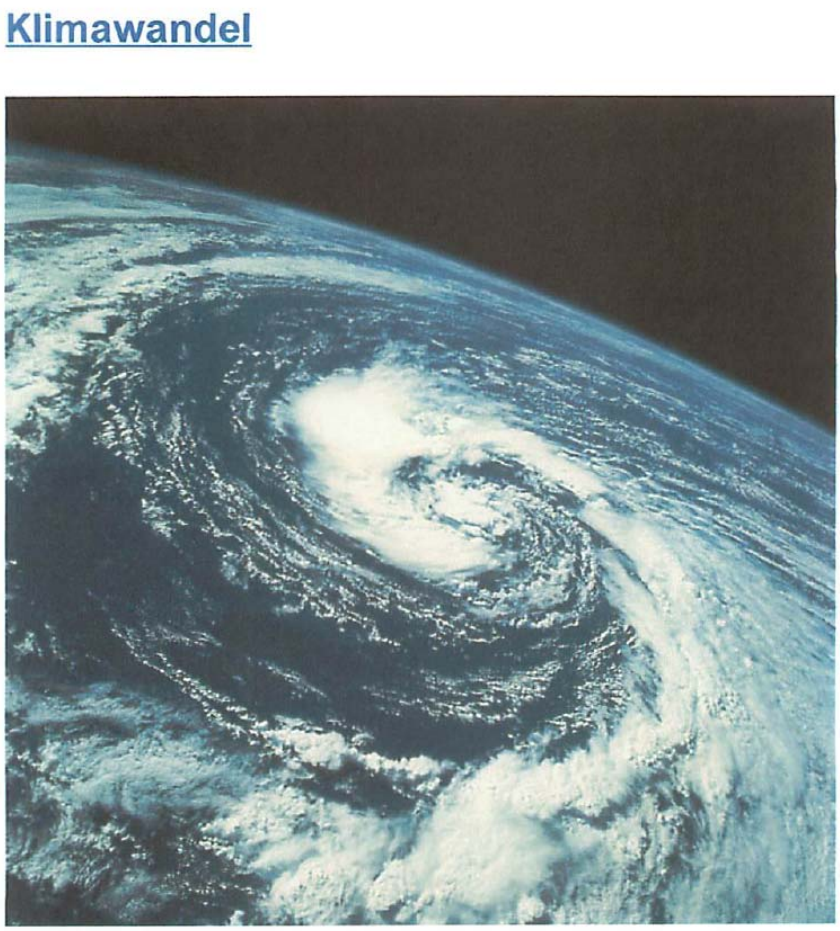
During the school year 2007/08, the CO_2-problem was thematically classified under the field of renewable energies during the first project phase and under the project "Climate Change" during the second. In the following school year, the topic was dealt with in the projects

"Alternative Energies" and "Climate Change". Further projects were rather a part of biology and were dealt with by the respective teachers independently from the TSP-project.

In the school year 2008/09, one project had been even more directly attuned to TSP. The topic "Global Warming and Carbon Dioxide in the Atmosphere" was realized with experts from the University of Education and Hochschule Mannheim.

At the beginning of every project phase, an initial meeting took place which consisted of discussing the planning, formulating the timetable, taking first measurements, as well as discussing the evaluation. In the progression, the students worked, at the given periods of time, in the corresponding rooms at school, i. e., computer room, laboratory, and library. The practical part contained 2 to 3 series of measurement. For the research, the students had access to a reserve in the school library and were given concrete web addresses for their internet research.

The students had to prepare a portfolio during the course of the project phases and hand in a detailed paper at the end of the project on which the final marking has been based.



Cover of a student portfolio:

The basic structure of the two project phases differs since the second phase contained a closer teamwork with the co-operation partners, i. e., visits from experts and excursions.

5.1 Learning results of the students

After the first run, from the beginning of the school year to Christmas, the following results have been achieved:

student	documentation	practical part
1	2.8	2.2
2	3.2	2.7
3	3.2	1.4
4	1.9	1.5
5	2.7	1.5
6	5.4	3.3
7	3.8	2.8
8	1.8	1.5
9	6.0	6.0
10	6.0	6.0
average	3.7 (3.1)	2.9 (2.1)

Due to personal problems two students had not handed in a paper. The values in brackets are the average values without these students.

After the second project phase the following results have been achieved:

student	documentation	practical part	subject specific verification
1	3.0	3.0	3.0
2	2.5	3.0	2.7
3	3.0	1.3	2.1
4	6.0	6.0	6.0
5	3.0	2.3	2.6
6	3.0	2.3	2.6
7	3.5	2.5	3.0
8	1.5	2.0	1.7
9	2.0	1.5	1.7
10	2.5	2.6	2.5
11	3.0	1.6	2.3
12	5.5 (plagiarism)	3.1	4.3
13	2.0	1.3	1.6

14	3.0	2.5	2.7
15	2.5	2.3	2.4
16	1.5	1.0	1.2
17	2.0	1.3	1.6
average	2.9 (2.7)	2.3 (2.1)	2.6 (2.4)

5.2 Assessment by the teacher

The future realization at school will not pose a problem because the school curriculum is a well-directed preparation for this kind of project work. Due to the unsatisfying results of the first cycle a well-directed project phase was established in grade 9 in order to prepare the students better for this kind of work. This does not create any additional time burden for the teachers. However, it has to be stated, that three excursions per half-year are too time-consuming for the school and the students. Two series of measurement / examinations should be sufficient and combined with one visit from experts in the school would be ideal to keep up the normal daily school routine.

The objectives of the TSP-project are considered to be very demanding for the general abilities of lower secondary schools and their students. For example, the students are able to recite complex theories rather than to interpret them. Therefore, the aim that students should do research on their own has not been accomplished in full. However, it was reckoned positive that the students became acquainted with the way of working of scientists in research in scientific institutes.

The students could acquire the following competencies:

- Researching an individual problem within a given context

  During the project phase the individual teams developed experiments which dealt with a problem defined by themselves. Students researched which requirements are necessary such that plants are able to assimilate CO_2. Photosynthesis is most effective if the plant is placed in the sunlight and the temperature is suitable. A different group discovered that CO_2 is also produced in the soil. Micro-organisms are producing carbon dioxide.

- Reflection and Assessment

  Many students reflected that they had a better understanding of the process of climate change now. In future, they will act more ecologically aware and change their behaviour in order to try and avoid CO_2 emissions. The TSP project has enriched the teaching at the Geschwister-Scholl-Realschule in the area of project oriented working. Due to the support of the experts and the excursions to authentic learning environments a significant increase has been found in the special appliance of the scientific way of thinking and working as well as in gaining insights. The communication processes among themselves as well as the interaction between scientists, teachers and students were furthering the engagement in the contextual problems of the topic area "Climate Change". The students are able to assess and evaluate social developments.

students present their work to the public during a school festival

6 Teaching-Learning-Materials

6.1 Introduction to gas chromatography (GC) analysis

An introduction in the process of gas chromatography (GC) was offered in the student laboratory *science-live!* as means of preparation for the project work of the students in the research institutes. (At Heidelberg University, samples from atmosphere are analysed by GC in the process of research). Assignments for the students have been: examining the relations between retention time and composition, height of peaks and peak area respectively with test mixtures of gases (methane and carbondioxide). A low cost GC (Kappenberg) which enables working at room temperature and a routine GC (trademark Carlo-Erba) were used. The student teams researched the climate gases methane and CO_2 with regards to retention times and quantity in gas mixtures.

Analyses with methane:

Preparing trial mixtures,

Injection into the gas-phase chromatograph,

Evaluating the chromatograms.

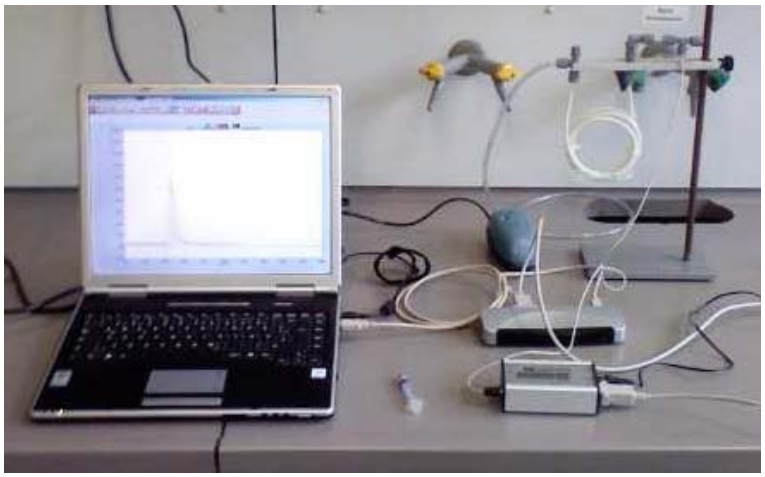
Analyses with carbon dioxide:

Preparing trial mixtures,

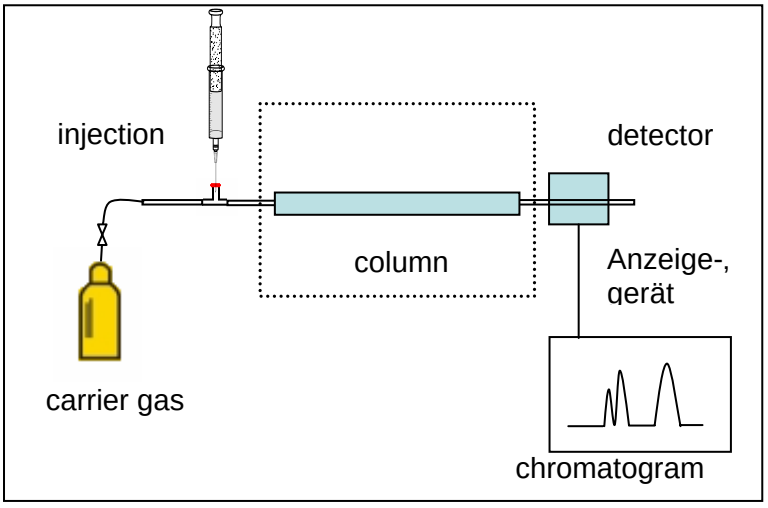
Injection into the gas-phase chromatograph,

Evaluating the chromatograms.

Constituent parts of the low cost GC by Kappenberg *: aquarium pump; polyethylene (PE) pouch with air sample; injection block; separating column: Chromosorb 102,60-80 mesh, length 0.8 m; WLD; measuring device

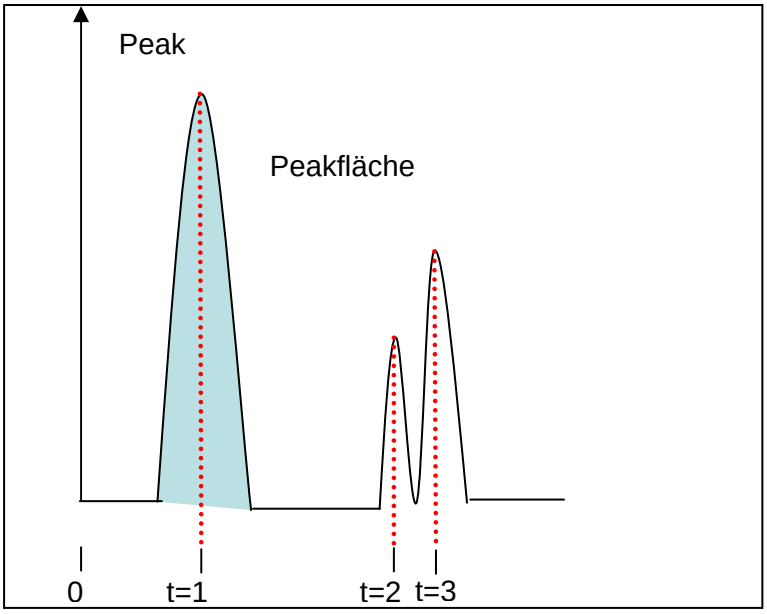


Low cost GC by Kappenberg with display / evaluation via laptop

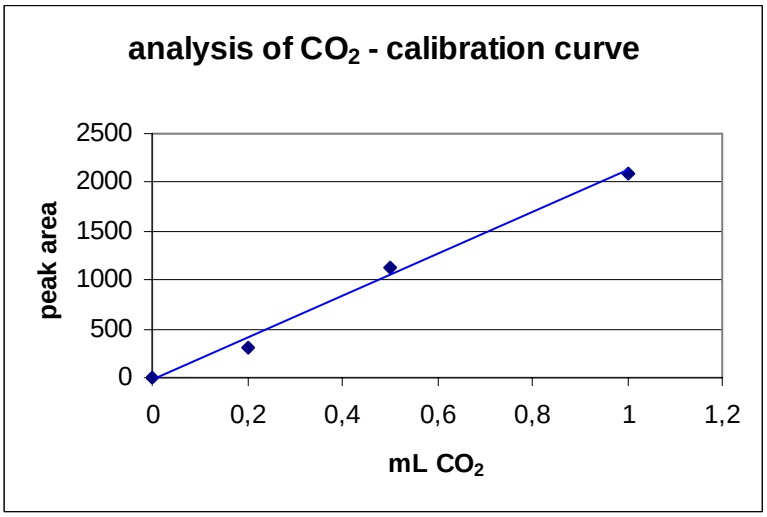


Principle of gas-phase chromatographic separation

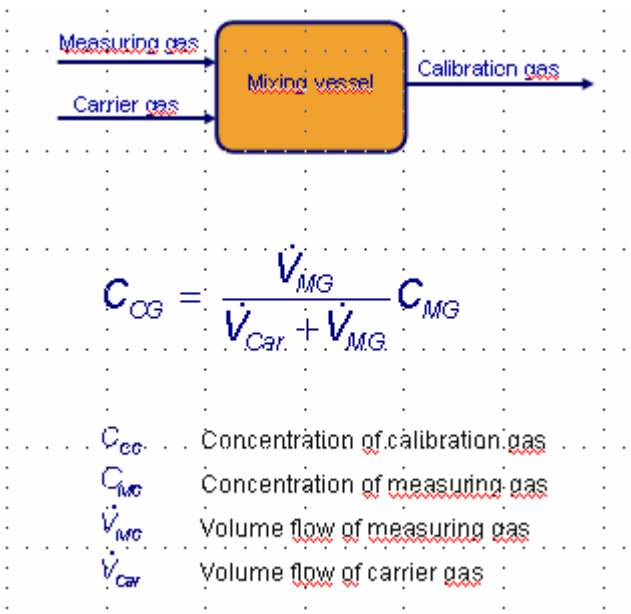
*http://www.kappenberg.com/pages/lowcost-chromatographie/gaschromatographen.html



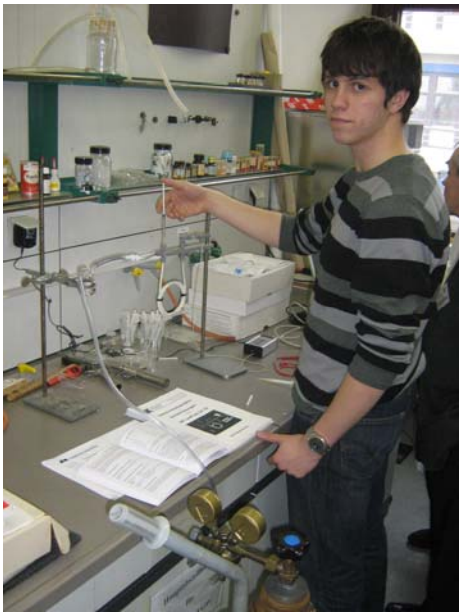
Evaluation of chromatograms



calibration of Vaisala sensors in the laboratory at Mannheim Hochschule



calibration equation



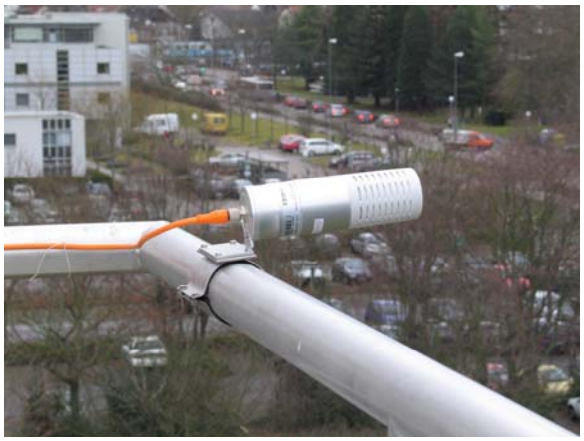
GC-analysis in the student laboratory *science-live!*

calibration of Vaisala sensors in the laboratory at Mannheim Hochschule

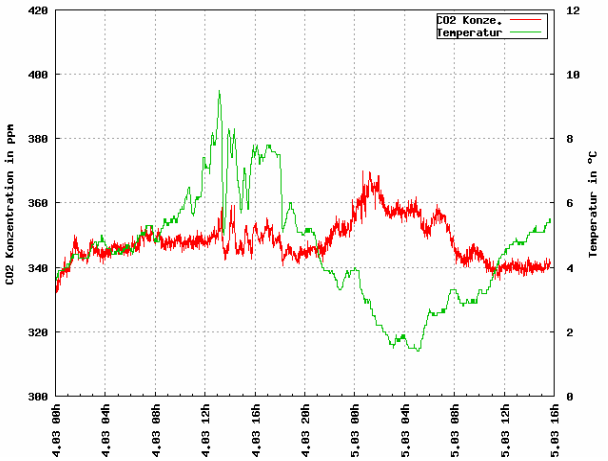
7 CO_2 Sensor and weather station

7.1 Continuous measurements of the carbon dioxide concentration in the atmosphere

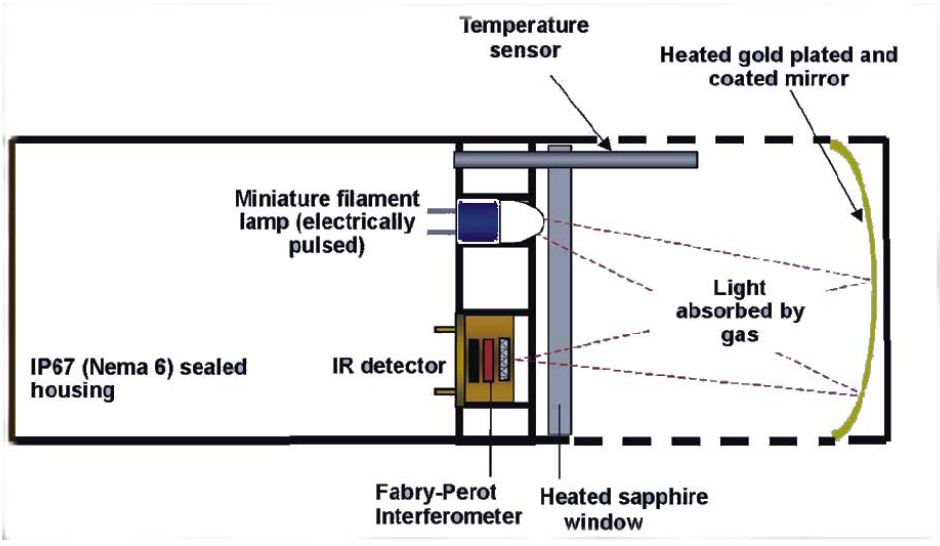
For the continuous measurements of the CO_2 concentration in the atmosphere a Vaisala CO_2-sensor GMP 343 was purchased and mounted on top of the roof of the building of the University of Education in Heidelberg which is located in "Im Neuenheimer Feld".



Vaisala Sensor GMP 343 on top of
Building INF 561.
Position: 44°25' 13.17N 8°40' 10.71O
height: 110m over ZL; building height: 18m



CO_2 concentration in ppm and
temperature in °C



Design of Vaisala sensorGMP 343

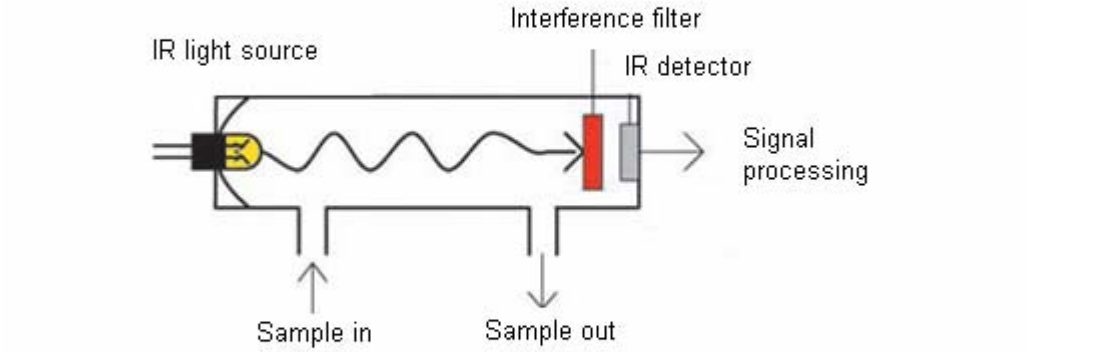
The instrument measures the CO_2 concentration in the air by means of an infrared measuring beam in the area of the maximum absorption of carbon dioxide. With regards to

accuracy of measurement, the sensor is of such quality that the values are acceptable for a co-operation with scientists. However, the device has to be calibrated regularly by means of test gases. This is accomplished at the Hochschule Mannheim in the institute of Prof. Kohl.

Starting January 2008, the device is in continuous operation and is protected by a stainless steel cover against rain.

A computer within the building saves the measured data which are fed to it directly via cable. By means of software, the values are graphically displayed on the website www.teacher-scientist-partnerships.eu . Once a day, all registered values are saved automatically as an e-mail in form of an excel file on the server of the University of Education Heidelberg. Due to this, the numerical values are able to be used in a later subsequent processing in the context of project work and be compared to the weather data which are also continuously measured.

For short-time projects mobile CO_2 sensors (Vaisala GM 70) were bought in the course of TSP activities. The principle of measurement is shown in the following diagramme:



The sensors may be borrowed for individual measurements at schools, or may be used by students pre-service for project seminars at the university of education. The instrument is connected to a data logger. Readings can be saved and processed by computer programmes for data analysis.

7.2 Weather Station Davis Vantage Pro 2

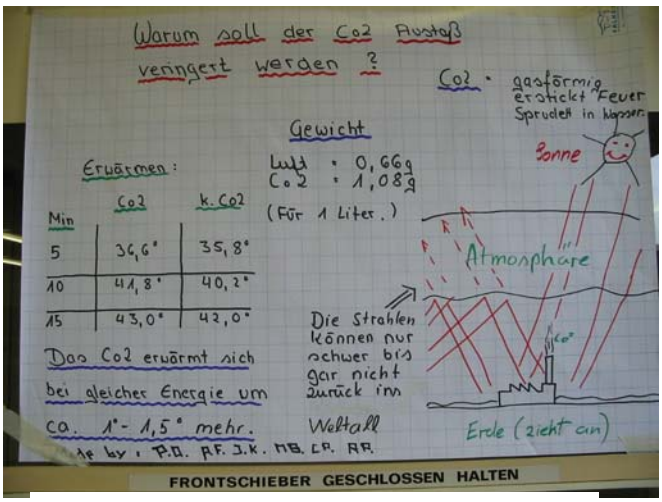
The weather station is a semi professional device which is also used by the project partners in the TSP-project and also serves for the interpretation of atmospheric concentration of CO_2 in dependence of meteorological data. The weather station is also mounted on top of the roof of the University of Education Heidelberg in "Im Neuenheimer Feld" in the vicinity of the Vaisala carbon dioxide sensor. The weather station is able to measure the usual data like temperature, wind speed, wind direction, precipitation amount, barometric pressure, relative atmospheric humidity, dew-point etc. The data are transferred wireless to a computer of the University of Education Heidelberg and are graphically displayed on the website www.teacher-scientist-partnerships.eu or can be made accessible in form of a saved excel file. Since the website is displayed also in English, our project partners from the European area are able to recall current data as well as saved data at any time.

An identical installation of Vaisala carbon dioxide sensor and Davis Vantage Pro weather station has been mounted on top of the roof of the Geschwister-Scholl-Realschule in Mannheim. The data collected with these devices are available in the school web. Unfortunately, we have not succeeded yet in making these data available in the internet because the website is hosted by a server of the city of Mannheim. This server does not allow external online access to any data. Regrettably, a short term solution to this problem has not been found yet.

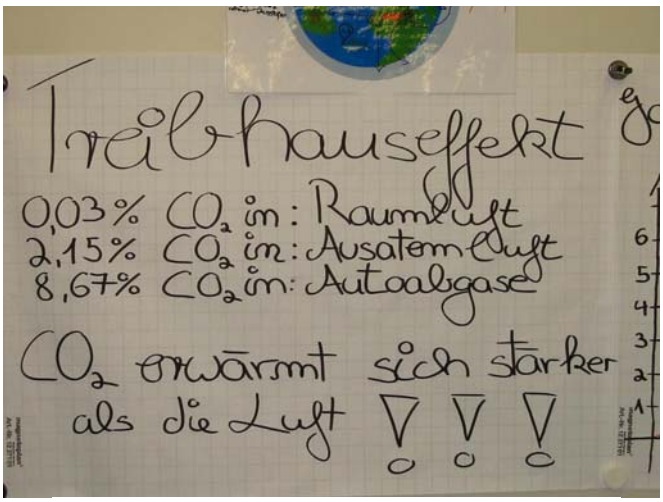
8 Simple experiments at student laboratory *science-live!*

Experimental design to measure the absorption of heat by different gases (air, methane, CO_2)

Experiment to research photosynthesis and absorption of CO_2



Students´ poster to present experimental results



Students´ poster to present experimental results

9 Examples of experiments at school: The Greenhouse (text taken from a student portfolio)

9.1 Why are we doing the experiment?

The actual idea of the experiment was originated at the information gathering for the subtopic "greenhouse". On this occasion, we stumbled across a greenhouse model by means of which the actual greenhouse effect was explained. Also, the CO_2 detection was involved with it. Therefore, the group decided unanimously to include this experiment in our project.

9.2 Construction manual

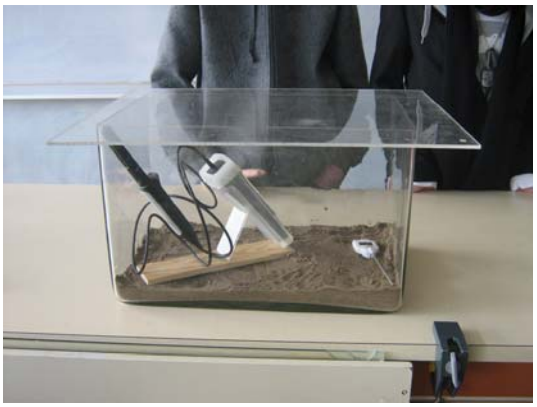
Materials: wooden crate, acrylic glass, wood glue

At first, we wanted to build a greenhouse consisting completely of acrylic glass but that would have been far too time-consuming. Therefore, we have been advised to use a ready-made box and mount a lid of acrylic glass on top of it. That is how this greenhouse came into existence.

Simple greenhouse

Experiment on plant respiration

Presentation of project results



Experiment on soil respiration

10 Integrating TSP-activities into teacher education

10.1 Initial training

The activities are completely integrated into the study regulations for the education of teacher students for lower secondary schools (Realschule, Hauptschule) as well as primary schools. For the study regulations for teaching at lower secondary schools (Realschule) the appropriate place is module 7. It includes chemistry as a part of integrated science teaching and in which school projects, in this case on the topic "Climate and Energy", are realized in the student laboratory *science-live!*

In the study regulations for educating teacher students for primary and lower secondary schools (Hauptschule) the activities are integrated into module 6. In this module chemistry is part of integrated science teaching (topic "matter – nature – technology"). The extent of the activities is 6 semester periods per week respectively, each connected with accompanying seminars. The objective is to enable the future teachers to integrate theory and practice and to gather experiences in the co-operation with external learning environments and the inclusion of external scientific expertise already in their initial training.

These courses are given regularly every semester and are obligatory for all students majoring in the scientific field.

What is more, the TSP-activities can be easily embedded in the faculty for natural sciences and social sciences at large in the so called integrated teaching of mathematics and sciences. In module 2, the content "One project with the involvement of the participating subjects on an exemplary topic with reference to real life" is mandatory. A four hour course in co-operation of at least two subjects is required. The first run has started in winter semester 2009/10 with a concerted workshop of chemistry and mathematics (Prof. Dr. Vogel) on the topic: "CO_2-concentration in the atmosphere".

10.2 Further education for in-service teachers

At the University of Education Heidelberg, courses in the further education program for in-service teachers are organized and held by the institute of further education in accordance with the regional board at Karlsruhe. These courses are official courses on further education of in-service teachers. Therefore the regional board at Karlsruhe grants the participants travelling expenses as well as a daily allowance with occupational safety and health insurance. Within the framework of this program, two courses for in-service teachers relating to TSP-activities are regularly offered:

A general introduction into using and learning in the student laboratory *science-live!* at the University of Education Heidelberg.

A well-directed intensified study of the project TSP with the title "teachers, students, and researchers are starting to network – authentic science teaching in specific".

A special feature is that the courses for further education for in-service teachers for the TSP-project are held together with the deputy headmaster of the Geschwister-Scholl-Realschule, Mr. Hendrik Tzschaschel, such that the in-service teachers in further education are also able to experience the networking of initial teacher training, research and school practicals in concept and in practice.

11 General experiences with the TSP-project

With regards to the school, it has proven to be of great advantage that the Geschwister-Scholl-Realschule had defined its own school curriculum in which the natural sciences as well as the project classes in the field of science are of high priority. With this, the school is

on a very good way of realizing the recommendation of the "Klieme-Expertise" (Klieme, Avenarius, Blum, et al. 2004) for the development of national educational standards for itself:

„The responsibility for structuring teaching and learning processes, even to the point of drafting a school curriculum, will increasingly be returned to the schools, although it may be given to departments rather than to the individual teacher. (pg. 44)

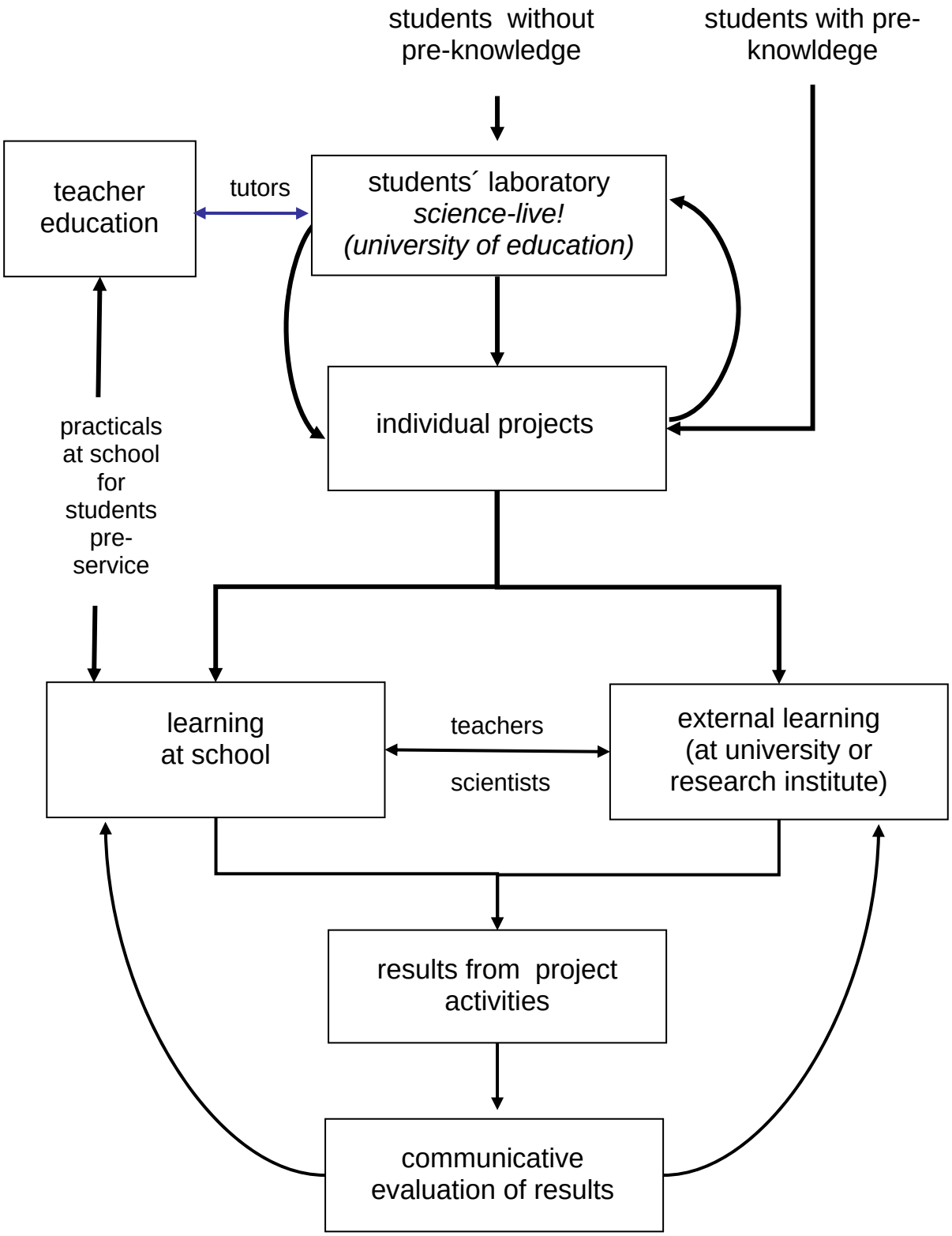
The teaching staff of each school will need to discuss and agree on how the standards can be met and to plan transitions and connections between grades, thereby helping to establish and maintain productive transitions between school forms (such as primary and lower secondary schools). This harmonisation will result in the emergence of a school curriculum for subject-related learning and the linking of subjects, in addition to the general pedagogical school programme, since the coexistence of national educational standards and detailed curricular requirements on the state level appears unlikely on the long term. (pg. 47)

School programmes are the primary medium in which strengths and problem areas are identified, developmental goals are formulated and measures are planned. All too often, however, school programmes are dominated by statements about the school's culture as a whole and cross-curricular activities and projects. Subject-specific teaching and learning processes and the establishment of competencies within learning areas often play a rather minor role – considering the vital importance of these issues for the success of the schools and learning – in these initiatives for internal school development". (pg 49)

According to the evaluation interviews with the head of the school, in future, grade 9 shall be used for the development of basic principles which can lead in grade 10 to informed project work and to a well-directed embedding of the general topic "Climate". The concept based on these considerations will be realized starting school year 2010/11 when an accordingly prepared grade 10 will realize the class projects. The conception stands for a sustained education in terms of the TSP-project objectives.

In conjunction with the school activities it has become clear, that the inclusion of different learning environments (student laboratory *science-live!*, Hochschule Mannheim, University of Education Heidelberg) in structured class projects requires systematic planning. The included organizational structure (see figure) provides a basis for this. It is necessary to distinguish between students who have no precognition in the field of the general topic "Climate" and those students who already have sufficient precognition from class. The latter would be able to start immediate considerations for planning an individual project and realizing it while students without precognitions need, as a first step, an introduction into experimental working in the student laboratory *science-live!* on the topic "Climate and Energy" in order to be able to generate individual research questions for the project work thereafter. In any case, the visit to the student laboratory *science-live!* can take place also several times, also for specific problems, until the individual project has gained a well-funded momentum.

As soon as any individual project is running, learning at school and at external learning environments (Hochschule Mannheim, University of Heidelberg, University of Education Heidelberg) can be planned in detail. At this stage of the project the concrete and direct co-operation between the teachers at school and the scientists from the external learning environments is necessary.


students without pre-knowledge
students with pre-knowldege
teacher education
tutors
students´ laboratory science-live! (university of education)
individual projects
practicals at school for students pre-service
learning at school
teachers
scientists
external learning (at university or research institute)
results from project activities
communicative evaluation of results

At the end of the project work of the students the focus lies on summarizing and discussing the project results based on the experimental work, the gathering of information from internet and the working out of the portfolio which are to be communicated and validated with the external experts and the participating teachers.

This way, as is intended, the students acquire the competencies demanded by the curricula for their grade.

Parallel to these activities the teacher education is involved co-ordinately because the tutors (pre-service teachers for the secondary school level I) have to be prepared and employed well-directed for supporting the students in the practical work in the student laboratory *science-live!* as well as in the school project work. The head of the school practice authority at the University of Education Heidelberg agreed to accept this school practical as part of the official science teacher training. It will be an obligatory part of the training concept within the framework of the TSP-project activities at the Geschwister-Scholl-Realschule. In this way, the school practical training is much more specific and also modified bindingly for the students (pre-service teachers) with regards to acquiring competencies in the field of scientific working. The responsible professor (Prof. Dr. Michael Schallies) is integrating the experiences from this co-operation into the training conceptions and curricula at the University of Education. Also, the experiences from this close co-operation between teacher initial training, school practice and research are included into teacher initial training and further education. For in-service teachers the institute of further education holds workshops for the further education of teachers about the topic "Teachers and Scientists are Starting to Network" or "Developing Scientific Understanding – Experimenting in the Student Laboratory *science-live!*". Therewith, the demand of a systemic approach for the improvement of the educational conceptions is made specified and sustainable.

Additionally, it should be acknowledged that the theoretical preparation with regards to methodology and didactics of science teaching and learning in the study regulations of the University of Education is not only realized in the field of chemistry but also in the interdisciplinary study field "Integrated Teaching and Learning" of the division for natural and social sciences. The linking of mathematics and chemistry in the project workshop "Chemistry and Mathematics are Linking: The Atmospheric Carbon Dioxide Concentration" in the current winter semester 2009/10 has set a start point to this. In this project workshop, small groups consisting of students (pre-service teachers) of mathematics and chemistry or biology, technology, and physics are working on the problem of systemizing measurement data in order to gain general evidence from it or to discover long term trends of the changes of these values in the atmosphere. It shows that the needs of the students (pre-service teachers) are such that they either use existing data from the continuous recording of the CO_2 concentration by the measuring station on top of the roof of the University of Education or plan their own experiments and measurement series as well as their evaluation.

In the latter case, the students (pre-service teachers) have access to the option of the CarboCap sensor technology which enables mobile measuring at such locations which are of interest to the students or at individual research stations. The demand of self-directed learning based on the interests of the students (pre-service teachers) can be fulfilled very well within the framework of the teacher initial training. In this context, the technical basics are formed not only for the natural sciences but also in the same way for mathematics and, in the context of practical problems, all students (pre-service teachers) can take a profit.

Reference: Klieme, E., Avenarius, H., Blum, W., Döbrich, P., Gruber, H., Prenzel, M., Reiss, K., Tenorth, H.-E., Riquarts, K., Rost, J., Tenorth, H.-E., & Vollmer, H. J. (2004). *The Development of National Educational Standards.* Berlin: Bundesministerium für Bildung und Forschung (BMBF). Publications and website devision.