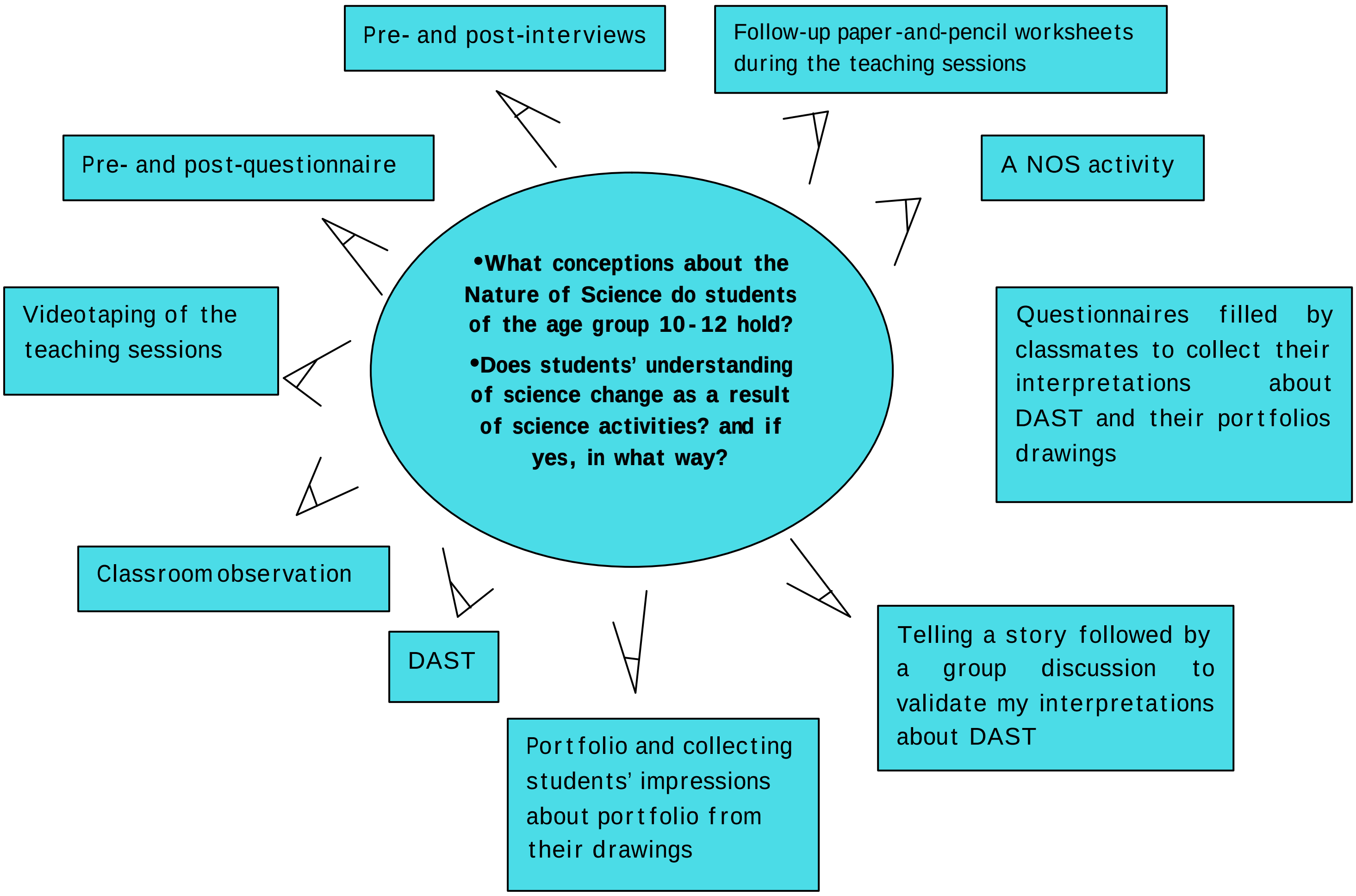
Chapter 5

Methodology of research used in two classrooms

Introduction

This chapter describes the various research methods used in assessing the teaching setting and collecting, analyzing and interpreting the data on students' nature of science changes.

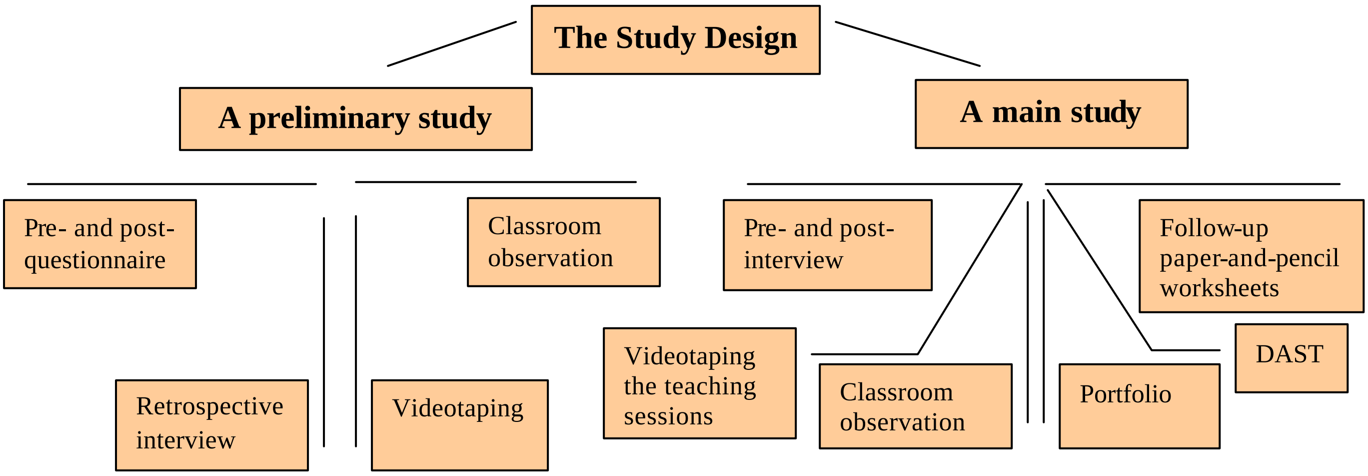
Schema 1 summarizes the different strategies applied at Bammental Gymnasium and at Linkenheim Realschule regarding the two research questions repeated in the center of schema 1:



Schema 1: gives an overview of the used research methods in the preliminary and the main studies.

21 The empirical research methods adopted in two science classrooms.

This paragraph focuses on the theoretical backgrounds of the different qualitative research methods applied. Note that I rely largely on Denzin *Handbook of Qualitative Research* (2000) and Flick *Introduction to Qualitative Research* (1998). Schema 2 gives a detailed overview of the methods used in Grade 6 at Bammental Gymnasium and Grade 5 at Linkenheim Realschule respectively.



Schema 2: summarizes the different data collection strategies used in Bammental and Linkenheim classrooms.

22 A Sum-up and overview of the aspects to be introduced in they study.

In the research study, I attempted to address the guiding following questions:

1. What conceptions do students of the age group 10-12 regarding the nature of science held?
2. Does students' understanding of science change as a result of discovery-based science activities taken from Alexander von Humboldt' scientific observations during his expedition to Latin America between 1799-1804?

This will be done by:
1. Gathering background information about pupils' images of scientists and how they work.
2. Designing the most appropriate learning environment for improving their understanding of science.

In the preliminary study realized in Bammental, I intended to make my first contacts with German students, thus getting to know better the school organization and the classroom teaching setting. On the other hand, I was trying to implement the developed Alexander von Humboldt's activities in the classroom (Appendix C).

The results of this preliminary study enabled me to learn more about students of this age group within the German school system, about their interests and it helped me to crystallize my ideas in adapting another way in applying Humboldt's lifework in the future realization of the intervention study.

The main study in Linkenheim aimed to deliver to students the message that science is a human activity by exposing them to the biography of Alexander von Humboldt at the beginning of the teaching. During the student-centered teaching process, students were asked also to reflect on their learning process.

The nature of science aspects that I intended to implement in my study are compared to the three large Nature-of-Science-studies described at large in chapter III in the table below and are printed in bold Note that these implemented nature of science aspects were chosen according to the students' age group, the allowed time of the teaching setting and the classroom learning environement:

McComas & Olson (1998) study of national standards	**Osborne et al (2003) Delphi study**	**Lederman et al (1998) study**	**My NOS aspects to be implemented**
Scientific knowledge is tentative	Science and certainty	Scientific knowledge is tentative (subject to change)	**Scientific knowledge is tentative**
	Science and questioning		**Science and questioning**
Science relies on empirical evidence	Analysis and interpretation of data	Empirically-based (based on and / or derived from observations of the natural world)	**The nature/purpose of an experiment**
Scientists require replicability and truthful reporting	Scientific method and critical testing	Subjective (theory-laden)	
Science is an attempt to explain phenomena	Hypothesis and prediction	Scientific knowledge necessarily involves human inference	
Scientists are creative	Creativity	Creativity (involves the invention of explanations) / Imagination	**Imagination/ Scientists are creative, we work as scientists!**
Science is part of social tradition	Cooperation and collaboration in the development of scientific knowledge	Distinction between observations and inferences	**Distinction between observations and inferences (Tricky Tracks)**
Science has played an important role in technology	Science and technology	Socially and culturally embedded	**Science and technology**
Scientific ideas have been affected by their social and historical milieu	Historical development of scientific knowledge		**History of Science- AVH as impulse for learning**
Changes in science occur gradually		The functions of, and relationships between scientific theories and laws.	**Science relies on empirical evidence**
	Diversity of scientific thinking		**Diversity of scientific thinking**
Science has global implications			
New knowledge must be reported clearly and openly			

Table 3: summarizes the different nature of science aspects mentioned in the literature and the nature of science aspect to implement in my study, inspired from these studies.

On the whole, in this empirical qualitative study, I attempt to study the students' epistemologies about science and scientists, the learning environment and their changes in their views after the realization of the teaching setting, if there was a change.

In order to get different perspectives on the problem under study, I will use a combination of research methods ("triangulation") in my study, described in details below, thus fulfilling to the needs of reliable qualitative research.

21. 1 Triangulation.

Fontana and Frey (1994, pp. 373) reported that an increasing number of researchers are using multi-method approaches to achieve broader and often better results. This they referred to as triangulation. In triangulating, a researcher may incorporate several methods in different combinations, such as surveys, interviews, and observations. Since then this key word is used in qualitative research to name the combination of different methods, study groups, local and temporal settings, and different theoretical perspectives in dealing with a phenomenon (Flick, 1998).

Moreover, Flick (1998, pp. 50, 140) augmented the meaning of 'triangulation' to the combination of appropriate research perspectives and methods that are suitable for taking into account as many different aspects of a problem as possible. In order to increase the expressiveness of the data gathered, triangulation of observations with other sources of data, and also the employment of different observers has been suggested by him.

Denzin (1978, p. 340 & 1989b, cited in Flick, 1998, pp. 229-230) distinguishes four dimensions of triangulation:

1. *Theoretical triangulation* involves the use of several different perspectives in the analysis of the same set of data. The purpose of the exercise is to extend the possibilities for producing knowledge.
2. *Data triangulation* attempts to gather observations with multiple sampling strategies. Observations on time, social situations, and persons in various forms of interaction can all be gathered. The use of data triangulation ensures that a theory is tested in more than one way, increasing the likelihood that negative cases will be uncovered. Denzin makes a distinction between time, space and persons and suggesting studying phenomena at different dates and spaces and from different persons.
3. *Investigator triangulation* means the use of more than one observer in the field situation. The advantages of multiple observers are obvious: tests on the reliability of observations can be quickly made, and the respective observers' bias can thus be judged. Thus investigator triangulation does not mean a simple division of labor or delegation of routine activities to assistants but rather a systematic comparison of different researchers' influences on the issue and the results of the research. It is a major tool to enhance reliability.
4. *Methodological triangulation* can take two forms. The first is *within-method*, and the second is *between-method*. The former is applied when an investigator employs varieties of the same method; for example three different scales that are used for measuring other-directedness. An example for the first strategy in my work is to use different sub-scales for measuring an item in a questionnaire, whereas an example for

the second strategy would be to combine the questionnaire with a semi-structured interview.

While it may be difficult for any single investigation to achieve this full combination, it is certainly possible to utilize multiple data levels and methods.

Stake (2000, p. 443-444) concluded that to reduce the likelihood of misinterpretation, researchers employ various procedures, two of the most common being redundancy of data gathering and procedural challenges to explanations. Triangulation has been generally considered a process of using multiple perceptions to clarify meaning, verifying the repeatability of an observation or interpretation. But acknowledging that no observations or interpretations are perfectly repeatable, triangulation serves also to clarify meaning by identifying different ways of the phenomenon is being seen.

20. 2. Case study and iteration.

Stake (2000, pp. 435- 448) outlined in the *Handbook of Qualitative Research*, that case studies have become one of the most common ways to do qualitative inquiry, but they are neither new nor essentially qualitative. As a form of research, a case study is defined by interest in individual *cases*, not by the *methods of inquiry* used. So, a case may be simple or complex. It may be a child, or a classroom of children. Thus, the time spent concentrating our inquiry on the case may be long or short.

This researcher identified three types of case study: an *intrinsic case study* if it is undertaken, because, first and last, the researcher wants better understanding of this particular case. An *instrumental case study* is when a particular case is examined mainly to provide insight into an issue or to redraw a generalization. The third type is the *collective case study*: a researcher may study a number of cases in order to investigate a phenomenon, population, or general condition.

Stake concluded that case study is a part of scientific methodology, but its purpose is not limited to the advancement of science. In fact, case studies are also of value for refining theory and suggesting complexities for further investigation, as well as helping to establish the limits of generalizability.

Between June and July 2002, a *preliminary* case study was made in my case for Grade 6 students. The sample constituted of 30 students (18 girls and 12 boys). Due to the restricted time and the many difficult administrative procedures, it was only allowed to realize the teaching setting in 5 sessions in the ‘Naturphänomene’ or natural phenomena class for Grade 6 students and one field trip. The experience gathered in this preliminary case study was the used to improve the second (the “main”) case study. This way of proceeding is commonly called “iteration”. Normally more than just one iteration is applied. It was the lack of time to continue in my case.

Summary of Stages of my Teaching Concept

1- Launching my investigation:
Proposing an investigative area and determining the sample investigative questions

2- Selecting the right methods and instruments:
Showing every group how to use properly the instruments, how they function and how to collect measurement

3- Conducting:
Field trip: each group gathers data

4- Making sense of the findings:
Analyzing and interpreting the findings, drawing conclusions and communicating

5- Interview:
Collecting students' comments and if their questions were answered

Schema 3: summarizes the different steps of the teaching concept applied in Bammental.

20. 3 Intervention study.

In action research, individuals or groups of teachers undertake a small-scale research project relating to an aspect of teaching and learning. An action research focuses on a specific local problem and results in an action plan to address the problem faced. The results of such research are used to improve school development planning.

The intervention action study took place from May till July 2003 at the Realschule Linkenheim. It was realized in 26 sessions on Thursdays and Fridays.

Because the science teacher, who was very seriously and actively involved in our project, changed his teaching strategy during my intervention study, this intervention study may also be called an action research.

- The sample consists of 31 students (11 boys and 20 girls) of Grade 5d in NWA (Thursdays 2 sessions divided in 2 groups of 18 and 13 students and on fridays the whole class is regrouped).
- The teaching and learning conditions in the classroom before the teacher (T.E) took the job: An experienced science teacher taught in a very productive way the class. Mr. Eggert took over the class after ½ year and had reached: (a) the questions count and not the topics, (b) his teaching enhances the self-understanding, (c) there is a liberty to find own solutions, (d) students' proposals for solutions are very welcome, (e) NWA is connected with work and achievement. Achievements are judged in the class, but the teacher has the final say and (f) a general students'estimation: NWA is interesting.

- After 10 participatory observations and introducing students to write a portfolio, 10 students(5 girls and 5 boys) were chosen as a focus group to be interviewed. These students were chosen in accord with the teacher and as results of the classroom observations. Here I intendend to have a wide range of students' performance; from brillant to weak performance students. Before the interview, they were asked to draw a scientist at work, and later they were asked about their drawings.

Summary of Stages of my Improved Teaching Concept

1- Presenting as a story the life of Alexander von Humboldt, his trip to Latin America:
This historical introduction aimed to inspire students to formulate their investigative questions

2- Formulating their questions about themes of their interests related to NWA:
Selecting in a class discussion the sample investigative questions

3- Gathering information relevant their themes:
Students looked by themselves for information and they were provided with books, videos and CDs

4- Conducting their experiments:
Every group was performing his investigation independently or under the teacher supervision

5- Communicating their findings:
Every group presented his work with a poster to the others

6- Evaluating their works:
In a class discussion, students set criteria to evaluate their portfolios, every students evaluated 2 portfolios

Schema 4: summarizes the different steps of the improved teaching concept applied in Linkenheim.

20. 4 Pre and post-questionnaires.

There are numerous paper and pencil instruments, which assess some aspects of students' meta-conceptual understanding of science and or/ the scientific method. Namely, the TOUS of Klopfer and Carrier in 1970, the Test of Understanding Science, for junior high school students. This test is a multiple-choice, written test, which assesses students' understanding of science as a human endeavor and as a social institution. Because such type of tests have a clear limitation: they did not allow students to give their own questions. Further, multiple choice assessment necessarily place constraints on what can be revealed of students' own initial conceptions (Carey et, 1988).

Another instrument is the Views on Science – Technology – Society (VOSTS) developed by Aikenhead, Ryan, and Fleming in 1989. The VOSTS is an inventory of multiple choice items. Each item consists of a statement with several related reasoned viewpoints or positions. This instrument has a disadvantage: when used outside the Canadian context in particular and the Western context in general, the various VOSTS positions would create a situation not substantially different from the one in which the responses are imposed

by researchers or instrument developers. In addition, the forced-choice nature of VOSTS items limits the space of answers available to respondents (Lederman et al, 2002).
Indeed, when given the choice, several Lebanese science teachers indicated that their views on the nature of science issues elicited by some VOSTS items were either not represented among, or were combinations of, the provided viewpoints (Abd-El-Khalick & BouJaoude, 1997).

Carey et al (1988) have developed a 24-item, multiple choice, written pre- and post-test which included items from TOUS and other standardized instruments. It attempted to evaluate students' understanding of scientific inquiry and knowledge, and of experimental design. This researcher found that as a research tool the test was a less sensitive measure than her clinical interview. Furthermore, Lederman et al (2002) have used the VNOS in conjunction with individual interviews to provide meaningful assessments of learners' views about/ and the range of nature of science aspects.

For the preliminary study in Bammental, I used a pre-questionnaire (Appendix D) of 8 questions, designed in German and considered as a primary source of information about students, at the beginning of the investigations to (a) record pupils' interests about chosen natural phenomena topic, (b) collect "what pupils have in mind" about the chosen natural phenomena and (c) know their understanding of natural phenomena relevant to Humboldt observations, as well as where and how they like to learn about such topics.

The post-questionnaire (Appendix E), administered at the end of the school year in Bammental, constituted of 15 questions (many were closed-ended questions) and was used to record pupils' acquired knowledge as well as their comments and suggestions concerning the experiments and the way they were implemented.

The most important factors, that contributed to use this type of instruments, are that I was novice in the German language and because of the limited time for implementing the teaching setting. Finally, note that almost all the data collection strategies in this study, such as questionnaires, interviews were initially designed in English and conducted in German, after they have been revised by my German friends and my research group and the class teachers themselves.

For Linkenheim Realschule students, I administered a questionnaire in the last scholar year (Appendix F) formed of three questions about seven pictures drawn by students of Grade 6 (5 girls and 2 boys) who were involved in the main study. These pictures were chosen by an educator in the chemistry education department, regardless of the gender and according to their good drawing quality, as well as, these pictures or metaphors represented a good description of students' impressions about portfolios.
The second questionnaire (Appendix G), consisted of 4 questions, was used to collect students' answers about the Draw-a-scientist-task; twenty four students (9 boys and 15 girls) filled it in, by showing them with the means of an OHP the 10 drawings (all drawings were presented at the same time) about the DAST task of their classmates, while the focus group (10 students) were present in another classroom, making a group discussion about their drawings. The questionnaires took each 20 minutes for filling-in and for both, students were asked to work as they like, either alone or in groups, and they were supervised by their science teacher.
In fact, I seek from these 2 questionnaires to validate my interpretations about the students' metaphors and the DAST.

21. 5 Verbal data: semi- structured interviews.

Mayan (2001, pp.15-16) remarked that a semi-structured interviewing collects data from individual participants through a set of open-ended questions asked in a specific order. Although the questions are set, participants can answer freely in contrast with a close-ended questionnaire in which predetermined answers must be chosen. The number of questions asked should be minimal to avoid interrupting the flow of the interview. Questions also must be clear and not leading. The questions need to be ordered in a logical manner and address just one issue each.

Finally, to check the order and the questions, the researcher must test and revise them with colleagues or friends in advance of the first interview.

For Flick (1998, p. 95), the advantage of this method is that the consistent use of an interview guide increases the comparability of the data and that their structuration is increased as a result of the questions in the guide.

Abdullah and Scaife (1997) used the 'interview about concepts' method to probe the extent of knowledge about forces of 9-year-old-students. The researchers found that, with younger children, they needed to ask them follow-up questions after their initial responses; otherwise they tended to remain quiet.

The post-interview for Bammental Grade 6 students was an *evaluation interview*: to learn about students' perspectives on the strengths and weaknesses of the project. The post-interview questions consisted 17 questions (Appendix H), categorized as experience questions, feeling questions and suggestions, with respect to students' activities as well as their reactions regarding enjoyment and acquiring knowledge of the teaching. Ten students (7 girls and 3 boys) were post-interviewed after 4 months of the realization of the project. I conducted the interviews with the help of the class teacher, who interfered sometimes to clarify my German.

For the first interviews, the teacher was present and when I noticed that students were not feeling free in expressing their comments on the project (because, they thought that it was a part of their regular teaching), I chose to conduct the interviews alone.

The pre- and post interviews were used for Linkenheim Grade 5 students. The pre-interview (Appendix I) aimed to assess students' perceptions about science and scientists and using a framework drawing on the following areas: characteristics of scientists, history of science and the epistemology of science. The post-interview (Appendix J) assessed students' changes in their views about science and scientists and the relationship of their work with Alexander von Humboldt after the teaching setting.

Both interviews were conducted by a science teacher and also an educator working at the teaching chemistry education department and myself. He was posing the questions and he took the task to clarify my questions when I was also asking questions. A focus group of this class (5 girls and 5 boys) were pre- and post-interviewed. The interviews were held in an easy atmosphere, because the students were used already to us.

21. 6 Visual data: classroom observation.

A form of observation, which is more commonly used in qualitative research is participant observation. In participant classroom observation, one immerses oneself in a chosen setting for a period of time to gain an inside perspective of the setting (Mayan, 2001, pp. 11-12). Moreover, participant observation can be used to access information that is otherwise unavailable. By participating in the setting, the researcher gains awareness through personal experience by getting to know the group involved.

Only in Linkenheim (7 classrooom observations, Appendix K), I made *short-term observations* and I was present as a *complete observer*, where I was sitting in the classroom recording observations about students (questions, what they were doing, etc.) and the teaching setting in my field notebook without interacting with the activities.

To record	Brief description of the class	Data collection plan	Remarks
Date: Class: Theme: Pupils number: Girls no: Boys no:	✓ The classroom environment ✓ Atmosphere during teaching 1. how pupils behave: bored, sleepy, participant etc.. 2. how the teacher behaves: frontal teaching, writing all the time, arising pupils' interests, etc.. 3. interaction between pupils and their teacher. ✓ Goal of the session.	✓ Tools used by the teacher ✓ Time spent on teaching, organization of the lesson, using graphs, the blackboard, looking for the homework, etc.. ✓ Questions raised by pupils (with respect to gender, whether boys are asking often, whether their questions were properly answered). ✓ Questions raised by the teacher (whether they are answered). ✓ Time spent on questions ✓ Time spent on exercise ✓ How pupils are working: in groups or alone.	✓ Let the pupils know what I am recording and why. ✓ What kept the students engaged? ✓ When did students get lost or lose interest? ✓ To see if the teacher is giving directly the right answer or working with pupils to find out the solution. ✓ Writing my reflections.

Table 6: represents the following guiding questions for my recorded observations.

21. 8 Draw-a-scientist-task (DAST).

The Draw-a-scientist test has been used in research for a long time in different formulations and with slight modifications. (For instance, Mead and Metraux 1957, Chambers 1983 and Sjøberg 2000). The first attempt to describe systematically the standard image of scientists at work was Mead and Metraux's study (1975, pp. 386-387) of its presence in a population of American high school students. The stereotypical portrait, which Mead and Metraux drew, based on their research (reported in Chambers, 1983), and remains the most succinct and useful description in the literature:

> The scientist is a man who wears a white coat and works in a laboratory. He is elderly or middle aged and wears glasses ... he may wear a beard ... he is surrounded by equipment: test tubes, Bunsen burners, flasks and bottles, a jungle gym of blown glass tubes and weird machines with dials ... he writes neatly in black notebooks ... One day he may straighten up and shout: "I've found it! I've found it!" ...

> Through his work people will have new and better products ... he has to keep dangerous secrets ... his work may be dangerous ... he is always reading a book.

Song and Kim (1999) list 15 papers published between 1983 and 1998 reporting studies of the images held by pupils ranging from elementary school to high school age. For instance, Chambers (1983) in the United States, Canada and Australia. In the Western world the popular picture of the scientist was widely held, regardless of country or age.

Moreover, Finson, Beaver, and Cramond (1995) developed the Draw-A-Scientist checklist (DAST-C). Each item on the DAST-C represents a stereotypic characteristic derived from reviews of literature relating to students' images of scientists. These researchers used the standardized checklist in combination with a structured interview.

Why using the Draw-a-scientist test at the beginning of the teaching approach?

First of all, there is a broad agreement that all teaching should "build on" the *interests* and *experiences* of the child. In particular, everybody who subscribes to (some version of) educational constructivism will take such a stance for granted. For the educational contents to be meaningful for the learner, it must have some sort of relevance, and it must fit into the personal or societal context of the child (Sjøberg, 2000).

The popular pictures of scientists seem to be common worldwide and begin to form at a very early stage of development, at least from a very early stage of development and remains stable for many years (Newton and Newton, 1998). Furthermore, it is particularly important for students to have positive images and attitudes towards scientists when they need to make decisions about their future careers (Kelly, 1987, cited in Song and Kim, 1999).

In addition, almost all research studies dealing with assessing students' understanding of nature and epistemology of science emphasize the importance for science educators and school teachers to depict students' perceptions about science and scientists or the "mental luggage" (Sjøberg, 2000) as prerequisites for an appropriate and accurate science learning (For instance, Ryan and Aikenhead, 1992. Boylan et al, 1992. Ryder, Leach and Driver, 1999. Sjøberg, 2000).

Moreover, Larochelle and Desautels (1989) hypothesize that the success of a constructivist approach to learning science may be contingent upon an adequate understanding of the epistemology of science (cited in Ryan and Aikenhead, 1992).

In the main study at Linkenheim, a focus group of ten students (5 males and 5 females) were chosen from the sample, and were asked at the beginning of the approach to draw a scientist at work (Appendix I). They were also interviewed individually about these pictures at the beginning and at the end of the research. Moreover, during the interview, these students were faced to the drawing representing Alexander von Humboldt and Aimé Bonpland in the "Urwaldlaboratorium am Orinoco" (Figure 6). This aid-material aimed to make students a comparison with their drawings. In this way, they have a concrete example of scientists at work in the past.

Figure 6: A painting made by Eduard Ender representing *Humboldt et Bonpland sur l'Orénoque*, 1871. Académie des sciences, Berlin.

At the end of the teaching, and after approximately 6 months, I went back to Linkenheim in order to administer a questionnaire to the class who was involved in the last year in the project, and at the same time, I asked the focus group (9 students, 1 boy was absent) to validate my interpretations concerning their drawings about scientists at work.

21. 9 Portfolio.

Initially, portfolios were used in the education of teachers; the work of Schulman (1987, 1988) and the Teacher Assessment Project at Stanford University (Collins, 1991a) gave rise to a large interest in portfolios. The purpose of that work was to explore new approaches to teacher evaluation, especially alternative forms of teacher assessment.

Since the 1990s, portfolios were applied in primary and secondary school, and have grown as tools for students to represent what they have learned in a variety of curricular areas (Yancy, 1992).

In her introduction, Burke (1997) wrote: "to make student assessment more authentic, educators have begun using student portfolios to capture evidence of growth and development over time. Teachers are now asking students to reflect on their learning, share their findings with peers, and set new goals based upon their strengths and weaknesses. Many educators, students, and parents find that portfolios show a dimension of the students' learning that is often not found in traditional and standardized tests. The portfolio is more personalized, allowing choice and encouraging reflection". In addition, Wolf (1989) described a portfolio as a portrait of development.

What is a portfolio? Collins (1992) defined portfolios as "a container of collected evidence with a purpose". Evidence is documentation that can be used by one person or group of persons to infer another person's knowledge, skill, and/ or disposition. The requirement that the evidence in a portfolio be focused on a purpose is key both to designing and to developing one.

Depending on the tradition, the purpose, and the context, a portfolio may be evidence of one's work, the work of others, solitary work, mentored work, some work, best work, or all work. A portfolio is whatever the community using the portfolio wants it to be. Because of this variety, the possibilities for portfolios in science education are numerous. It is seldom that a community is able to create its traditions consciously, but the community of science educators is in the position to form portfolios into whatever they want them to be.

What might be some uses for the portfolios? The portfolio becomes a tool for clarifying what are the goals for teaching and learning science. A portfolio purpose statement implicitly creates a rational for what is taught in the science class and what the students are expected to learn. The use of the portfolio can move science teaching beyond covering material in a textbook and answering questions at the end of the chapter.

Yancy (1992) reports that portfolios in schools began with primary and secondary school students constructing portfolios about their abilities, and have grown as tools for students to represent what they have learned in a variety of curricular areas (Cole, Messner, Swonigan & Tillman 1991; Collins & Dana 1993; Knight 1992). Wolf (1994, p. 113) states the belief among educators ‘that portfolios can greatly enhance student and teacher learning has fuelled an intense exploration of portfolios across a variety of educational contexts’. Framed by Collins (1992) as ‘a container of collected evidence with a purpose’, a portfolio in science education can be used to assess the knowledge, skill or disposition of the portfolio preparer.

Collins emphasized that purpose is the most important aspect of the portfolio design process. In deciding the purpose, the designer of the portfolio is making a host of decisions including how the portfolio will be used and what evidence is acceptable. As a student assessment tool, the portfolio can be the space for a student to document and demonstrate her or his growing understanding of a particular science concept during a specific period.

Wolf (1989) stated the following:“Portfolios in the classroom can be related to the use of portfolios by artists. They reflect the student's own perceptions of the learning and production process, and they can enable students to take control of their learning. Portfolios bridge the gap between assessment and instruction. They are at the same time instruments for evaluation and instructional tools. Development of a portfolio should reference the following guidelines:

(1) Portfolios must show the process of student reflection on learning.
(2) Students should own the portfolio; they should therefore select what goes into it.
(3) Portfolios are not cumulative folders; inclusion should be meaningful.
(4) Student classroom activities should be conveyed by the portfolio (including metacognitive activities).
(5) The portfolio should, ultimately, contain only that information that the student is willing to make public.
(6) Portfolio purposes should not conflict (e.g., student versus school district goals); they should reflect instruction related progress.
(7) Student growth should be illustrated.
(8) Students should be given portfolio models.

Portfolios should, therefore, show student performance in context, involve the student as participant in assessment, and offer a place for students to become independent, self-directed learners”.

Wolf (1996, p. 34, cited in Burke) remarked that a teaching portfolio should be more than a miscellaneous collection of artifacts or an extended list of professional activities. It should carefully and thoughtfully document a set of accomplishments attained over an extended period.

Hebert (2001) posed the following question: "How should a student's learning be measured and assessed? In her opinion, standardized tests show "Which child knows more?", whereas student portfolios can show "What does each child know". For her, portfolios implemented with elementary level students can serve as a powerful motivational tool by encouraging students to assess their own work, set goals, and take responsibilities for future learning.

Why should students assess themselves? What purpose is served by a child telling the story of personal learning? These questions formulated and answered by Hebert (2001, p. 5), who believed that all scholls recognize their responsibility to prepare children to assume an active and constructive role in the society of their future. To that end, it makes good sense to engage children in understanding themselves as learners as soon as possible.

Because one of the aims of this study is to encourage students in reflecting on self-learning process, I used portfolios as a relevant and consistent instrument to this task in order to collect students' reflections on their learning on one hand, and to collect the acquired nature of science aspects on the other hand.

The portfolio tool was applied in Linkenheim Realschule. At the beginning, students were initiated to the portfolio work in 3 sessions: they had to formulate questions of their interests about a common theme, which were the Locusts (Stabheuschrecken). I noticed in the classroom a terrarium full with these insects, that students had to bring them food and water, and cleaning it once a week. In fact, I got the idea about this theme in order to introduce the portfolio work in the classroom in an easy way to students. Some students' questions were: where they live, what they eat, do they have all wings, etc.. and this was the cornerstone to launch in this new learning instrument.

For the second portfolio, students were independent; they already knew about portfolio and thus they could start to focus on the themes of their interests. Students started with their portfolios from mid-May till the beginning of July, 2003.

One session on Fridays was devoted to portfolio work, where there was a real student-teacher and student-student interaction, class and group discussions and filling-in pen-and-pencil sheets, in order to follow students with their learning process and being aware of students needs about portfolios, as well as, to provide them with books and materials. To notice that students were in their second portfolio work, which means that students were used to this form of learning. Students get at the beginning a detailed checklist "Wie schreibe ich mein Portfolio" (Appendix L) and the end of the activities another detailed checklist of "Portfolio Bewertungskriterien" (Appendix M) to develop insight of the criteria that they will be used to assess their portfolios, but there was a class discussion, where students set the assessment items. Portfolios were then assessed (each student had to evaluate 2 portfolios) according to students' self-set criteria. At the end, students made posters summarizing their activity and because of the lack of time, only 2 groups (the barometer and the volcano groups, 5 students) were able to present their works to the class.

At the end of the year, the portfolio sample constituted of 28 portfolios. Students get notes, which were also discussed in the research group including their teacher and one educator expert.

21. 10 The metaphors.

Lakoff and Johnson (1980, cited in Moser, 2000) assume that conceptual thinking is generally metaphorically structured and while metaphors are seen as an expression of thought rather than language, they reason that metaphors consequently also structure and influence action.

Moser showed that it is possible to combine a cognitive understanding of metaphor with a research scope in individual, social and cultural differences in metaphor use and mental models of the self. At the same time, it proved to be very useful to combine qualitative as well as quantitative approaches to metaphor analysis. Analyzing metaphors thus not only gives access to the tacit knowledge and mental models which shape the individual understanding of the self, but also to the cultural models provided by language to express individuality, self-concept and the 'inner world'.

Thomas Häcker, my colleague of the Heidelberg group of Prof. M. Schallies, is using portfolios at all levels from K-12 as well as in teacher education as a tool to raise the quality of learning (vgl. Häcker 2001; 2002), especially self-determination in learning processes (Häcker et al. 2002; Häcker 2003; 2004a; 2004b). In his portfolio research projects he investigates the impacts of the portfolio-method on individual learning, instruction and the learning environment. He uses and analyzes metaphors as a possibility for students to sum up their experiences with the portfolio.

I used this research strategy to record students' emotions and thoughts about the work with portfolio, as a part of the science portfolio assessement, which is a new trend in science education. In fact, metaphors are currently used in cognitive linguistics, as well as in other disciplines such as cognitive anthropology, computer science, and philosophy of language, and to a smaller extent also in psychology (Moser, 2000).

I used this research strategy with the sample of Grade 5 students at Linkenheim Realschule, who were asked at the end of the scholar year to draw their impressions about portfolio. This method seemed to be very efficient, because within this age, students express their thoughts better by drawing than talking. Moreover, students liked very much this activity.

21. 11 A nature of science activity: Tricky Tracks!

Among the inappropriate conceptions of the nature of science frequently portrayed in textbooks is the notion that for every question posed about the natural world, scientists will eventually find 'the correct and absolute' answer. This idea is reinforced when students are expected to come up with 'the' correct answer to end-of-chapter textbook exercises; choose the *one* correct answer on multiple choice tests; or reach *the* right conclusion in 'cook-book' laboratory sessions (Lederman, 1998, p.85).

'Tricky Tracks!' (Appendix O) can be typically used to introduce students to the nature of science. It can be used to establish an atmosphere that supports students'active participation in classroom discussion. It conveys to students the message that every idea counts irrespective of it being the "correct" answer. Students completing this activity will gain experience in distinguishing between *observation* and *inference* and realizing that, based on the same set of evidence (observations or data), several answers of the same question may be equally valid and that inferences must be consistent with the evidence.

It was taken from Lederman et al activities (1998, pp. 85-91). Moreover, the scientific knowledge prerequisite is minimal and it can be applied for upper elementary, middle, or high school. Finally, the activity can be presented in a nature of science unit or can be infused throughout a science content course of study.

At the beginning of the project, students were initiated to a nature of science aspect, which is "the difference between observation and inference" as an activity taken from Lederman et al (1998) study, called "tricky tracks". This activity was introduced in Linkenheim at the beginning of the teaching setting. There was a class discussion and during it, students were asked to record their thoughts in paper-and-pencil paper (Appendix P). Students participated in an active way, showing creative thinking and imaginative mind, by presenting numerous stories about the 3 pictures, which were introduced in the 3, 1 and 2 order.

During the class discussion, students were asked to write down their stories and comments in a pencil-and-paper sheets. After 2 months (at the end of the project), the 10 students of the focus group were interviewed again about these pictures, such as, "Was hast du aus dieser Geschichte gelernt?", "Was ist für dich Schlussfolgerung und eine Beobachtung?", "Wenn Du jetzt die Geschichte hier ansiehst, was hat das für Dich mit wissenschaftlichem Denken zu tun oder mit Wissenschaft zu tun? ".

21. 12 Telling a story.

From the work of Solomon in Britain and Carey classroom researches carried out in the USA (using stories of Pasteur and yeast and the microbes that he found in bad wine), using stories combined with practical work, Solomon (2000) believed that starting by telling a story "is the basic sort of research - classroom action research, where we find out whether the wonderful ideas which we had about teaching the history of science really work".

Based on these reasonings, I tried at the end of the approach, to ask the focus group to validate my interpretations about their DAST drawings, by telling these interpretations in a story (the German version is in Appendix Q). The group discussion was video recorded; their discussion was transcribed and coded for later analysis. To get a better validation, the rest of students of the sample, supervised by their teachers, were asked, at the same time, to interpret students DAST pictures as well as their interpretations about the students' metaphors relative to portfolios.

Note that Howard (1987) and Newton and Newton (1992) found out, that changes in the science education a child receives could give rise to changes in their conceptions and, in turn, in their drawings of scientists. This is why, I am collecting students own interpretations of the drawings, and a particular I attention took to Question no 6.

Story about students' drawings and interviews

Liebe Schüler,

Ich hoffe, dass ihr euch noch an unseres Projekt erinnert, das für meine Promotionsarbeit an der Pädagogischen Hochschule Heidelberg wichtig ist.
Wir treffen uns heute, weil ich ein Rückgespräch für meine Arbeit benötige. Aber zuerst möchte ich euch mitteilen, was habe ich bis jetzt mit euren Zeichnungen und Interviews gemacht! Ich analysierte eure Zeichnungen hinsichtlich meiner ersten Ziele: wie nehmt ihr einen Wissenschaftler an der Arbeit wahr? Dann verglich ich sie mit den Arbeiten in den USA, Großbritannien, usw..
Jetzt erkläre ich euch als eine Geschichte was ich in euren Zeichnungen und Interviews beobachtete und will später eure Zeichnungen besprechen:

Eure Zeichnungen zeigten weiße Männern, die alle in einem Labor arbeiten. sie tragen Schützbrillen oder normale Brille und sie versuchen chemische Untersuchung zu tun. Sieben Wissenschaftler lächeln und andere nicht. Der Arbeitsplatz ist ähnlich wie euer Klassenzimmer: ein beleuchteter Raum mit einem großen Arbeitstisch in der Mitte, hinter dem der Lehrer normalerweise am Anfang jedes Experimentes stand, die benutzten Materialien und die chemischen Reagenzien in den Zeichnungen waren dieselben, die im Thema über Säuren verwendet wurden. Mädchen hatten mehr Aufmerksamkeit für die Einzelheiten: der Gebrauch von mehr farbigen Räumen in euren Zeichnungen und 3 von euch zeichneten das Terrarium, das im Klassenzimmer während des letzten Schuljahres anwesend war.

Wenn ich diese Informationen deute, kann ich folgendes sagen: für euch haben Wissenschaftler die Aufgabe immer was Neues herauszufinden und vielleicht macht ihre Arbeit Spaß, deswegen lächeln sie. Auf die andere Seite denken 3 von euch, dass die Arbeit von Wissenschaftler vielleicht langweilig ist. Aus diesem Grund lächeln einige von den dargestellten Wissenschaftlern nicht. Sie arbeiten immer allein im Labor und sie machen ähnliche Arbeit, wie die, die ihr in NWA gemacht habt. Zum Beispiel, im Umgang mit Natron und Saure.

Während der Interviews sagten manche von euch, dass diese Wissenschaftler ein Professor oder ein Lehrer sein könnten, der seinen Schüler Experimente zeigt. Viele von euch erkannten, dass auch Frauen Wissenschaftler sein konnten. Sechs Schüler glaubten, dass Wissenschaftler mehr Zeit in einem Labor zu verbringen mussten, wegen der einfachen Zugänglichkeit des Mittels, wie Chemikalien, Technologie und Bücher. die anderen 4 Schüler erkannten, dass Wissenschaftler auch draußen und zu Hause arbeiten konnten was ist abhängig von der Tätigkeit. Alle von euch sagten, dass der dargestellte Wissenschaftler ein Experiment durchführt.
Wir fragten euch „Warum experimentieren Wissenschaftler?". Viele von euch glaubten, dass Wissenschaftler etwas Neues herausfinden wollen und dass sie immer neue Sachen erlernen, indem sie Instrumente benötigen

Am Ende des Schuljahres, wurdet ihr gefragt, ob ihr Wissenschaftler anders zeichnen würdet, oder noch etwas in den Zeichnungen ändern. 3 Schüler wollten die Zeichnungen so lassen, wie sie sind und 7 Schüler wollten etwas dazu zeichnen. Z. B., wollte einer zeichnen „einen anderen Mensch mit einem Kittel", oder 6 Schüler wollten mehr Bücher zeichnen würden und dass die Wissenschaftler auch draußen in der Natur arbeiten können.

Schema 5: represents the story told before the focus group.

- **The discussion took place within the context of the following questions:**

1. Was denkt ihr jetzt über eure Zeichnungen?
2. Was haben die Bilder für euch gemeinsam?
   The teacher will ask then the following leading questions:
   - ✓ Warum arbeiten sie in einem Raum?
   - ✓ Warum arbeitet er allein?
   - ✓ Warum lächeln einige Wissenschaftler auf der Zeichnungen und andere lächeln nicht?
   - ✓ Warum ist das Labor wie eur Klassenzimmer (der Arbeitstisch, das Terrarium)?
   - ✓ Warum sehen sie ordentlich aus (Notizblock, rasiert)?
   - ✓ Sind sie Wissenschaftler immer weiße Menschen?
   - ✓ Ihr habt Beispiele über seine Arbeit gegeben und ich finde, dass die Beispiele gleich waren, wie ihr in NWA gelernt habt, warum?
3. Wissenschaftler sind beschäftig auch mit Physik, Biologie, Archäologie usw. Warum macht der dargestellte Wissenschaftler nur chemische Experimente (Reagenzgläser, Bunsenbrenner usw ...)?
4. Einige von euch haben in ihren Interviews über gefährliche und giftige Sachen gesprochen. Warum?
5. Woher hast du deine Vorstellung von Wissenschaftlern?
6. Hat unser Unterricht eure Meinung über die Wissenschaftler und ihre Arbeit verändert? Was waren die Veränderungen?

21. 13 Videotaping.

In both classrooms, all the teaching sessions were videotaped. Some students and I took the task to record students at work, which aimed to keep a registered record in case I missed or forgot some aspects of teaching, which able me to return all the time to these records.