SciencEduc – Work package 3 – Deliverable N° 3

Evaluation Report and data base

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Introduction

The objective of this work package is a development of database of all evaluations made within each partner country and comparisons of results obtained. "Evaluation" means here: evaluation for the systemic aspects of science education renovation, and whenever possible, evaluation of differential performance achievements of pupils in schools. The participant countries in this work package are Estonia, France and Sweden.

Inquiry based science education in Estonia, France and Sweden

Under Scienceduc framework, our objectives were to establish a database that aims to provide objective criteria of evaluations made within the large scale on-going actions undertook in France (*La main à la pâte*), Sweden (NTA) and Estonia and if possible to compare results obtained. A comparative approach between EU and foreign countries using the inquiry based approach in primary school was also considered.

During the first year of SciencEduc Estonia, France and Sweden collected "everything" written about their own program. With "everything" we meant documents written by researchers, school inspectors, teachers or student teachers. We found a lot of different types of documents as investigations, evaluations, articles, book chapter, conference papers, proceedings, master thesis, thesis for Teacher examination (Bachelor degree), development work at schools and reports of different kinds. The problem was that most of them were written in the native language.

In annex 1-3 there are short descriptions of primary school in Estonia, France and Sweden and a summary of the evaluation reports in these countries. All have programmes on Inquiry Based Science Education in Primary School but different ways of implementing them. In Estonia they got a new curriculum in 2002 where the main goal for science is to develop higher order cognitive skills. The problem is that situation in school is not supporting implementation of hands-on activities. As the textbook is the main source in the learning and teaching process their first task is to develop new teaching material. In France La main à la pâte started as a small project which then grew and influenced their new standards from 2002. In Sweden a new curriculum entered into affect in 1994 with goals not only for biology but also for physics, chemistry and technology in primary school. As schools in Sweden had no tradition in teaching physics and chemistry at primary level but also a great freedom to decide what to teach about there was little change. The implementation of the NTA programme has made a big difference in the municipalities who have adopted it. All these reports of inquiry based science education methods in primary school give a positive picture. The pupils are happy, the teachers are happy and they all learn a lot of science.

Inquiry based science education in partner countries

This year we started with asking all the other partners (Germany, Hungary, Italy and Portugal) to send us evaluations and articles about their program but we got little responses. The reason was that inquiry based science education have just started in these countries and therefore they have no written documents of their programmes.

Sources of references

So instead we decided to search for publications about evaluation of Inquiry Based Science Education in Primary Schools. The bibliography: Students' and Teachers' Conceptions and Science Education" compiled by Reinders Duit from Kiel University, was of help as well as different databases as ERIC and EBSCO. When searching we tried different combinations of the words evaluation, inquiry, science, education, primary and also with their synonyms but found very few publications. Using a broader search gave us more articles and there are about 50 references interesting for our projects. So instead of a database of all available evaluations made in the partner countries Deliverable 3 in SciencEduc will be a database of relevant articles about Science Education in Primary School. The database is done in a program called EndNote but also accessible as a Word-file. This data base includes all kind of published and unpublished documents existing about the topic. For the latter group of documents a URL or a contact person was indicated

Description of the database
The database consists of the following types of documents

a. Book
b. Book section
c. Journal article
d. Conference proceeding
e. Conference paper
f. Report (investigation, evaluation, …)
g. Thesis (doctoral, master, bachelor, ..)
h. Unpublished work

Trends in the database
It is not possible to summarize these articles about inquiry based science teaching in primary school as concept like inquiry, teaching, learning and attitudes are not well articulated and understood and the research methods and focus are very different, often small scale qualitative studies. This was also recognised by the *Inter Academy Panel* (IAP) working group of evaluation of inquiry based science education program. One of their aims now is to develop instruments for assessing students' learning in science and make it possible to compare the outcomes.

The articles show that primary science is an area of concern all over the world. In some countries it is changes in the curriculum and syllabuses which are the motive power in others it is the Academies of Science. In the US there are two large ongoing projects *Science and Technology for all children* (STC) and *Insight* which have inspired national projects in European countries. Many of these national projects have started in a small scale and then grew to large, national projects. Good examples are *La main à la pâte* in France and *NTA* in Sweden. In turn these projects have inspired to projects in other countries. A common idea in these projects is the need of teacher training and kit based instructions.

There are few articles dealing with the same topic, instead many authors suggest further studies. In the following you will find some trends about the science programs and their effects on teachers and students.

Science programmes in primary schools

- There is a great potential for development. Science teaching in primary school has improved but more needs to be done.
- The effect on school level depends on the headmasters and the conditions given by the municipality.
- The way of working supports pedagogical discussions in school.
- The inquiry approach could be improved. The phase where students face their results to validated scientific knowledge is often insufficient

- Program should be more flexible and adapted to different requirements and the needs of different teachers.
- It is important to identify salient aspects of pedagogy training of science teachers
- Assessments could be used not only to evaluate student performance but also to suggest changes in instructional practice to support effective learning.
- Language facilitated the construction of scientific concepts. Pupils need to explain, to argue, to discuss, to write and this allows the construction of the knowledge. At the same time the scientific activities allowed to develop some language skills
- Inquiry ability enhanced regardless of grade, achievement, gender, ethnicity, socioeconomic status (SES), home language, and English proficiency.

Teachers

- The role of the teacher, his/her attitude and knowledge are extremely important and are a precondition for success.
- Professional developments for the teachers are very important.
- Kits of material and pedagogical support are necessary
- Teachers attempt lessons that they would not have tried before.
- They teach much more science and especially more chemistry, physics and technology. Their way of teaching has changed to a more pupil centred way of working.
- Many teachers have changed their way of asking questions and talking to the children in the classroom. They now ask more open-ended questions.

Pupils

- The pupils learn about science and many become interested in the subject area.
- Pupils become more lively and excited when involved in hands on
- Hands-on activities were likely to result in higher levels of motivation amongst pupils than text book work
- Students that were not interested in any classroom activities, are now interested in these inquiry based lessons.
- There is evidence that children, particularly lower achievers, perform better on more interactive, practically based tasks than on comparable tasks presented in a purely pencil and paper format.
- Students that have trouble in reading, sometimes out-perform some of the other students.
- The longer they are in the program, the higher their scores are in science, writing, reading, and mathematics compared to pupils outside the programme
- Students extend their own knowledge by replicating investigations or rebuilding models at home.
- The types of questions that pupils generated in groups enable more science investigations but they related to fewer topics.
- Freedom and flexibility, fun and lecturer support are of importance for confidence motivation and cognitive engagement.
- The pupils need to learn different tools such as documenting, reading and understanding drawings, in order to learn science.
- Working together is important as they discover and process content knowledge constructed from their investigations.

Primary school in Estonia

Pupils in the primary school are of age 7-12. Kindergarten level is more or less also included into educational system; they have to take care for kid's preparation for school. Reformed national curriculum of primary, basic and high school education of Estonia was implemented into schools in 2002 and it is mandatory. Kindergartens are free to develop their own curriculum (for ages 2-6).

Main goals of science curriculum for primary, basic and high school are presented in a way that fulfilling of those requirements will guarantee *development of higher order cognitive skills of students at school.* The problem is that teaching methods and assessment of student's knowledge and skills at school are not supporting implementation of hands-on inquiry in science studies due to the fact that teacher training and available materials for teachers (study books, workbooks and content of studies), also controlling system are not fitting to the new concept of inquiry based method. Content of science education standard is rather broad, including headings from environment, biology, geography, physics and chemistry.

Situation in schools

Aims of 2002 curriculum are still not fulfilled in school. *The textbook is the main source in the learning and teaching process* and this is very traditional situation at school, where both, teacher and students "have to pass through the book". Mainly textbook is controlling the learning and teaching process, in most cases activity of teachers and students is rather low.

In Estonian schools there exist many teachers, who are preparing experiments for demonstrations or student's practical works with the aim to initiate the learner's activity and to achieve better results in teaching. But in the case of demonstrations and so called "cook-book activities", the students have to fulfill the work according to the instructions. Students are still working with rather low activity and they do not understand deeply the content of the task. In this type of experimental work students will participate only in a passive way.

In Estonian schools all subjects are clearly defined and they are still taught separately, practically without any integration. Students have to learn mainly by memorizing facts and ideas. The explicating and interpreting are very common methods in schools today; assessment of knowledge is performed on this basis. As a result it will hinder the creative thinking of student's. Most of students don't have any positive attitude towards science taught this way.

Evaluation of inquiry methods in primary science teaching - ESTONIA

1. Evaluation of the science unit «Comparing and Measuring» in kindergartens of city Pärnu (2005)

In the Pärnu city inquiry science project in 2004/05 4 kindergartens participated with 7 groups. Kids in the groups were in age 4-7, in one group children with special needs were present. Project was oriented to the unit «Comparing and Measuring», adapted from STC program for Estonian schools. All teachers joined the teacher training program and kindergartens were provided with set of materials for this unit. Before teaching in the classroom teachers were asked about their attitude towards inquiry method and classroom activities in science. Lessons of this unit were carried out within 2 month, after that period we have organised a seminar in Pärnu. All participants of the project were asked to give their opinion about the unit and student's work and development during the unit. Feedback from teachers was of high importance because this was first time this unit was in use in kindergarten level. All teachers were asked to give their recommendations about the content and provided materials. Most of teachers were satisfied with student's ability to carry out different measurements and they just were pointing to some possibilities to make the kit of this unit more comfortable and suitable for kindergarten level. Two groups (in different kindergartens but with kids of the same age 4) have tried to use other objects for measuring having in mind to use more convenient things in the classroom. From the feedback we have got the information that children were very active in the lessons and they have continued the same activity after lessons in their own games. Teachers have appointed the need to shorten some activities due to the fact that kids of younger age are not able to follow up for a longer period with the same activity.

2. Evaluation of the implementation of science unit «Comparing and Measuring» in kindergarten level and using it for integration with math and language (2006)

Two developments of science unit «Comparing and measuring» were made by kindergarten teachers Leili Randjärv and Maiki Kruuda towards integration of existing unit to other subjects taught in kindergarten level for 7 years old kids. This evaluation was performed in Tartu with two groups of children. In both groups the unit materials were combined with development of reading and calculating skills of students. Teacher's guide was also complemented with special issues for integration which need some assessment in other classrooms. Evaluation showed better ability of children in both subjects (reading and calculating) compared with those not having inquiry based hands on lessons with the unit.

3. Evaluation of development of personal skills using inquiry method in primary science. Performed by Tiiu Leibur, Pärnu (2005).

Students (32) were interviewed before and after inquiry lessons (unit «Solids and liquids») and their development in emotional and other personal properties was determined. Author of this evaluation is stating that inquiry approach was very exciting for kids and they wanted to continue with next units. They had grown in their self consciousness and in conversational skills. They were open to speak up and very proud about their new knowledge they have got in experimenting with solids and liquids.

4. Evaluation of three science units compiled with general studies in grades 1-3 performed by Loona Pärl, Türi Gymnasium, 2006

Loona Pärl was one of the first teachers who joined Estonian inquiry program in 2000. She has been very innovative and creative in working out new approaches in STC curriculum. Current evaluation was performed 2002-2005 in Türi Gymnasium where she is working as a primary teacher. In the evaluation participated students of two parallel classes, grades 1-3. Inquiry approach was introduced by Loona Pärl with integration with other disciplines: Estonian, Math, Art and Gym. In the other class traditional approach was used by her colleague. Students were evaluated twice, before and after studies in language, math and science. Students from inquiry class had better skills in oral communication, writing and calculation; the other class was a little bit better in writing. Emotional attitude and motivation towards studies were better in inquiry class.

The primary school in France

Generalities

Age range: 3-11 (School compulsory from 6 to 16)
Number of children at primary school: > 6 million
Average number of children by classroom: 25
Primary school teachers are generalists
Curricula are national and directed by the French Ministry of Education

Science education at primary school

Current standards were implemented on 2002. They are inquiry based according to *La main à la pâte* approach:
- pupils observe of a phenomenon and express their hypotheses,
- they imagine experiments and make them,
- they look for documentation,
- they discuss together,
- they exchange their points of view, express some results, by speaking and writing,
- they compare their results to the theory,
- they learn to live together (listening , respecting others...).

Science Standards (contents)

• *Pre-school: ages 3-5*
1 – Sensory discovery
2 – Exploring matter world
3 – Discovering living world
4 - Discovering objects, security education
5 – Self location in the space
6 – The running time
7 - Discovering shapes and sizes
8 – Introduction to quantities and numbers

• *Cycle 2 : ages: 6-8*
1 – Going from familiar to far environments
2 - The running time
3 – The matter
4 –The living world
5 – Objects and materials
6 – ICT

• *Cycle 3: ages:9-11*
1 - The matter
2 – Unity and diversity of the living world
3 – Environnemental education
4 – The human body and health education
5 – The Energy
6 – The sky and earth
7 – Human constructions
8 - ICT

Structure of primary school *(Time tables - 26 hours/ week)*

- **<u>cycle 2</u>: Basic learning (ages: 6-8)**

SUBJECTS	MINIMUM	MAXIMUM
French	9 h	10 h
Living together (civic instruction)	0 h 30 (weekly discussion)	
Mathematics	5 h	5 h 30
Discovering the world	3 h	3 h 30
Foreign or local language	1 h	2 h
Art education	3 h	
Sport	3 h	
DAILY ACTIVITIES (*)	**MINIMUM**	
Reading and writing	2 h 30	
(*) Reading and writing are daily activities carried out through each subject		

- **<u>cycle 3</u>: Complementary learning (ages: 9-11)**

SUBJECTS	FIELDS	MIN.	MAX.	SUBJECT TIMETABLE
French Human and literary education	Literature (speaking, reading, writing)	4 h 30	5 h 30	12 h
	Language (grammar, conjugation, spelling, vocabulary)	1 h 30	2 h	
	Foreign or local language	1 h 30	2 h	
	History and geography	3 h	3 h 30	
	Living together (debate)	0 h 30	0 h 30	
Science education	Mathematics	5 h	5 h 30	8 h
	Experimental sciences and technology	2 h 30	3 h	
Artistic education	Music and Visual arts	3 h	3 h	
Sport		3 h	3h	

TRANSVERSE FIELDS	TIMETABLE
Mastery of French language	13 h over each subject (2 daily hours for reading and writing)
Civics	1 h over each subject, 0 h 30 for a weekly debate

Evaluation of inquiry methods in primary science teaching – France

Pamela Lucas, La main à la pâte, ENS, France

Introduction

A data collection about inquiry assessment carried out on France showed that available references about the impacts on teachers, pupils or community as well the effects of such programs promoting inquiry methods was carried out.
Evaluation is a process that could be justified, both for teachers and pupils: Through a diagnostic evaluation, the teacher detects difficulties and the gaps of the pupils when manipulating. He/she can thus set up situations of training and solution. The evaluation of the experimental situation is necessary, during and at the end of the teaching sequence.
Evaluation French bibliography (and worldwide) on inquiry process or inquiry programs is abundant if we refer to secondary and higher scientific education but for primary school, references are scarce. The very few ones concerning only primary school and science education couldn't be compared because of the variety of protocols and objectives of the studies. As a general trend, references reported qualitative studies on very little samples of students or teachers, pointing out the difficulty to carry out convenient exhaustive studies. In general, formative and somative evaluation of the students' experimental practice is often neglected in sciences teaching essentially because of material reasons. It was also noticed that only theoretical knowledge is generally evaluated, but there is no convenient tool for evaluation of the experimental practice. In addition the samples selection and the analysis of the data do not always provide a proper view of the situation.

Inquiry Impacts

Despite of that, interesting qualitative information may be extracted from some references, and especially from 3 reports progressively drawn up by Education inspectors by a Ministry order and devoted to determine the effects of La main à la pâte approach (in 1999), to assess the impact of the plan of renovation of science teaching (2002) and the degree of implementation of new standards (on 2005). They were basically founded on teacher's interviews and classrooms observations. They offer a wide and also biased view of the inquiry based science teaching in France at the 3 key moments: 2 years after the launching of the pilot experience named La main à la pâte (in 1999); after the implementation of the plan of renovation of science and technology teaching at primary school (in 2002) and 2 years after the publication of the new science standards in 2005.
The main positive effects reported are:

- At knowledge level, it was observed an improvement of:
  - Basic scientific knowledge (on the basis of the examination of the experiment book)
  - Language skills as well as oral as written, particularly for foreign children
  - Mother tongue speaking and general culture.
  - Unifying effect of scientific activities, in multicultural contexts.
  - Reasoning: pupils are able to reinvest in other fields, different of sciences
  - The number of hours devoted to sciences lessons (1h40 by week even if the standards state 2h30) and the number of training sessions for teachers is raising.
- At attitudes level, it was observed an improvement of:
  - Confidence and self esteem of low achievers (They are more confident and also better perceived by other students)
  - Pupils were more engaged in thinking
  - Teacher's attitude towards science changed positively. This is felt as a pedagogical renewal

- **The main impact was observed at behavioural level: children are more attentive, they have a better collective behaviour: They used to speak each other and listen themselves by testifying a mutual respect.**

The French Education Ministry considered in 1999 that behavioral and communication skills effects were enough to pay attention to La main à la pâte approach. Such results justified the launching of the plan of renovation of science teaching (in 2000) followed by the publication on 2002 of new standards drawing up lawful texts implementing this science teaching approach on the basis of La main à la pate experience.
It is difficult evaluate exactly the number of classes involved in renovation of sciences and technology education. It was estimated in 2002 (by classrooms observations) to an average of 15-20 %, classes of pupils from 8 to 11 years old (to 47% in areas involved in La main à la pâte since 1997).
Today, we can say that in France there is a better science teaching: 30-40% of French primary pupils (from all ages) have science lessons (1/4 of those follow science lessons according to the French standards and 1% benefit of best inquiry science teaching particularly in the areas covered by the Pilot centres, references of inquiry pedagogical practices in France).

Teachers' reactions

Surveys of teachers provided relevant information about their expectances and opinions. They considered (in order of importance) that the implementation of the inquiry based science teaching allowed them:
1- To participate to training sessions,
2- The transfer of the process to other disciplines,
3- The experimentation and investigation
4- The diversification of pedagogical practices.

Teachers considered that the implementation of the inquiry based science teaching allowed to pupils:
1- A better oral expression,
2- The motivation of low achievers students,
3- Improvement of language mastering,
4- Improvement of readings skills

The main difficulties reported in implementing inquiry in the classroom, were (the first 4 mentioned):
1- Lack of material (equipment),
2- The high number of ministry priorities,
3- Their lack of scientific knowledge (scientific background),
4- National standards so ambitious (to many subjects to be tackled).

In order to better implement the process, the teachers would like to have:
1- More material kits available,
2- More pedagogical support (they would like to have the possibility to participate to more training sessions).

Factors for implementing inquiry successfully

Several factors were identified: Training and coaching have played in France a determining role in dissemination. Availability of self-training tools as those proposed online at La main à la pâte website (which counts on 200 000 hits/ month) were also of importance. Collective

actions at school level were needed in order to make more dynamic teachers actions. About engagements, the long term ones were required. At least two years of continuous work on inquiry process were needed to evidence the first results on pupils. Of course, local education and politic authorities' support was also required allowing locally the creation of resources centres, of new positions for "leaders in science" (for teacher coaching), the organization of science trainings for teachers and of scientific events for pupils. Ministry education agreement and engagement was needed to introduce changes at school level.
In addition, some other elements need to be taken into account to success in the process implementation.
A strong piloting structure is required as well as a convenient implementation of coaching tools for teachers. The attitudes of teachers are of importance for the renewal of science teaching. Such process is easily implemented by teachers that use to work on active methods (young teachers are often more engaged). It is important to consider the generalization as a long term process.

Challenges/problems for practical implementation of inquiry process

Pedagogical problems

- In certain classes, the acquisition of knowledge is a minor objective and sometimes it could be non-existent. Often, an exclusively technological activity could be also a reducing activity (It can consists in the realization of an object, without any other specific aim).
- Sometimes teachers have problems stating conclusions and confronting them to the scientific knowledge. They may have no scientific knowledge confrontation at all.
- The time granted to one topic may be too long with the consequence that standards are not fully tackled. Inquiry could be considered as time consuming.
- Some teachers may know the theory of the process without being aware that they are not necessarily implementing the inquiry approach in their class…
- A pedagogical freedom of teachers in France may have the inconvenient that at the end of the primary cycle, pupils may have different backgrounds despite a common curriculum because they have tackled very different subjects.

Scientific problems

- Teachers are scared to deal with science at school especially when they have not a scientific background. However teachers having a scientific background are of help for those starting and that need to feel confident respecting to science teaching.
- There is an imbalance between the disciplines (biology occupies twice more time than physics and technology).

Evaluation perspectives in France

A better feed-back about La main à la pâte actions carried out since 10 years now is required as well as the identification of factors of development to be stressed to enhance the process dissemination.
For the generalization of the inquiry process in France, some recommendations were done by the reporters: The Ministry of education should take particular care to enroll teachers having a basic scientific and epistemological knowledge in the whole disciplinary fields of primary school. The timetables of the institutes for teachers training should be reinforced. It is necessary to publish documents for supporting teachers for curricula implementation. At the school level, teachers must be help in the establishment of planning and progressions, within

the framework of training activities or school network. In order to fulfill standards recommendations, it is necessary to give an increased attention to written records of pupils: texts presentation, spelling, copybooks and folders structuring as well as to the precision and exactitude of scientific vocabulary employed in conclusion sentences.
During 2007, La main à la pâte will participate to the implementation of the evaluation of scientific skills and knowledge of 11 years old pupils. This evaluation will be carried out by the French Ministry of Education. In addition, an evaluation of teachers' practices on the French Pilots centres will be carried out on the same year. Such evaluation will be launched in collaboration with the Colombian program "Pequeños científicos". More results will be available in the coming years, within the framework of the IAP working group of evaluation of IBSE programs.

Primary school in Sweden

Preschool

Swedish childcare has twin aims. One is to make it possible for parents to combine parenthood with employment or studies and the other is to support and encourage children's development and learning and help them grow up under conditions that are conducive to their well-being. Preschool activities are designed for children aged 1 and up until they start school. Preschool has its own curriculum which marks the importance of the preschool as the first step in life-long learning. The educational principles of the preschool curriculum build on care and education going hand in hand. Proper care is a prerequisite to learning and development, at the same time as the care itself has educational content. Further, the importance of play in the child's learning and development is stressed, as are the child's own activities. Preschool should be fun, safe and educational for all children who participate.

Preschool class

The preschool class is a non-compulsory form of education but the municipalities have an obligation to offer children a place in a preschool class the year before the child starts compulsory school. The education given in the preschool class shall stimulate the learning and development of each child, and lay the foundations for continued schooling.

Compulsory School

In Sweden, all children between the ages of 7-16 must attend school. The recent curriculum for compulsory education entered into effect in 1994 and states the school's fundamental values and basic objectives and guidelines. There are also nationally approved syllabi for the individual subjects. The Swedish school system is a goal-based system with a high degree of local responsibility. The syllabuses are designed to make clear what all pupils should learn, at the same time as they provide great scope for teachers and pupils to choose their own materials and working methods. In each subject there are *Goals to aim for* which clarify the quality of knowledge which is essential in the subject. These goals are the main basis for planning teaching and do not set any limits to the pupils' acquisition of knowledge. There are also *Goals to attain* which define the minimum knowledge to be attained by all pupils in the fifth and ninth year of school.

The aim of science studies is to make the results and working methods of science accessible. The education contributes to society's efforts to create sustainable development and develop concern for nature and Man. At the same time the education aims at an approach to the development of knowledge and views which resonate with the common ideals of the natural sciences and democracy on openness, respect for systematic investigation and well-founded arguments. The education should also consolidate the fascination and joy of discovery and Man's wonder and curiosity. In science studies three aspects recur, namely knowledge about *nature and Man*, knowledge of *scientific activity*, as well as *the use of this knowledge* to determine personal views on values connected with, for example, environmental and health issues.

Goals that pupils should have attained by the end of the fifth year in school

Pupils should

concerning nature and Man

- have a knowledge within some scientific areas,
- have a familiarity with narratives about nature which are to be found in our culture and that of others,

concerning scientific activity

- be able to carry out simple systematic observations and experiments, as well as compare their predictions with actual results,
- be familiar with some episodes in the history of science and through this have an insight into different ways of explaining nature,
- have an insight into different ways of understanding nature, through on the one hand science with its systematic observations, experiments and theories, as well as on the other hand by the approaches used in art, literature, myths and sagas,

concerning use of knowledge

- have a knowledge of how Man's attitude of curiosity to scientific phenomena has led to social progress,
- have a knowledge of management of resources in daily life and about practical measures for conserving resources,
- have an insight into how arguments over daily environmental and health issues can be built up through the use of personal experiences and scientific knowledge.

These are the overall goals for science education and then there are corresponding goals for biology, chemistry and physics written in the same way. Taking the first, "have knowledge within some scientific areas", could in biology stand for "be able to give examples of life cycle of some plants and animals and their different growth processes", in chemistry "be familiar with different kinds of mixtures and solutions" and in physics "have an insight into basic meteorological phenomena and contexts". These aims are very open and give the teachers much freedom.

In Sweden every municipality shall adopt a local school plan showing how the schools in the municipality are to be organized and developed. The curriculum, syllabi and school plan then allow the principals, teachers and students of individual schools the flexibility to adapt content, organization and work methods to local conditions. The planning of these elements is laid out in the school's work plan.

In Sweden we have a long tradition of teaching biology in primary school. Besides learning about the human body, outdoor education is very popular. Here the pupils learn about animals, plants, environment, seasons and weather. When the new syllabuses entered into effect in 1994 we also got very clear goals for physics, chemistry and technology in primary school. The problem is that the teachers don't feel comfortable teaching subjects they have little experience and knowledge in. At the same time the Royal Swedish Academy of Sciences learn to know about *"Science and Technology for all Children"* from the academies in the US and also got permission to try it out. They started the project in a small scale in one municipality. From the start the participation had increased to 60 municipalities or about 10 % of the pupils in Sweden.

Evaluation of the NTA-programme in Sweden

Schoultz, J. & Hultman, G. (2002). ***NTA is a great idea. We don't do things just to get bored but because we want to learn.*** **Department of Educational Science, University of Linköping**

The evaluation has focussed on three central aspects:

- pupils' ability and opportunities to participate and take initiatives in the classroom teaching
- to what extent NTA stimulates pupils' curiosity about and interest in science
- pupils' ability to observe, experiment, predict, argue, discuss and document

During our work with evaluation we have mainly been focussed on pupils' learning and development in NTA. But during our observation visits and interviews we have more and more come to understand the great importance of the teacher for the pupils' development and learning progress. We feel then that it is not possible to evaluate pupils' development and learning without at the same time looking at the constraints and opportunities inherent in the teaching situation. These constraints can differ greatly. The teacher here has an important task to organise the teaching situation and adapt teaching material to the group of pupils. The role of the teacher is extremely diverse, with the teacher's strategies, thoughts, values and actions jointly creating the learning situation. What happens when a new project makes its debut in a complex classroom situation?

We conclude in our evaluation that there is a great potential for development in the NTA concept, which is not always achieved in the concrete school situation. The pupils learn about science and many become interested in the subject area. But the NTA material is not sufficient in itself. The role of the teacher, his/her attitude and knowledge are extremely important and are a precondition for success. Professional development for the teachers in the form of working-team meetings, theme meetings, contact with universities, experienced teachers are all very important factors in the NTA concept. The concept has its limitations but also great possibilities. Properly used it will provide a platform for both pupils and teachers to develop their scientific knowledge.

Schoultz, J., Hultman, G. & Lindkvist, M. (2003) ***At first we got to use our imagination and that was fun.*** **Evaluation of pupils' and teachers' learning and development within the NTA-project. Department of Educational Science, University of Linköping**

Pupils and teachers feel happy with the NTA concept. The material fills a need and teachers and pupils have great opportunities to develop within it. But it demands active participation on the part of the pupils and teachers. The pupils have an opportunity to learn about and understand science, not just facts but also processes and ways of seeing, discovering and describing. They develop their ability to communicate about science with the help of words and terms. The image of the pupil as the little researcher who finds his knowledge himself is at variance with our discoveries in the classroom. NTA is no self-sufficient material. It requires a teacher who is active, knowledgeable and sensitive and who will lead the pupil on the path to new knowledge. The result of the NTA work in the classroom depends on the combination of pupils, teachers and materials. A teacher, who is well prepared, is familiar with the NTA concept, the framework of the classroom and the ability of the pupils can choose his/her own path through the material. He/she chooses the tasks, which suit the pupils and the goals, which are to be achieved. The teacher is present as a discussion partner with the pupils and supports them in various ways in their work and helps the pupils create a whole from their fragmentary pieces of knowledge. The pupils must be given time to reflect upon what they have done in the science project. But sometimes the projects can be too much about ¨doing¨ and leave too little time for reflection.

The teachers are positive to NTA and appreciate the structure and the training involved in the concept. The method of working is still steered by the material and the guides. But in time it is hoped the teachers will feel freer to leave the theme and give space to the pupils' thoughts and ideas.

The pupils become curious about and interested in science. But the problem is to maintain this interest also in grades 5 and 6 and when the theme does not appear to be particularly interesting. The teachers' role here is important.

Among the participating teachers science is no longer seen as so difficult and demanding and their view of the area has been broadened. Science is no longer just the forest. Many teachers testify that they have changed their way of asking questions and talking to the children in the classroom. They now ask more open-ended questions. Here we feel we must advise caution. Too open-ended questions and instructions can be very confusing to the pupils and it is essential that the teacher is present and can support and sum up.

Planning time has increased for most of the teachers. But this is seen as essential in order to adapt the material to the pupil group in question. So far the pupils have not participated in any remarkable degree in the planning but in future, when the teachers have gained more experience of NTA, this is something that can be developed.

The collaboration between teachers in the working teams can in a similar fashion be developed in future. The NTA concept has a potential for development which be made better use of in future. Our opinion is that the teachers in future projects should be given more time to discuss and to learn more about what science means, about what the ¨essence¨ of science is.

Ekborg, M. & Lindahl, B. (2006). *Evaluation of the professional development programme within NTA.* Stockholm: NTA Production and Service.

The main question for this study is *"What effects have the professional development programme on teachers and their set of values and also at level of individual schools and municipalities?"* The data is collected in two steps. First all teachers in the NTA-programme were asked to answer a questionnaire on the web about their view of science and the professional development. After analysing the questionnaire some municipalities were chosen for a deeper analysis where teachers, headmasters and school development managers were interviewed.

The result shows that most teachers are women with a very short education in science. They are very fond of working with NTA and think they have got a very good professional development in science teaching. The NTA programme helps the teachers to stimulate the pupils' fascination and curiosity in nature and joy of discovery. It also supports inquiry based teaching and develops science and technology teaching. The effect of the professional development according to the teachers is an improvement of their knowledge and self-efficacy in science and technology. They teach much more science and especially more chemistry, physics and technology. Their way of teaching has changed to a more pupil centred way of working. They also give example of ways to improve the in-service training with content as evaluation, open-ended tasks, using ICT and most important is time to discuss and follow up their experiences later on.

The effect on school level depends on the headmasters and the conditions given by the municipality. Headmasters who can see and understand the power in the project can also use the project to improve teaching and learning in all subjects in school. The way of working in NTA supports pedagogical discussions in school.

Evaluation data base

Amaral, O. M., Garrison, L., & Klentschy, M. (2002). Helping English Learners Increase Achievement Through Inquiry-Based Science Instruction. *Bilingual Research Journal, 26*(2), 213-239.
This study summarizes the results of a four-year project in science education conducted in a rural setting with English learners in grades K–6 in the El Centro Elementary School District in southern California. Data were collected to measure student achievement in science, writing, reading, and mathematics for participating students. These data were analyzed relative to the number of years that students participated in kit- and inquiry-based science instruction that included the use of science notebooks. Results indicated that the achievement of English learners increased in relation to the number of years they participated in the project. The longer they were in the program, the higher their scores were in science, writing, reading, and mathematics.

Aubusson, P., & Steele, F. (2002). *Evaluation of Primary Investigation* (Australian Academy of Science ed.). Sidney: University of technology, Sidney.
This evaluation was commissioned by the Commonwealth Department of Education, Science and Training and the Australian Academy of Science, in response to a recommendation made by Goodrum, Hackling and Rennie in their report, The status and quality of teaching and learning of science in Australian schools (2001). Primary Investigations (PI) was developed by the Australian Academy of Science in answer to a growing need for a hands-on, investigation-based sequence of activities for primary school science. It endeavoured to provide a whole school, step-by-step guide to the teaching of primary science, using a constructivist theoretical framework. The program was extensively trialled before its launch in 1995 and initial indications were that PI was very successful in helping reluctant primary school teachers begin to teach science (Featherstone, 1995; Goodrum, 1996). However, a recent national study of science teaching in schools (Goodrum, Hackling and Rennie, 2001) showed that many primary schools are still not teaching science, and that more needs to be done to improve the quality of primary science. As PI has now been available for seven years, it is timely to evaluate its performance.

Bartholomew, H., Osborne, J., & Ratcliffe, M. (2004). Teaching students "ideas-about-science": Five dimensions of effective practice. *Science Education, 88*(5), 655-682.
In this paper, we report work undertaken with a group of 11 UK teachers over a period of a year to teach aspects of the nature of science, its process, and its practices. The teachers, who taught science in a mix of elementary, junior high, and high schools, were asked to teach a set of ?ideas-about-scienc? for which consensual support had been established using a Delphi study in the first phase of the project. Data were collected through field notes, videos of the teachers' lessons, teachers' reflective diaries, and instruments that measured their understanding of the nature of science and their views on the role and value of discussion in the classroom. In this paper, drawing on a sample of the data we explore the factors that afforded or inhibited the teachers' pedagogic performance in this domain. Using these data, we argue that there are five critical dimensions that distinguish and determine a teacher's ability to teach effectively about science. Whilst these dimensions are neither mutually independent nor equally important, they serve as a valuable analytical tool for evaluating and explaining the success, or otherwise, that individual teachers of science have when confronted with teaching aspects about science. In addition, we argue that they are an important means of identifying salient aspects of pedagogy for initial and in-service training of science teachers for curricula that incorporate elements of ?ideas-about-science? © 2004 Wiley Periodicals, Inc. Sci Ed, 88:655-682, 2004

Baxter, G. P., & Elder, A. D. (1996). *Assessment and instruction in science classroom* (CSE technical report No. 418).
Changes in knowledge underlie the cognitive capabilities that are displayed in competent performance and the acquisition of improved performance. It is important to bring these knowledge-generated processes to attention because they represent possibilities of instructional design that might improve learning. In this paper, the role of performance assessments in making relevant cognitive activity apparent to teachers and students is discussed. Descriptions of the cognitive activity of fifth grade students while carrying out a science performance assessment reveal critical differences between those who think and reason well with their knowledge of circuits and those who do not. Differences of quality of explanations adequacy of problem representation, appropriateness of solution strategies, and frequency and flexibility of self monitoring indicate more or less effective learning of the subject matter. Awareness of an attention to these cognitive characteristics of competent performance in an assessment situation provide teachers the necessary feedback to construct classroom environments that

encourage reasoning and knowledge integration. In this way, performance assessments not only evaluate student performance but suggest changes in instructional practice to support effective learning in the elementary science classroom.

BÉRARD, J.-M., CLAUS, P., DAVID, J., & LOARER, C. (2005). ***Sciences expérimentales et technologie, Histoire et géographie - Leur enseignement au cycle III de l'école primaire*.**

The general inspectors of the primary education group wanted to check the degree of implementation of new standards published on 2002 on history, geography and experimental sciences and technology for students on cycle 3 (9-11 years old). The study was carried out during the third quarters of the school years 2003- 2004 and 2004-2005 in 14 academies and 23 departments. (NB: An academy corresponds to an administrative unit of the education system that do not fit necessary to the geographical administration, there are 30 academies on France, the department is a geographical unit of administration)

The study was founded on collection of quantitative and qualitative data coming from teachers observations and students records. It focused basically pedagogical trends. Topics related to pupils' evaluation were not tackled. The observation of transdisciplinarity mastering of the language – sciences showed that these aspects were few or not tackled by the teachers during sessions of experimental sciences and technology, history and geography.

- the timetables displayed an intensity of about 1h40 per week for experimental sciences and technology whereas the programs stated a minimum of 2h30 and a 3 a.m. maximum per week.
- Less of quarter of the classes have a recent textbook. There is not necessarily one copy by pupil (but this is more frequent in history and geography that in sciences)
- In two cases out of three, the inspector noticed that the program planned seemed to be able to be fully treated.
- In general, eight topics are tackled during the school year. The observations done in the copybooks do not fit always to the progressions planned.
- Pupils write little and copybook holding is mediocre: in science, the experiment book has a positive effect in this sense.
- The followed methodology does not allow comparisons with the statistical elements included in the 2002 report of the general inspection related to the renovation of sciences and technology teaching at primary school.
- Teachers spend too much time on the same topic and in addition, the displayed timetable is insufficient and badly respected, they cannot release time needed to cover all the program.
- the scientific vocabulary is in general correct but poor
- work on preconceptions (initial representations) is rare

<u>Conclusions</u>

- Subjects tackled come from the standards instructions. They allow, very generally, the construction of knowledge. It was given to us to observe achievements of great quality, even within schools located in ZEP (Zone of priority education).
- the lack of teachers rigor is quite spread .
- the programs are not fully tackled.
- the teaching approaches do not always fit to expectations: in sciences, the inquiry approach is not still highly represented, the phase where students face their results to validated scientific knowledge is often insufficient
- History, geography and experimental sciences are not used to develop pupils' skills on mastering French.

<u>Proposals</u>

- Take particular care to enroll teachers having a basic scientific and epistemological knowledge in the whole disciplinary fields of primary school. Timetables of the institutes for teachers training should be reinforced
- Publish documents for supporting teachers in standards implementation
- To help the teachers in the establishment of planning and progressions, within the framework of training activities or schools network
- Give increased attention to pupils written records: texts presentation, spelling, copybooks and folders structuring
- To give particular attention to precision and exactitude scientific vocabulary employed in conclusion sentences.

(written by P. Lucas)

Bleicher, R., & Lindgren, J. (2005). Success in Science Learning and Preservice Science Teaching Self-Efficacy *Journal of Science Teacher Education, 16*(3), 205-225.

This study examined relationships between conceptual understanding, self-efficacy, and outcome expectancy beliefs as preservice teachers learned science in a constructivist-oriented methods class. Participants included 49 preservice elementary teachers. Analysis revealed that participants increased in self-efficacy, outcome expectancy, and conceptual understanding. Engaging preservice teachers in hands-on, minds-on activities and discussion were important contributors. Participants reported that they would be inclined to teach from a constructivist perspective in the future. One implication from this study is that increasing the quantity of science content courses that preservice elementary teachers are required to take may not be sufficient to overcome their reluctance to teach science if some of their learning does not take place in a constructivist environment. In our teaching, we have tried to integrate pedagogy with learning science content.

Briscoe, C., & Wells, E. (2002). Reforming primary science assessment practices: A case study of one teacher's professional development through action research. *Science Education, 86*(3), 417-435.
Calls for reform have suggested that classroom practice can best be changed by teachers who engage in their own research. This interpretive study examines the process of action research and how it contributes to the professional development of a first-grade teacher. The purpose of the study was to explore the research process experienced by the teacher as she examined whether portfolios could be used as an effective means for facilitating and assessing young children's development of science process skills. Data sources included a journal kept by the teacher, documents produced by the teacher and students as part of the portfolio implementation process, hand-written records of teacher's informal interviews with students, and anecdotal records from research team meetings during the study. Data analysis was designed to explore how the teacher's classroom practices and thinking evolved as she engaged in action research and attempted to solve the problems associated with deciding what to assess and how to implement portfolio assessment. We also examined the factors that supported the teacher's learning and change as she progressed through the research process. Data are presented in the form of four assertions that clarify how the action research process was influenced by various personal and contextual factors. Implications address factors that facilitated the teacher as researcher, and how this research project, initiated by the teacher, affected her professional development and professional life.

Brugiere, C., & Lacotte, J. (2001). Fonctions du cahier d'expériences et role de la médiation enseignante dans un dispositif " La main à la pate " en cycle 3. *Aster, 33*, 135 -161.
This study examines the written work produced by a class of 9-10 years old pupils during a session on fossilisation that is part of La main à la pâte program. The program recommends the use of a "laboratory notebook" in which each pupil writes notes on the procedure followed. In this class, the notebook serves mainly to record the path followed collectively (where we left from and where we ended up) and to support individual oral expression during discussions in the classroom. The didactical analysis of the content of the notebook shows that it plays a minor role in the individual conceptual construction since the scientific reasoning, in this case is mainly elaborated in a collective manner, under the guidance of by the teacher.The verbal interactions between the teacher and the pupils lead to the production of another type of written work, transcribed in the "science exercise book", which respects the norms of the scientific discourse and which will later be memorised or even published in the scholl's scientific journal the constructivist process promoted by La main à la pâte is therefore used more during the collective oral sessions where the teacher plays an important role of mediation, than in a systematic use of their own personal writings by pupils.

Carlisle, J. F., Fleming, J. E., & Gudbrandsen, B. (2000). Incidental Word Learning in Science Classes *Contemporary Educational Psychology, 25*(2), 184-211.
The purpose of the project was to investigate students' incidental word learning in science classes that depended on discussion and hands-on activities. In separate studies, 4th- and 8th-grade students were given pretests and posttests that assessed depth of knowledge of topical words used in a single unit. In both studies, students made significant improvement in their knowledge of topical words; knowledge of nontopical words did not improve. Students who started the unit with partial knowledge of topical words were likely to learn meanings appropriate for the unit. Depth of topical word knowledge also contributed significantly to improvement on a test of applied problems. While significant incidental word learning occurred over the science units, students with little or no understanding of topical words at the outset tended to make limited progress in both word learning and learning the ideas and information of the unit. The educational implications are potentially serious and need to be explored in further studies.

Carulla, C., Duque, M., & Figueroa, M. (2003). Percibir el mundo con los cinco sentidos. Emociones y Razones para innovar la enseñanza de las ciencias. Siete experiencias pedagógicas de la Escuela Básica. (Perceive the World with 5 senses. Feelings and reasons for innovating sciences teaching: 7 pedagogical experiences at primary school.). In IDEP (Ed.), *Emociones y Razones para innovar la enseñanza de las ciencias. Siete experiencias pedagógicas de la Escuela Básica.*: IDEP.

This paper presents examples of qualitative effects of inquiry based science education through the testimonies of Colombian teachers implementing it in their classes. The paper refers to the example of the school La giralda of Bogota, for low income students where, 20 classes and close to 500 children are involved in Pequeños cientificos, the local inquiry based science education program. Teachers were trained (in service training) to implement first the "insight" unit: the 5 senses. Teachers noticed that students performed their observation skills, and enhanced their scientific vocabulary related to the senses. But also teachers gain on noises discrimination. One of the problems encountered by the teachers was to leave bigger independence to students respecting to traditional teaching. First attempts were hard but with the time they were benefit for teachers management of big groups (40 students by class) and for students its was the occasion to develop their collaborative skills. About language, main initial focus was rather given to the development of oral skills, then place to written skills was given progressively. Teachers recognized that the scientific coaching was vital to implement that type of teaching in their classes. It was basically provided by under graduated engineering students of the local University that help teachers during the science sessions. Pedagogical coaching was weekly provided in order to solve teachers' questions (visits of Karen Worth were welcome providing tips and suggestions of how better perform in the classroom. This was particularly true for questions related to students' socialization.
(written by P. Lucas)

Chin, C., & Kayalvizhi, G. (2002). Posing Problems for Open Investigations: what questions do pupils ask? . *Research in Science & Technological Education, 20* (2), 269-287.
The purpose of this study was to (a) find out the types of questions that pupils ask for open-ended science investigations, and (b) discuss how teachers can help pupils to identify problems and pose questions that are feasible for investigations. The study was conducted in a class of 39 primary 6 pupils of mixed ability. The pupils wrote down questions for two investigations that they would like to work on. The questions for the first investigation were generated individually, but those for the second investigation were posed in groups after the pupils were shown some examples of investigable questions. Among the questions that were posed individually, only 11.7% could be answered by performing hands-on investigations. Most of the questions asked were based on general knowledge and covered a wide range of topics. However, when questions were generated in groups after examples were shown, there was a significant increase in the number of questions that were amenable to science investigations (71.4%) but they related to fewer topics. A typology of investigable and non-investigable questions is proposed. Suggestions on how teachers can help pupils to pose problems and questions that are feasible for investigations are given.

Chittenden, E., & Jones, J. (1998, Feb 6- 8, 1998). *Science Assessment in Early Childhood Programs.* Paper presented at the Forum on early childhood science , mathematics and technology education Washington, D.C.
The momentum toward reform of science education brings pressures on schools and teachers to evaluate or otherwise account for children's progress in science. Although this interest can bring with it a certain amount of rush to judgment, it brings an opportunity to explore assessment alternatives that are fundamentally different from conventional evaluation methods. This paper focuses on one purpose of assessment, to inform instruction and support learning, starting from the premise that the foremost function of classroom assessment in the early years is to enhance teachers' powers of observation and understanding of children's learning. The paper discusses the guiding principles of preschool assessment: (1) including multiple forms and sources of evidence; and (2) using evidence collected over time, evidence highlighting what the individual knows, and evidence showing the collective knowledge of groups of learners. The paper also discusses documentation as an approach to assessment, including children's talk, guidelines for documenting science discussions, and a sample document recording a class discussion. The paper concludes with an examination of how lessons from early literacy assessment can be applied to early science assessment. (EV)

Ciotola, N. A., Ragona, A. J., & Ulrich, D. (2004). *A Review of The Teachers Academy for Mathematics and Science 13 Year Experience Implementing Inquiry Based Learning in Illinois Public Schools*. Chicago, IL: Teachers Academy for Mathematics and Science.
Since 1991 Teachers Academy for Mathematics and Science ("TAMS" or the "Academy") has been providing training in inquiry-based learning to schoolteachers of mathematics and science. TAMS serves exclusively teachers of students in grades pre-kindergarten through 8. Located in Chicago, Illinois the Academy has limited its professional development services to low-income public schools in the State of Illinois. The teaching and learning environments for TAMS schools are challenging. The term "low-income school" means that at least

75% of the students in the school are eligible for the free or reduced lunch program funded by the U.S. government.
Much of this paper presents the results of quantitative data that shows the effects of TAMS training on schools, teachers and students. The Academy has invested much time and money in developing assessments and in gathering and analyzing data. You will see that there are issues with both the data and the analytics. The statistical work uses a number of techniques. Each technique has its limitations. However, collectively the body of analytical work points to a clear conclusion. Students of teachers practicing inquiry-based methods show significant improvement on Illinois state tests.

Corrigan, G., & Taylor, N. (2004). An Exploratory Study of the Effect a Self-Regulated Learning Environment Has on Pre-Service Primary Teachers' Perceptions of Teaching Science and Technology. *International Journal of Science and Mathematics Education 2*(1), 45-62.
The effects of a Self Regulated Learning (SRL) environment on pre-service primary teachers of Science and Technology were investigated in this exploratory study. A representative sample of teachers was interviewed about their experience and how it impacted on them pedagogically, affectively, conceptually and metacognitively. The preliminary results suggest that students' understanding of how to implement activity-based learning was enhanced by the SRL environment. Additionally they claimed to be more confident about their ability to teach. However, conceptual understanding did not appear to improve. These findings will inform a larger study involving SRL that will also address the issue of subject content knowledge and attempt to develop overall teaching competence in primary Science and Technology.

Cros, P., & Respaud, S. (2001). Articulation entre des pratiques d'écriture et la construction des savoirs à l'école primaire : Une étude de cas
(Relations between written records and knowledge construction at primary school: a case of study. *Aster, 33*, 163-188.
The setting up of a sequence on changes of state has enabled 10 year old pupils to discover some properties of water: That water evaporates and that water vapour can condense under certain conditions. This sequence also enables them to discover , formulate and use, in communication situations, the criteria for realising certain types of written work which are met frequently in science: reports sheets (written as a group) and explanatory texts(written individually).
The authors set the hypothesis that on the one hand, improving writing leads to improving knowledge building, and on the other, that experimenting and experiencing an investigative process leads to an improved writing of what has been experienced. Three evaluations (before starting the sequence, immediately after finished and a month later) showed that the construction of knowledge is fragile and that it needs time, whereas it would seem that attitudes and writing practices can be improved quickly.

Cuevas, P., Lee, O., Hart, J., & Deaktor, R. (2005). Improving science inquiry with elementary students of diverse backgrounds. *Journal of Research in Science Teaching 42*, 337-357.

This study examined the impact of an inquiry-based instructional intervention on (a) children’s ability to conduct science inquiry overall and to use specific skills in inquiry, and (b) narrowing the gaps in children’s ability among demographic subgroups of students. The intervention consisted of instructional units, teacher workshops, and classroom practices. The study involved 25 third- and fourthgrade students from six elementary schools representing diverse linguistic and cultural groups. Quantitative results demonstrated that the intervention enhanced the inquiry ability of all students regardless of grade, achievement, gender, ethnicity, socioeconomic status (SES), home language, and English proficiency. Particularly, low-achieving, low-SES, and English for Speakers of Other Languages (ESOL) exited students made impressive gains. The study adds to the existing literature on designing learning environments that foster science inquiry of all elementary students.

Ekborg, M., & Lindahl, B. (2006). *Evaluation of the professional development programme within NTA.* Stockholm: NTA Production and Service. .
The main question for this study is “What effects have the professional development programme on teachers and their set of values and also at level of individual schools and municipalities?” The data is collected in two steps. First all teachers in the NTA-programme were asked to answer a questionnaire on the web about their view of science and the professional development. After analysing the questionnaire some municipalities were chosen for a deeper analysis where teachers, headmasters and school development managers were interviewed.

The result shows that most teachers are women with a very short education in science. They are very fond of working with NTA and think they have got a very good professional development in science teaching. The NTA programme helps the teachers to stimulate the pupils' fascination and curiosity in nature and joy of discovery. It also supports inquiry based teaching and develops science and technology teaching. The effect of the professional development according to the teachers is an improvement of their knowledge and self- efficacy in science and technology. They teach much more science and especially more chemistry, physics and technology. Their way of teaching has changed to a more pupil centred way of working. They also give example of ways to improve the in-service training with content as evaluation, open-ended tasks, using ICT and most important is time to discuss and follow up their experiences later on.

The effect on school level depends on the headmasters and the conditions given by the municipality. Headmasters who can see and understand the power in the project can also use the project to improve teaching and learning in all subjects in school. The way of working in NTA supports pedagogical discussions in school.

Gott, R., & Duggan, S. (2002). Problems with the Assessment of Performance in Practical Science: which way now? . *Cambridge Journal of Education, 32*(2), 183-201.

This paper presents an overview of the problems associated with the assessment of practical work in science. We identify two theoretical positions from which different emphases for teaching and assessment flow and examine some of the available evidence on possible methods of assessment which articulate with these two positions. We consider the position adopted by the UK National Curriculum in science and its response to the problem of reliability. We explore possible ways forward which maintain the integrity of investigative work within the curriculum. Finally, the notion that there might be a separate ability, namely an ability to do practical work, is addressed and its consequences considered.

Gouvernement du Québéc, M. d. l. é. (Ed.). (2002). *Echelles des niveaux de compétence: Enseignement primaire : 4.2- Science et technologie.*
***The competency levels by cycle : Primary school (Québec Gouvernment)*. Montréal: Direction de la formation générale des jeunes, Gouvernement du Québéc, Ministère de l'éducation.**
Presentation of grids designed to support pedagogical interventions of teachers related to pupils learning and standard aims. They describe the progression of the pupils and thus make possible to have a global view of the skills development in order to best orient learning or to draw up evaluation.

Gray, D., & Sharp, B. (2001). Mode of Assessment and its Effect on Children's Performance in Science. *Evaluation and Research in Education, 15.*(2), 55-68.

The research described here was an attempt to focus on and examine the phenomenon of differential performance on different modes of assessment noticed in the Assessment of Achievement Programme (Science), in Scotland. The research examined the performance of a sample of Primary 6 (10/11 years old) children non two modes of assessment.
Comparable tasks were devised in both pencil and paper and more 'practical' formats and children's performance on these tasks analysed. The assessments and procedures used were refined and repeated in a second phase. Results suggest there is evidence that children, particularly lower achievers, perform better on more interactive, practically based tasks than on comparable tasks presented in a purely pencil and paper format. There is also evidence to suggest that there may be gender related differences in performance.

HANEY, J. J., & MCARTHUR, J. (2002). Four case studies of prospective Science teachers' beliefs concerning constructivist teaching practices *Science education, 86*(6), 783 - 802.

This article begins by identifying the major components of constructivist teaching practices. These components come from an article by Brooks & Brooks (1999) and describe a classroom "in which students are viewed as partners in the learning process." The components include: an emphasis on big concepts in the curriculum, pursuit of student questions, heavy reliance on primary sources of data, viewing students as thinkers, teachers mediate and create an interactive environment, teachers value the students' point of view, assessment is based on student learning during activities and demonstrated through exhibitions and portfolios, and students often work in groups. These components are compared with a traditional classroom, which largely consists of reliance on a fixed curriculum, textbooks, teachers behaving didactically, teachers looking for correct answers, and assessment through testing.The research section of the article looks at 4 prospective science teachers and seeks to compare their beliefs about constructivist teaching with their implementation of constructivist teaching in the classroom. The authors use a survey called the Classroom Learning Environment Survey (CLES), developed by Taylor, Fraser, and White (1994), to determine which science teachers they chose for the study. They chose four with varying scores, and therefore varying beliefs about constructivist teaching. The survey and study looked at beliefs and implementation of the following ideas by the teachers: 1) scientific uncertainty (no certain answers), 2) student negotiation (group work), 3) shared control of the curriculum by students and teacher, 4) critical voice (students' questioning why they are studying a given topic), and 5) personal relevance of curriculum to students' lives. The study identified the prospective teachers' core beliefs (those that were being implemented) and peripheral beliefs (those that were not being implemented). The study found that the core beliefs of the constructivist-minded prospective teachers were #1, 2, and 5, but they were struggling to implement #3, which was called a peripheral belief. #4 was hardly mentioned. A conflict existed for the teachers who desired to implement shared control of curriculum decisions (#3). This conflict existed because of pressure on them to implement a more or less fixed curriculum which covered certain content and prepared students for state/national tests. I could very much relate to this conflict. In the conclusion, the article also brought up the idea of whether student teachers should be paired with cooperating who have the same/different beliefs about constructivist teaching practices. In two of the cases, the student teachers said they felt supported by their coop. in implementing constructivist practices, while two of the student teachers did not feel supported.

Harlen, W. (2004). ***Evaluating Inquiry-based Science Developments*** **Paper presented at the Evaluation of Inquiry-based Science. Retrieved. from http://www7.nationalacademies.org/bose/Inquiry_Based_Science_Homepage.html.**

This paper is written to provide an introduction to discussions of what can be learned from existing research and experience relating to the effects of inquiry-based teaching
and learning. It considers the meaning of inquiry and of inquiry-based instruction and the obstacles to implementation and evaluation, some of which follow from the nature of the
changes in teaching that are required. Some case studies of evaluations are used to illustrate factors that need to be taken into account, and from these are drawn
implications for future evaluations.

Heins, G. (1990). ***The Assessment of Hands-On Elementary Science Programs*****: North Dakota Study Group on Evaluation.**

This document contains 15 chapters on various topics related to elementary science assessment. A comprehensive description of efforts to introduce alternatives to multiple-choice, paper and pencil tests to assess science learning is provided. The monograph includes an analysis of assessment issues, descriptions of current practice, and suggestions for new assessment methods. Part One, "Lessons from the Assessment of Reading and Writing," discusses literacy and testing, and contains papers by Brenda Engel and Patricia Stock. Part Two, "Assessment Theory," discusses thinking skills of students, and the validity of science assessments; articles are written by Audrey Champagne, Jerome Pine, and Frank Davis. In Part Three, "Large Scale Assessments," state assessments and the United Kingdom's Assessment of Performance Unit (APU) are discussed in studies by Joan Baron and Patricia Murphy. Part Four, with articles by Maryellen Harmon and Jan Mokros, and by Rosalind Driver, "Assessment in Science Education Research and Development," assesses the NSF elementary science curricula and the progress of children's understanding in science. Part Five, "New Approaches to Science Assessment," includes young children's discussion of science topics and a source of data for assessment in elementary school science based on children's investigations; contributions are by Edward Chittenden and Hubert Dyasi. (KR)

HICKEY, D. T., & ZUIKER, S. J. (2003). A new perspective for evaluating innovative science programs ***Science education 87*** **(4), 539 - 563.**

This paper outlines a stridently sociocultural perspective on educational program evaluation. This perspective emerged across successive attempts to evaluate science programs in a manner consistent with sociocultural views of knowing and learning, while still yielding conventional evidence of achievement. The perspective is characterized by (1) rigorous use of multiple-choice tests, performance assessments, and interpretive event-based analyses, (2) a dialectical approach to reconciling conflicting conclusions from different types of individual assessments, and between individual and event-oriented assessments, and (3) a pragmatic focus on the differences among various implementations of the innovation, with judicious, targeted use of comparison groups. Innovators facing the tension between contemporary views of knowing and learning and conventional views of accountability should find this perspective particularly useful. It is relevant for a broad range of evaluation contexts, including large-scale externally funded innovations as well as more informal practitioner-initiated studies, and should be useful in many content domains.

Jarvis, T., & Pell, A. (2002). Changes in primary boys' and girls' attitudes to school and science during a two year science in-service programme. . *The Curriculum Journal, 13* (1), 43-69.

A pupils attitude test was developed to monitor change over the two years of a primary science in-service programme. It explores pupils' views about school in general so that changes in science attitudes can be contextualized within the whole school experience; feelings towards science experiments; and perceptions of real-world science. The test was piloted with schools outside the in-service programme. Approximately 2000 pupils were tested in January 1999, September 1999 or January 2000. A random sample of children were retested in June 1999 and compared with a 'control' school. All the children in the project were tested again in July 2000. The results indicate a generally positive attitude towards coming to school, with particular preferences for work with computers and working together. As the pupils get older, their enthusiasm for science falls as they find it less difficult or demanding. This relationship appears to be broken by teacher in-service to some extent. Girls in particular showed a greater enthusiasm for independent investigative science after the programme.

Kern, B. B. (2002). Enhancing accounting students' problem-solving skills: the use of a hands-on conceptual model in an active learning environment *Accounting Education, 11*(3), 235-256.

This study documents and evaluates the effectiveness of using a hands-on conceptual model in an active learning environment in a first accounting class. A hands-on model that can be used to help students learn inventory cost allocations is described. The model's potential for enhancing student learning is assessed. Three learning scenarios are evaluated. The first is predominately a traditional lecture-oriented approach using numerical examples to illustrate concepts. The second adds the use of a model within a lecture setting. The third uses an active learning approach along with the model. Student performance and preferences are assessed. Students indicate they perceive that the model helped them understand inventory cost allocations better than solely using numerical examples. Results from an assessment instrument indicate that students who use the model in an active learning environment show enhanced problem-solving skills over that which can be attained in a lecture-oriented environment. There is no evidence, however, that the use of a conceptual hands-on model enhances conceptual recall over that which can be attained in a lecture-oriented environment.

Kilfeather, P., O'Leary, M., & Varley, J. (2006). Adapting science performance tasks developed in different countries for use in Irish primary schools *Irish Educational Studies, 25*(1), 3-33.

This article describes a four-year project undertaken to develop a set of performance tasks that could be used for assessing hands-on science in Irish primary schools. It begins by considering some of the literature on performance assessment and concludes with a discussion on the potential of the tasks to support teaching and learning in science. The main body of the article is structured to reflect the five phases of the research project itself. In phase one, science assessments used in a variety of educational systems in Australia, Canada, New Zealand, the United Kingdom and the United States were located and catalogued. In phase two, approximately 170 performance tasks were selected and adapted by the authors to suit the requirements of the Irish primary science curriculum. In phase three, a purposive convenience sample of teachers evaluated the extent to which the tasks (a subset of 67) were suitable for use at different grade levels. The teachers' feedback was used to amend tasks. In phase four, the researchers observed 11 different tasks being implemented in classrooms. The eleven teachers involved were interviewed about their experiences immediately afterwards. Again, based on the outcomes of this study, changes were made to the tasks. The fifth phase of the project, due to be completed in 2006, will involve the dissemination of 124 of the tasks to teachers via a booklet and a CD-ROM. Future prospects relating to other elements of the project such as Web-based resources, professional development courses and exemplars of performance are also discussed.

Lee, O., & Luykx, A. (2005). Dilemmas in scaling up innovations in science instruction with nonmainstream elementary students. ***American Educational Research Journal, 42*****(3), 411 - 438.**

In the climate of standards-based instruction and accountability, scaling up educational innovations is necessary to bring about system-wide improvements. Due to fundamental tensions around effective educational policies and practices for diverse student groups, scaling up is especially challenging in multilingual, multicultural, and inner-city settings. This paper maps out major difficulties that arise in scaling-up efforts, specifically with regard to students' linguistic, cultural, and socioeconomic diversity in elementary school science. Grounded in the instructional congruence framework, it highlights the challenges facing schools and teachers in articulating science disciplines with non mainstream students' linguistic and cultural experiences while also promoting English language and literacy. Rigorous attention to such challenges is needed to make scaling up of educational interventions more effective and to resolve the impasses around the question of what constitutes "best policies and practices" for diverse student groups.

Lewandowski, A., CARRER, S. S. L., MELGUEN, Y., & POULLAIN, L. (2005). Et si on évaluait aussi les capacités expérimentales à l'école primaire ?
(What if we do also the evaluation of experimental skills at primary school?). ***Bulletin de l'union des physiciens, 99*****(870), 59-66.**

The inquiry based teaching recommended by the Plan of renovation of science and technology teaching at school (PRESTE inspired by La main à la pâte) is strongly based on experiments conducted by children themselves. A good observation of a physical or biological phenomenon depends on a good experiment implementation.
This teaching method deserves then to be evaluated. Moreover, it takes into account attention, cooperation, dexterity, fine motor skills of children seldom evaluated at the school within "traditional" frameworks.

LEVITT, K. E. (2002). An analysis of elementary teachers' beliefs regarding the teaching and learning of science ***Science education 86*** **(1), 1 - 22.**

The purpose of this study was to ascertain the beliefs of elementary teachers regarding the teaching and learning of science and the extent to which the teachers' beliefs were consistent with the philosophy underlying science education reform. Sixteen teachers from two school districts involved in a local systemic initiative for science education reform participated in the study. Each teacher was observed teaching a lesson from the program. The observation served as the context for an interview with the teacher regarding his or her beliefs about the teaching and learning of science. One overarching belief emerged: Teachers believe that the teaching and learning of science should be student centered. Five patterns of teachers' responses support this characterization of the teachers' belief. Although varying gaps exist between the teachers' beliefs and the principles of reform, the teachers' beliefs suggest that the teachers are moving in a direction consistent with science education reform. A modified case study of three teachers represents the patterns of beliefs expressed by teachers.

Loarer, C. (2002). ***La rénovation de l'enseignement des sciences et de la technologie à l'école primaire (Renovation of science and technology teaching at primary school)*** **(Report to the French education Ministry). Paris.**
The report shows the situation and the evolution of science and technology teaching at the end of October 2001, the second year of application of the renovation program. The survey was carried out by general inspectors of the Group of primary education teaching in seven academies (or Local Education Authorities), in each one of these seven academies, ten classes randomly chosen within two different districts of national education inspectors were visited. The study also integrates, information collected by interviewing of vice-chancellors and their advisers, and also of inspectors leaders of academy of national education departmental services (IA-DSDEN) and their collaborators. It also examines, the degree of implementation of coaching measures at national, academic and departmental level

Luera, G. R., & Otto, C. A. (2005). Development and Evaluation of an Inquiry-Based Elementary Science Teacher Education Program Reflecting Current Reform Movements ***Journal of Science Teacher Education 16*****(3), 241-258.**

The National Science Education Standards (National Research Council 1996, National science education standards. Washington, DC: National Academy Press) and various other national and state documents call for teachers who possess science content knowledge, employ an inquiry approach in teaching, and engage in reflective practices. This paper describes a rationale for choosing particular recommendations to implement and how we incorporated those as we revised our elementary science education program. An analysis of the impact of the reformed inquiry-based content courses revealed that students who take more than one reformed content course improve their science content knowledge and efficacy towards teaching science significantly more than students who take fewer courses.

McGinnis, J. R., & Parker, C. (1999, April 19-23, 1999). ***Teacher Candidates' Attitudes and Beliefs of Subject Matter And Pedagogy Measured Throughout Their Reform-Based Mathematics And Science Teacher Preparation Program.*** **Paper presented at the Annual meeting of the American Educational Research Association, Montreal, Canada.**
This study reports the use longitudinally of a valid and reliable instrument to measure teacher candidates' attitudes and beliefs about the nature of and the teaching of mathematics and science. The instrument used, Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science, was developed for the Maryland Collaborative for Teacher Preparation (MCTP), a National Science Foundation funded undergraduate teacher preparation program for specialist mathematics and science elementary/middle level teachers. In this analysis, we report how MCTP teacher candidates' attitudes toward and beliefs about mathematics and science evolved over a three year period. During the Fall 1995 and Spring 1996 semesters the instrument was administered in MCTP classes twice each semester to the study participants (N=104; 100% response). During the Fall 1996, Spring 1997, and Fall 1997 semesters the instrument was mailed to the study participants at the end of each semester (46% Fall 1996 response; 75% Spring 1997 response; 78% Fall 1997 response). Since individual responses to the questionnaire were not independent, we used as the unit-of-analysis responses from five institutions participating in the program. We aggregated survey responses within each institution, and analyzed changes (repeated-measures t-test design). We determined that the MCTP appears to be affecting participating teacher candidates' attitudes towards and beliefs about mathematics and science in the direction intended. The MCTP teacher candidates' attitudes and beliefs moved in the desired direction on all five subscales of the instrument. Moreover, the magnitude of change was statistically significant at the .05 level for the subscales measuring "Beliefs about the Nature of Mathematics and Science," "Mean Attitudes Toward Mathematics and Science," and "Beliefs about Teaching Mathematics and Science." In addition, the magnitude of change for the subscale measuring "Attitudes Towards Teaching Mathematics and Science" approached statistical significance (0.8). These findings make a highly significant contribution to the science and mathematics education research communities interested in charting the attitudinal and belief journeys of teacher candidates participating in a reform-based teacher preparation program.

MEN : Académie de Créteil, I. a. d. S.-S.-D. (2002). ***Evaluation sciences et technologie CM2 (2002) Livret de l'élève, de l'enseignant, résultats et analyses 2002.*** **(formative assessment, report, France): Ministry of education.**
The assessment of scientific skills and knowledge of CM2 pupils (10-11 years old) from Seine Saint Denis department was demanded by the Academy Inspector to the pedagogical commission of science and technology created on 2001. The aim was to obtain a panorama of the reality of pupils' knowledge, two years after the publication of the Plan of Renovation of science and technology teaching at primary school. Assessment was carried out on May 2002, on whole classes (CM2: 10-11 years old pupils) of the department which represents nearly 19380 pupils. Tests intended to measure the impact of training activities, of coaching of the various devices aiming at encouraging the practice of scientific activities in the classes, and taking into account the application of the national and departmental orientations. The evaluation was carried out by measuring knowledge acquired by pupils.

MEN : Académie de Créteil, I. a. d. S.-S.-D. (2003). ***Evaluation sciences et technologie CM2 (2003). Livret de l'élève, de l'enseignant, résultats et analyses 2003.*** **(assessment report): Inspection académique de Seine-Saint-Denis.**
Second edition of the assessment of scientific skills and knowledge of CM2 pupils (10-11 years old) from Seine-Saint Denis department carried out on 2003.
The assessment of scientific skills and knowledge of CM2 pupils (10-11 years old) from Seine Saint Denis department was demanded by the Academy Inspector to the pedagogical commission of science and technology

created on 2001. The aim was to obtain a panorama of the reality of pupils' knowledge, two years after the publication of the Plan of Renovation of science and technology teaching at primary school. Assessment was carried out on May 2003, on whole classes (CM2: 10-11 years old pupils) of the department which represents nearly 19380 pupils. Tests intended to measure the impact of training activities, of coaching of the various devices aiming at encouraging the practice of scientific activities in the classes, and taking into account the application of the national and departmental orientations. The evaluation was carried out by measuring knowledge acquired by pupils.

MEN : Académie de Créteil, I. a. d. S.-S.-D. (2004). *Evaluation sciences et technologie CM2 (2004). Livret de l'élève, de l'enseignant, résultats et analyses 2004.* (assessment report): Inspection académique de Seine-Saint-Denis.
Third edition of the assessment of scientific skills and knowledge of CM2 pupils (10-11 years old) from Seine-Saint Denis department carried out on 2004
The assessment of scientific skills and knowledge of CM2 pupils (10-11 years old) from Seine Saint Denis department was demanded by the Academy Inspector to the pedagogical commission of science and technology created on 2001. The aim was to obtain a panorama of the reality of pupils' knowledge, two years after the publication of the Plan of Renovation of science and technology teaching at primary school. Assessment was carried out on May 2004, on whole classes (CM2: 10-11 years old pupils) of the department which represents nearly 19380 pupils. Tests intended to measure the impact of training activities, of coaching of the various devices aiming at encouraging the practice of scientific activities in the classes, and taking into account the application of the national and departmental orientations. The evaluation was carried out by measuring knowledge acquired by pupils.

MEN : Académie de Créteil, I. a. d. S.-S.-D. (2005). *Evaluation sciences et technologie CM2. Livret de l'élève, de l'enseignant, résultats et analyses 2005.*
Fourth edition of the assessment of scientific skills and knowledge of CM2 pupils (10-11 years old) from Seine-Saint Denis department carried out on 2005.
The assessment of scientific skills and knowledge of CM2 pupils (10-11 years old) from Seine Saint Denis department was demanded by the Academy Inspector to the pedagogical commission of science and technology created on 2001. The aim was to obtain a panorama of the reality of pupils' knowledge, two years after the publication of the Plan of Renovation of science and technology teaching at primary school. Assessment was carried out on May 2005, on whole classes (CM2: 10-11 years old pupils) of the department which represents nearly 19380 pupils. Tests intended to measure the impact of training activities, of coaching of the various devices aiming at encouraging the practice of scientific activities in the classes, and taking into account the application of the national and departmental orientations. The evaluation was carried out by measuring knowledge acquired by pupils.

National Council for Curriculum and Assessment. (2004). *ASSESSMENT IN PRIMARY SCHOOLS*.Unpublished manuscript, Ireland.
Assessment is integral to teaching and learning. Assessment relates to all aspects of the curriculum and encompasses the cognitive and affective domains. There is a variety of assessment modes, each of which is appropriate in particular circumstances. Assessment can play a critical role in the early identification of learning difficulties. Schools should implement procedures both at school and classroom levels for recording and reporting assessment outcomes. It is important for teachers to recognise the technical qualities of different assessment instruments. Teachers need support in the implementation of assessments, and in the recording and reporting of assessment outcomes.

NSESSI, N. S. E. S. o. S. I., & Council, N. R. (2000). *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*
from http://darwin.nap.edu/html/inquiry_addendum/
http://www.nap.edu. .
Turning to assessment, the committee discusses why assessment is important, looks at existing schemes and formats, and addresses how to involve students in assessing their own learning achievements. In addition, this book discusses administrative assistance, communication with parents, appropriate teacher evaluation, and other avenues to promoting and supporting this new teaching paradigm.

Pell, T., & Jarvis, T. (2001). Developing attitude to science scales for use with children of ages from five to eleven years. ***International Journal of Science Education, 23*** **(8), 847-862.**

This paper reports on the development stages of three attitudes to science and school scales for use with children aged from 5-11 years. The investigation is part of a project intended to improve pupil achievement in science in 16 schools in an English city. The base-line performance of the attitude scales with over 800 pupils is reported. Attitude sub-scales measure 'liking school', 'independent investigator', 'science enthusiasm', the 'social context' of science, and 'science as a difficult subject' with Cronbach Alpha reliabilities for the year groups varying from above 0.8 to below 0.7. For the sample, both boys' and girls' enthusiasm for science declines progressively with age alongside a similar decline in their perception that science is difficult.

Primo, M. A. R., Li, M., & Shavelson, R. (2002). ***Looking Into Students Science Notebooks: What Do Teachers Do With Them ?*** **(CSE technical report**
No. 562): Center for the study of evaluation, National center for research on Evaluation, UCLA.
We propose the use of students' science notebooks as one possible unobtrusive method for examining some aspects of teaching quality. We used students' science notebooks to examine the nature of instructional activities they encountered in their science classes, the nature of their teachers' feedback, and how these two aspects of teaching were correlated with students' achievement. We examined the characteristics of students' science notebooks from 10 fifth-grade classrooms. Six students' notebooks in each classroom were randomly selected. Each entry of each student's science notebook was analyzed according to the characteristics of the activity, quality of student's performance as reflected by the notebook entry, and the teacher feedback in the notebook. Results indicated that (a) raters can consistently classify notebook entries despite the diversity of the forms of communication (written, schematic or pictorial). They can also consistently score the quality of a student's communication, conceptual and procedural understanding, and the quality of a teacher's feedback to the student. (b)
The intellectual demands of the tasks required by the teachers were, in general, low. Teachers tended to ask students to record the results of an experiment or to copy definitions. (c) Low student performance scores across two curriculum units revealed that students' communication skills and understanding were far from the maximum score and did not improve over the course of instruction during the school year. And (d) teachers provided little, if any, feedback. Only 4 of the 10 teachers provided any feedback to students' notebook entries, and when feedback was provided, comments took the form of a grade, checkmark, or a code phrase. We concluded that the benefits of science notebooks as a learning tool for students and as a source of information for teachers were not exploited in the science classrooms studied.

Quintanilla, G., & Packard, T. (2002). A participatory evaluation of an inner-city science enrichment program ***Evaluation and Program Planning, 25*****(1), 15-22.**

A participatory evaluation (PE) of an inner-city science enrichment program for elementary school youth was conducted using an evaluation team consisting of staff, board members, students, parents, and representatives of the agency's major funder. This evaluation team designed and implemented the entire evaluation with guidance from an evaluator-consultant and researchers from a local university. Data gathered from surveys of alumni, parents, students, and teachers revealed high satisfaction with the program and a validation of the hands-on teaching model. Alumni reported that the program impacted their scientific and social competence. The highly participative design process was seen as very successful by all participants, and offers useful guidelines for other PE, including active participation of all stakeholders, commitment to a shared vision, and a good match between the organization and the evaluator.

Reimstad, K., Stärner, E., & (2005). ***Klurigt småprat - Perspektiv på och reflektioner kring praktiskt arbete i naturvetenskap. (Ingenious Small Talk- Perspectives on and Reflections about Student´s Practical Work in Science Learning.).*** **Department of behavioural science, Linköping university.**

The aim of this study is focused on the interaction between pupils when they are using experimental methods in science. The reason why we have chosen to study pupils working with investigations is due to the role practical experimental it often plays in science teaching and learning.
The study has an exploratory approach. The data was collected using some qualitative research methods such as videotaping, participating observations with an ethnographic direction, field notes and semistructured interviews with pupils.
After analyzing the collected data, we investigated what happened in different learning situations involving experimental exploration. To get a better understanding, and to deepen our reflections, we have studied research covering different learning theory perspectives.
In conclusions, the findings revealed:

- The importance of pupils´ small talk and the way , in which it occurs when they are doing the investigations. It has some influence on how collaboration between pupils work. It also has some influence on how the experimental work proceeds. The teams of pupils solve their challenges through their small talk.
- The first glimpse of classrooms where pupils are experimenting may give chaotic appearances. However classrooms in our study show pupils first learned how to manage material then they engaged in critical thinking and dialogue with peers during the investigatins.
- The small talk is sometimes more reflective and thoughtful. In other words, the pupils build "islands of knowledge". Working together they discover and process content knowledge constructed from their investigations rather than just talking about how they handle the practical side of the investigations. We call this ingenious small talk.
- The pupils need to learn different tools such as documenting, reading and understanding drawings, in order to learn science. The tools should be considered first steps in learning science.

The school environment must create many opportunities for pupils to move around in classrooms, engage in small talk and learn to use tools to be able to ingenious small talk as they investigate science phenomena.

Respaud, S. (Writer) (2004). Current status on science teaching in Ariège primary schools, *La main à la pâte seminars*. Montrouge.
Since four years now, the department of Ariège began its PRESTE (Plan of Renovation of Sciences and Technology Teaching at Primary School) by creating and equipping a science classroom, an Internet site and by organizing many training activities for teachers. First outcomes of the inquiry held on those actions by La main à la pâte Pilot Site of Pamiers. Questionnaire proposed to teachers also available on line.

Rosenquist, A., Shavelson, R. J., & Ruiz-Primo, M. A. (2000). *On the "Exchangeability" of Hands-On and Computer-Simulated Science Performance Assessments*
(CSE Technical Report No. 531): CRESST/Stanford University.
Inconsistencies in scores from computer-simulated and "hands-on" science performance assessments have led to questions about the exchangeability of these two methods (e.g., Baxter & Shavelson, 1994), in spite of the former's highly touted potential (e.g., Bennett, 1999). Five possible explanations of students' inconsistent performances were considered: (1) inadequate exposure to computers and simulations, (2) differential views of computer-simulated (2-dimensional icons) and hands-on tasks, (3) different methods tapping different aspects of achievement, (4) partial or incomplete knowledge, and (5) a combination of partial knowledge and method differences. The first explanation was ruled out by the fact that students had computers in their classes and used them for a variety of purposes, including simulation. The second explanation was ruled out using talk-aloud data, randomized experiments, and student questionnaire responses. If explanation 3 were tenable, the correlation between Electric Mysteries scores at time 1 and time 2 for either hands-on or computer simulation should be higher than the correlation between hands-on scores and computer simulation scores at either point in time. Shavelson, Ruiz-Primo, and Wiley (1999) provided correlations that did not jibe with this expectation. To explore the remaining two possible explanations dealing with student expertise, we compared the performance of high school physics students ("experts") to that of Baxter and Shavelson's elementary school students and found, somewhat surprisingly, that these "experts" were far from expert. Indeed, they were no more expert than the elementary students. Consequently, we have narrowed the possible explanations for the lack of exchangeability between computer-simulated and hands-on performance assessments to one of two choices: partial knowledge or the interaction of partial knowledge with method. The jury is still out.

Ruiz-Primo, M., Li, M., Ayala, C., & Shavelson, R. (2004). Evaluating Students' Science Notebooks as an Assessment Tool. Research Report. *International Journal of Science Education, 26*(12), 1477-1506

The idea of using science notebooks as a classroom assessment tool is not new. There is general agreement that science notebooks allow teachers to assess students' conceptual and procedural understanding and to provide the feedback students need for improving their performance. In this study we examined the use of science notebooks as an unobtrusive assessment tool that can also be used by individuals outside the classroom (for example, school district personnel), and as a means for obtaining information about students' learning and their opportunities to learn. More specifically, in this study students' science notebooks were used as a source of data about the (a) implementation of a curriculum's intended activities, (b) students' performance, and (c) quality of teachers' feedback. Our results indicated that: (1) Students' science notebooks can be reliably scored. Unit implementation, student performance, and teacher feedback scores were highly consistent across raters and units. (2) High and positive correlations with other performance assessment scores indicated that the student performance score can be considered as an achievement indicator. And (3) low performance scores across the two units revealed that students' communication skills and understanding were far away from the maximum score and did not improve over the course of instruction during the school year. This result may be due, in part, to the fact that no teacher feedback was found in any of the students' notebooks across the six classrooms studied. This may reflect some characteristics of the teachers' assessment practices that may require further professional development.

Russell, T., & McGuigan, L. (2001). Making formative use of a national summative assessment regime. In H. Behrendt, Dahncke, H., Duit, R., Gräber, W., Komorek, M., Kross, A. and Reiska, P. (Ed.), *Research in science education-Past, present and future* (pp. 71-76): Kluwer academic publishers.
While the impact of formative assessment practices on learning outcomes is receiving increasing attention, the dominant function of the statutory assessment system in England and Wales is summative. As authors of the statutory end of Key Stage 2 tests between 1995 and 1999, we are aware of a volume of test items and pupil performance data that has been generated in the course of the summative regime. Summative performance data are available on the cohort of 600,000 pupils at age 11 assessed annually. We have further illuminated these data by an annual qualitative re-marking of a sub-sample stratified by three overall achievement levels.
We suggest that many test items are analogous to concept probes within the constructivist paradigm. Qualitative re-marking using a cross-sectional sample yields diagnostic data which invite developmental inferences about conceptual progression. When pupils' assessed understanding can be mapped onto such lines of progression, assessment can have a powerful formative capability in informing classroom teaching and learning practices. The characteristics of test items which may combine summative and formative utility are discussed in the context of pupils' ideas about Forces.

Sarmant, J.-P. (1999). *Rapport d'étape sur l'opération "La main à la pâte" et l'enseignement des sciences à l'école primaire*
***(General intermediate report of La main à la pâte and the science teaching at primary school.)*. Paris: Inspection générale de l'Éducation nationale.**
This report was established, in 1999, by a request of the minister of Education. It was drawn up by the general Inspector of Ministry of Education in order to determine the effects of La main à la pâte approach (this because La main à la pâte launched a pilot experience over France in 1997. On 1995, only 5% of the French classes got sciences sessions – whatever the approach).
Three types of data collection were employed: meetings (institutional actors, project managers), visits of classes (27) followed by interviews (192 persons in total).
The sample was divided into 2 groups (= 2 separated investigations): The first one linked to 3 most implied departments: Loire Atlantique, Haute Savoie and the Rhone. It aimed at measuring the intensity and the nature of engagement on La main à la pâte approach. The observations were carried out in the classes by the IEN (National Education Inspector), they were focused on the application of the ten principles of la main à la pâte. The second investigation aimed at specifying the characteristics (quantitative and qualitative) of the sciences teaching in two departments very few or not at all implied on this type of approach (Vienne and Indre).
Results:
- In general, there is a better science teaching (inquiry teaching) (in terms of N° of hours devoted to scientific teaching) and in terms of N° of training sessions for teachers.
- At the level of the non implied departments, the teachers approach was descriptive and "affirmative"
- On implied departments, the activity of pupils during the classroom was higher and their attitude more engaged in reflection. A better teacher's attitude towards science (felt as a pedagogical renewal) was noticed.
- The effects are very positive in social and moral behavior fields, the speaking of the mother tongue and the general culture but not necessary at knowledge level.

- The most obvious results were noticed under the sociological and specifically on behavioral field: children are more attentive, they have a better collective behavior. They used to speak each other and listen themselves by testifying a mutual respect.
- In multicultural contexts, a unifying effect of scientific activities was observed.
- La main à la pâte approach has also a benefic effect for a higher proportion of children having school difficulties = low achievers (They are more confident and better perceived by other students)
- The improvement of expression skills was also observed, as well oral as written: particularly for the immigrant children.
- Better effects on logic: pupils are able to reinvest in other fields, apart from the sciences
- Benefits are evident for classes engaged for at least two years
- The effects obtained on behaviour and the expression skills are enough to justify the attention of the ministry of education
-Examination of scientific notebooks shows that there is also a gain in basic scientific knowledge required by the standards.

Some observed difficulties:
- In certain classes, the acquisition of knowledge is a minor objective, even non-existent (and this also on most implied departments). Sometimes an exclusively technological activity could be also a reducing activity (realization of an object, without any other aim).
- Sometimes teachers have problems stating conclusions and confronting them to the scientific knowledge (Sometimes there is no scientific knowledge confrontation at all).
- A strong piloting structure is then needed followed by the implementation of coaching tools for teachers.
- In spite of the prestige of its founders and the mediatisation of the approach, teachers are inclined to grant value only to the ministry instructions coming through the school territorial inspection.
- Teachers having a scientific background are of help for those starting and that need to feel confident respecting to science teaching.
- For some teachers la main à la pâte approach seems to be so time consuming bringing difficult to cover the standards
- About the units “insights “opinions collected are very divergent. Opinions go from enthusiasm without reserve to a frank hostility because those considered that they provide a too assisted pedagogy. They often say "I would like to know the insights, to help me in my beginnings, but I will probably leave them once I feel more confident. Then there is a special need to propose documents coming from different sources. Internet website may play an important role.

Conclusions:
- It is important to consider the generalization of the approach even if not possible at medium term.
- The objectives of the institution (ministry) should overlap those of La main à la pâte by the drawing up lawful texts implementing a science teaching based on la main à la pâte approach
- La main à la pâte must keep its own dynamics and preserve its own specificity based on the association of scientific partners

(Written by P. Lucas)

Schoultz, J., & Hultman, G. (2002). ***NTA is a great idea. We don’t do things just to get bored but because we want to learn.*** **: Department of Educational Science, University of Linköping.**

The evaluation has focussed on three central aspects:

- pupils’ ability and opportunities to participate and take initiatives in the classroom teaching
- to what extent NTA stimulates pupils’ curiosity about and interest in science
- pupils’ ability to observe, experiment, predict, argue, discuss and document

During our work with evaluation we have mainly been focussed on pupils’ learning and development in NTA. But during our observation visits and interviews we have more and more come to understand the great importance of the teacher for the pupils’ development and learning progress. We feel then that it is not possible to evaluate pupils’ development and learning without at the same time looking at the constraints and opportunities inherent in the teaching situation. These constraints can differ greatly. The teacher here has an important task to organise the teaching situation and adapt teaching material to the group of pupils. The role of the teacher is extremely diverse, with the teacher’s strategies, thoughts, values and actions jointly creating the learning situation. What happens when a new project makes its debut in a complex classroom situation?

We conclude in our evaluation that there is a great potential for development in the NTA concept, which is not always achieved in the concrete school situation. The pupils learn about science and many become interested in the subject area. But the NTA material is not sufficient in itself. The role of the teacher, his/her attitude and knowledge are extremely important and are a precondition for success. Professional development for the teachers in the form of working-team meetings, theme meetings, contact with universities, experienced teachers are all very important factors in the NTA concept. The concept has its limitations but also great possibilities. Properly used it will provide a platform for both pupils and teachers to develop their scientific knowledge. (written by B Lindahl)

Schoultz, J., Hultman, G., & Lindkvist, M. (2003). ***At first we got to use our imagination and that was fun. Evaluation of pupils' and teachers' learning and development within the NTA-project.*** **: Department of Educational Science, University of Linköping.**

Pupils and teachers feel happy with the NTA concept. The material fills a need and teachers and pupils have great opportunities to develop within it. But it demands active participation on the part of the pupils and teachers. The pupils have an opportunity to learn about and understand science, not just facts but also processes and ways of seeing, discovering and describing. They develop their ability to communicate about science with the help of words and terms. The image of the pupil as the little researcher who finds his knowledge himself is at variance with our discoveries in the classroom. NTA is no self-sufficient material. It requires a teacher who is active, knowledgeable and sensitive and who will lead the pupil on the path to new knowledge. The result of the NTA work in the classroom depends on the combination of pupils, teachers and materials. A teacher, who is well prepared, is familiar with the NTA concept, the framework of the classroom and the ability of the pupils can choose his/her own path through the material. He/she chooses the tasks, which suit the pupils and the goals, which are to be achieved. The teacher is present as a discussion partner with the pupils and supports them in various ways in their work and helps the pupils create a whole from their fragmentary pieces of knowledge. The pupils must be given time to reflect upon what they have done in the science project. But sometimes the projects can be too much about ¨doing¨ and leave too little time for reflection.

The teachers are positive to NTA and appreciate the structure and the training involved in the concept. The method of working is still steered by the material and the guides. But in time it is hoped the teachers will feel freer to leave the theme and give space to the pupils' thoughts and ideas.

The pupils become curious about and interested in science. But the problem is to maintain this interest also in grades 5 and 6 and when the theme does not appear to be particularly interesting. The teachers' role here is important.

Among the participating teachers science is no longer seen as so difficult and demanding and their view of the area has been broadened. Science is no longer just the forest. Many teachers testify that they have changed their way of asking questions and talking to the children in the classroom. They now ask more open-ended questions. Here we feel we must advise caution. Too open-ended questions and instructions can be very confusing to the pupils and it is essential that the teacher is present and can support and sum up.

Planning time has increased for most of the teachers. But this is seen as essential in order to adapt the material to the pupil group in question. So far the pupils have not participated in any remarkable degree in the planning but in future, when the teachers have gained more experience of NTA, this is something that can be developed.

The collaboration between teachers in the working teams can in a similar fashion be developed in future. The NTA concept has a potential for development which be made better use of in future. Our opinion is that the teachers in future projects should be given more time to discuss and to learn more about what science means, about what the ¨essence¨ of science is. (written by B. Lindahl)

Scott, R. H., & Fisher, D. L. (2002, 1-5 December). ***The impact of an in-servive course for primary teachers.*** **Paper presented at the annual conference of the Australian Association for Research in Education, Brisbane, Australia.**

Reform is now common, with people from nearly every nation engaging in improving science teaching as political leaders recognise that knowledge of science has economic consequences (Gallagher, 2000). A purpose of this study was to preserve the voices of teachers who had participated in a university course as a "special treatment" program with those of "control" teachers. A program was launched for the training of Specialist primary science teachers in twelve schools. These 17 teachers attended a unique, four-week, in-service course (Zaitun, 1999) and regular school-based workshops. It was hoped that teaching methods would become less traditional and less teacher-directed. Also, it was anticipated that the ability of participants to use questioning techniques to probe students' understanding would improve (Zaitun, 1999). Three male and three female Specialist science teachers, experienced and less experienced, were chosen from various Project schools for interview including one male and one female teacher from the same school. Four teachers from Project schools, who were not involved in the Specialist science teaching Project, including two from the same school, were also interviewed to seek out and capture the essence of different participants' experience.

Shavelson, R. J., Gao, X., & Baxter, G. P. (1993). Sampling variability of performance assessments, *CSE Technical Report* (pp. 26). Los Angeles, CA: National Center for Research on Evaluation, Standards, and Student Testing (CRESST) - UCLA.

In this paper, performance assessments are cast within a sampling framework. A performance assessment score is viewed as a sample of student performance drawn from a complex universe defined by a combination of all possible tasks, occasions, raters, and measurement methods. Using generalizability theory, we present evidence bearing on the generalizability (reliability) and convergent validity of performance assessments sampled from a range of measurement facets, measurement methods, and data bases.

Results at both the individual and school level indicate that rater-sampling variability is not an issue: raters (e.g., teachers, job incumbents) can be trained to consistently judge performance on complex tasks. Rather, tasksampling variability is the major source of measurement error. Large numbers of tasks are needed to get a reliable measure of mathematics and science achievement at the elementary level, or to get a reliable measure of job performance in the military. With respect to convergent validity, results suggest that methods do not converge. Performance scores, then, are dependent on both the task and method sampled.

Songer, N. B., & Gotwals, A. W. (2004). *What Constitutes Evidence of Complex Reasoning in Science?* Paper presented at the Sixth International Conference of the Learning Sciences (ICLS) Mahwah, NJ: Erlbaum.

The laboratory has been given a central and distinctive role in science education, and science educators have suggested that rich benefits in learning accrue from using laboratory activities. Twenty years have been elapsed since we published a frequently cited, critical review of the research on the school science laboratory (Hofstein & Lunetta, Rev. Educ. Res. 52(2), 201-217, 1982). Twenty years later, we are living in an era of dramatic new technology resources and new standards in science education in which learning by inquiry has been given renewed central status. Methodologies for research and assessment that have developed in the last 20 years can help researchers seeking to understand how science laboratory resources are used, how students' work in the laboratory is assessed, and how science laboratory activities can be used by teachers to enhance intended learning outcomes. In that context, we take another look at the school laboratory in the light of contemporary practices and scholarship. This analysis examines scholarship that has emerged in the past 20 years in the context of earlier scholarship, contemporary goals for science learning, current models of how students construct knowledge, and information about how teachers and students engage in science laboratory activities.

Tedfors, J. (2000). *Nu talar alla - lärare och elevers arbete inom ramarna för projektet Naturvetenskap och Teknik för Alla". (Now everyone is speaking-teachers and students work within the frames of Natural Science and Technology for All.* . Department of behavioural science, Linköping university.

The purpose of the dissertation is to study the interaction between teachers and pupils in the classroom. The prerequisites for learning interaction in the classroom are studied in the framework of the school improvement program, the NTA program. The main focus of the study is the interaction in Swedish classrooms but the study also gives a perspective from some American classrooms without doing any comparisons between the two cultures. The method is qualitative with an exploratory perspective. The empirical data is eight unstructured interviews with teachers at two schools and notes written during observations in the classrooms. The conclusions- there are many existing cultures in the same school and the work with NTA helps the teachers to realize that. When teachers are working with NTA, their role becomes more complex. NTA supports both teachers and students to be active in the learning process and they learn in many different ways. The structure of the communication in the classroom when they are working with NTA allows and invites to a real (living) interaction.

Tsai, Y.-T. W. a. C.-C. (2005). Effects of constructivist oriented instruction on elementary school students' cognitive structures. *Journal of Biological Education 39* (3), 113.

The laboratory has been given a central and distinctive role in science education, and science educators have suggested that rich benefits in learning accrue from using laboratory activities. Twenty years have been elapsed since we published a frequently cited, critical review of the research on the school science laboratory (Hofstein & Lunetta, Rev. Educ. Res. 52(2), 201-217, 1982). Twenty years later, we are living in an era of dramatic new technology resources and new standards in science education in which learning by inquiry has been given renewed central status. Methodologies for research and assessment that have developed in the last 20 years can help researchers seeking to understand how science laboratory resources are used, how students' work in the laboratory is assessed, and how science laboratory activities can be used by teachers to enhance intended learning outcomes. In that context, we take another look at the school laboratory in the light of contemporary practices and scholarship. This analysis examines scholarship that has emerged in the past 20 years in the context of earlier scholarship, contemporary goals for science learning, current models of how students construct knowledge, and information about how teachers and students engage in science laboratory activities

Tytler, R., & Peterson, S. (2005). A Longitudinal Study of Children's Developing Knowledge and Reasoning in Science *Research in Science Education, 35*(1), 63-98.

The growth in science understanding and reasoning of 12 children is being traced through their primary school years. The paper reports findings concerning children's growing understandings of evaporation, and their changing responses to exploration activities, that show the complexity and coherence of learning pathways. Children's responses to identical explorations of flight, separated by two years, are used to explore the interactions between conceptual knowledge and scientific reasoning, and the manner in which they change over this time. The paper discusses the particular insights afforded by a longitudinal study design, and some attendant methodological issues.

Tytler, R., Waldrip, B., Griffiths, M. . (2004). Windows into practice: Constructing effective science teaching and learning in a school change initiative. *International Journal of Science Education, 6*(2), 171-194.

This paper outlines the development of a framework--the Science in Schools (SiS) Components--that describes effective science teaching and learning and that has become a central focus for the Science in Schools Research project that is being implemented in 225 Australian schools. The description is in a form that provides a basis for monitoring change, and which can be validated against project outcomes. The SiS Components were partially based on interviews with a small number of primary and secondary teachers identified as effective practitioners, and have been subject to a variety of validation processes. The focus of this paper is on a particular form of validation involving interviews with an expanded set of effective primary teachers, from three Australian states. Case descriptions of core elements of these teachers' beliefs and practice were constructed, and a review and mapping process used to examine the extent to which the SiS Components, as a distinct 'window into practice', align with and capture these core elements, and differentiate the practice of these effective teachers from other primary teachers in the project.

Watt, D. (2002). Assisting Performance: a case study from a primary science classroom. *Cambridge Journal of Education, 32* (2), 165-182.

The interactions of a primary school teacher with her class during two sessions of science are analysed to . nd the extent to which the teacher can be considered to be assisting the performance of her class. The qualitative analysis is in terms of both Tharp and Gallimore's six assisting behaviours and Coulthard's 'initiation–response–feedback' pattern for typical classroom discourse. The teaching shows features which suggest children's science concepts are being developed and features which are consistent with assisted performance, though it is not possible to show a causal relationship between these two aspects. It is suggested that there would be potential for exploring assisted performance further as a framework for teaching for conceptual development in primary science.

Wu, Y.-T., & Tsai, C.-C. (2005). Development of elementary school students' cognitive structures and information processing strategies under long-term constructivist-oriented science instruction. *Science Education 89*(5), 822-846.

The main purpose of this study was to explore the effects of long-term constructivist-oriented science instruction on elementary school students' process of constructing cognitive structures. Furthermore, such effects on different science achievers were also investigated. The subjects of this study were 69 fifth graders in Taiwan, while they were assigned to either a constructivist-oriented instruction group or a traditional teaching group. The research treatment was conducted for 5 months, including six instructional units, and students' cognitive structures were probed through interviews coupled with a metalistening technique" after the instruction of each unit. The interview narratives were transcribed into the format of flow maps. In addition, the information processing modes shown in the flow maps were also investigated through a series of content analyses. The findings showed that the students in the constructivist-oriented instruction group attained significantly better learning outcomes in terms of the extent and integration of their cognitive structures, metacognition engagement, and the usage of information processing strategies. Moreover, it was also revealed that both high achievers and low achievers benefited from the constructivist-oriented instructional activities, but in different ways. For example, both high achievers and low achievers in the constructivist-oriented instruction group attained better usage of information processing strategies than their counterparts in traditional teaching group did; but only high achievers displayed better usage of higher order information processing modes (i.e., inferring or explaining) than their counterparts in traditional teaching group did. The results in this study finally suggest a four-stage model for students' process of constructing cognitive structure under the constructivist-oriented science instruction, including cognitive structure acquisition, metacognition enrichment, cognitive structure integration, and cognitive structure refinement.

ZEE, E. H. V., & ROBERTS, D. (2001). Using pedagogical inquiries as a basis for learning to teach : Prospective teachers' reflections upon positive science learning experiences *Science education* *85*(6), 733 - 757.

The primary purpose of this study was to document and interpret ways in which the first author engaged prospective teachers in pedagogical inquiries and then assisted them in using their findings as a basis for learning to teach in her courses on methods of teaching science in elementary schools. The focus here is upon inquiries about factors that foster science learning. A second purpose was to trace some of the effects of such a pedagogical approach in the development of expertise in teaching, researching, and mentoring. A third purpose was to contribute to the developmeht of interpretative methodology, an example of a collaborative inquiry. Data included drawings made by prospective teachers on the first day of class in which they depicted memories of positive experiences in learning science. They also wrote captions for their drawings, identified factors that fostered their learning in these instances, and constructed a joint list of factors across these individual experiences. Throughout the semester, the prospective teachers also wrote journals describing science learning they observed and analyzing factors that fostered learning in those instances. Then they analyzed their own journals for common themes in order to develop personal frameworks for science teaching and learning. Data also included audio-taped interviews and written reflections by a graduate of the course about ways the course has influenced her evolving teaching and mentoring practices. The results suggest that these prospective elementary school teachers had entered a course on methods of teaching science with prior knowledge about science learning and teaching that could serve as a basis for learning to use approaches to science instruction advocated in the national standards. The reflective methods utilized in the course enabled at least one of these prospective teachers to articulate her philosophy of teaching in ways that helped her instantiate such practices as a beginning teacher.