www.pollen-europa.net

Depuis 2000, ***La main à la pâte*** anime un réseau de centres pilotes qui vise à promouvoir un enseignement de science et de technologie fondé sur l'investigation (ESFI). Ces centres coordonnent sur plusieurs années scolaires différentes actions qui permettent d'engager un nombre important de maîtres d'une zone géographique donnée.

Fruit et synthèse de ce travail de terrain, ce livret est destiné à aider les équipes pédagogiques qui souhaiteraient lancer et coordonner des projets similaires dans les écoles d'une ville, d'une circonscription, d'un réseau, voire d'un département.

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Seed Cities for Science

A COMMUNITY APPROACH FOR A SUSTAINABLE GROWTH OF SCIENCE EDUCATION IN EUROPE

Support Handbook for Establishing a Seed City

to Develop Science and Technology in Primary Schools

Strategies, Objectives, Examples and Recommendations

June 2009 – *La main à la pate*

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Seed Cities for Science

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The pollen project

Pollen is a research and development project supported by the European Commission Directorate-General for Research (Sixth Framework Programme for Science and Society), proposed by a group of pedagogical and scientific organisations from 12 European countries and coordinated by ***La main à la pâte*** (École Normale Supérieure, France). Pollen's main objective is to stimulate and support inquiry-based science teaching and learning at the primary school level by providing teachers with tools, training, coaching and assessment.

Pollen was launched on January 1st, 2006, and took place over a three-and-a-half-year period. It sought to provide stake-holders and national education authorities with an empirical illustration of a sustainable and efficient science teaching reform within schools at a local level, whilst involving the whole community, and thus to seek leverage effects. 12 Seed Cities for science were created for this purpose throughout the European Union. A Seed City is an educational territory that supports primary science education through the commitment of its community (families, education authorities, scientific and industrial partners, municipalities, museums and cultural centres, etc.).

Tools and resources were provided by project leaders in order to ensure the implementation of the local strategies designed within every Seed City. Pollen provided material and methodological and pedagogical support compatible with the framework of each local curriculum.

All of the materials produced as part of Pollen, as well as further information about the project, its progress, achievements and outcomes, can be accessed free of charge through the Pollen website: **www.pollen-europa.net**.

Preamble

Since 2000, *La main à la pâte* has headed a network of pilot centres designed to promote science and technology in schools at local level. The support initiatives at each centre are based on a range of methods integrated with, and adapted to, the academic year. They enable a large number of schoolteachers to participate in Inquiry-Based Science and Technology Education (IBSE).

This systemic approach is also being used in the European project Pollen (➔ **www.pollen-europa.net**), which between 2006 and 2009 established a network of *Seed Cities*[1] *for science* in 12 European countries.

Based on these experiences, this booklet provides an organisational framework for a Seed City to help educational groups who would like to establish and coordinate a structured and ongoing initiative in schools at a city, district, county, or regional level.

This framework offers perspectives and recommended best practice for the following seven strategies:

- teacher training and support,
- establishing a training network,
- giving teachers access to resources,
- assessment,
- coordinating a local support network,
- mobilising decision-makers,
- project management.

Each item is explained in detail below in an overview document containing objectives, real-life examples, links to annexes and recommendations. This is not intended to be a turnkey template. Rather, it provides examples of actions that, most importantly, should be adapted to local contexts, needs, and resources.

Since the ultimate goal of this type of project is to engage a large portion of teachers, plans must be made for a preparation phase that may last an entire year. This provides an opportunity to mobilise local actors and partners and to get them involved in developing the project. More specifically, the viability and success of the project depends upon the following conditions:

- a shared belief in the project's long-term challenges and outlooks,
- willingness from political institutions, including vital support from the local and national education system,
- effective mobilisation of local actors (local authorities, scientists, parents, associations, etc.) united around a single project with many partners,
- a clear commitment from all partners to allocate the necessary human and financial resources to support the project throughout its life (at least three years),
- institutional support for the teachers: trust, academic oversight, scientific guidance, training,
- a development plan that combines the project's strategic aspects and their subsequent actions and sets a timetable,
- an official agreement contracting all the partners' commitments for the duration of the project (at least three years).

By combining this partnership framework with the set of actions **prescribed by the project's development plan**, academic teams will achieve both significant quantitative and qualitative levels of IBSE.

We hope this brochure successfully conveys the experience acquired over the last few years in different European countries.

1 A Seed City is an educative territory that supports science education with the involvement of the local community.

Establishing a Seed City to Develop Science and Technology in Schools

Strategies to Apply

Mobilising Decision-Makers

Obtain support from authorities and decision-makers to ensure the project's viability.

Possible actions

Ongoing discussions, institutional meetings (steering committee, etc.), contract initiatives, informational campaigns, etc.

Assessment

Offer formative assessment tools:

- for teaching practice
- for student learning.

Measure the project's impact on classroom practice.

Possible actions

Diagnostic assessment, description of teaching practice, formative assessment, etc.

Teacher Training and Support

Develop and improve teachers' skills in teaching science and technology using inquiry-based methods by helping them overcome their apprehensions.

Possible actions

Training sessions focused both on specific content and scientific teaching, pedagogy, academic guidance, scientific guidance...

Objectives

- To implement inquiry-based science education in the classroom.
- To help pupils improve their knowledge and develop scientific, social and language skills.

Coordinating a Local Support Network

Link and systematize the competences of the local community that support work done in classrooms and schools.

Possible actions

Guidance from scientists, parent participation, partnership with cultural or scientific organisations (museum, planetarium, etc.), companies, associations, etc.

Creating Training Networks

Motivate and mobilise teachers to work together (and with other professionals) to build collective expertise in science education.

Possible actions

Collaborative projects to develop resources, assessment of practice, joint initiatives between schools, forums, etc. Support of School Principals is key to success of this element.

Giving Teachers Access to Resources

Offer all teachers logistical, scientific and educational support.

Possible actions

Develop a curriculum aligned with the national curriculum; provide materials and lesson plans, etc.

Provide an online forum for teachers to network and share ideas during and after the project.

Project Management

Duties of the coordinating committee: Assign a main contact person, serve as an intermediary between schools, institutions and partners, manage the budget, supervise planning, implement and assess the program's actions, provide a contact person for the pilot centre's events...

Mobilising Decision-Makers

Introduction

An innovative project intending to make substantial changes in classroom practice must have ongoing support from local community members. This can be ensured with backing from local authorities and decision-makers, which implies informing community representatives who may have an interest in the project and bringing them together for this reason. They could be academic or municipal authorities, the pupils' parents, academic and scientific organisations, museums, companies, associations, cultural centres, etc. It is important to link in, wherever possible, to synergistic organisations and networks doing similar work, so as not to push the project in as something totally «new», but as something than links in effectively with their infrastructure. Getting imputs from such groups early on in the project will ensure they take ownership of the project ideals (which should be strongly synergistic with their own). This is vital to ensure longer term sustainability of the project ideals and embedding of its actions into the larger education system long after the project is complete. This project advocates a behavioural change, so longer term support from partners will be essential to support teachers in their long-term journey.

Objectives

- Obtain support from authorities, decision-makers and community representatives to ensure the project's viability and have the means to effectively change classroom practice towards an inquiry-based educational approach.

Example Strategies

- Have regular discussions with all the local actors.
- Create an enlarged steering committee (p. 13) in order to involve community representatives and decision-makers in the project's orientations.
- Identify the local entities and people involved with/dedicated to science education.
- Hold institutional meetings.
- Contract the commitments and duties of the partners through agreements.
- Promote the program (develop a brochure describing the project, etc.).
- Invite decision-makers into the classrooms.

Recommendations

- As soon as the project starts, it is important to identify and inform local organisations that are likely to directly or indirectly contribute to the project. This means analysing each actor's interests and the role they could play in the project, as well as understanding how the project can meet each of their needs and interests.
- As soon as possible, identify the institutions and/or people who may be opposed to the project due to the nature of their business or their interests.
- Make the project's objectives clear to the interested parties, as well as the problems it poses for the school.
- Make it clear that when implementing this type of project, it may take some time before results can be noticed and measured.

Training and Support

Introduction

Teacher training and support are vital tools in changing teaching practice.

Training at the beginning of the project, even a short course (two or three days) will provide the educational and scientific support needed to understand inquiry-based science education (IBSE). Strong justification for IBSE and concrete examples of its benefits will help in convincing teachers that they have made the right decision to engage in, and commit to, changing their teaching practice. Then, support in the classroom and regular exchanges will help teachers to get started with the activities, to solve the problems that arise when implementing this new strategy, and to consolidate certain scientific concepts. Teachers gradually gain self-confidence and greater autonomy in their jobs while acquiring a deeper understanding of the content and thought process through their classroom practice.

Objectives

Basic training (for example, a two-day course) could have the following objectives:

- simulate an inquiry-based science class (raise a question, challenge teachers to solve it in a way that takes into account their expected scientific culture, etc.)
- provide teaching tools on topics to be studied during the school year (materials, modules, learning sequences…)
- begin a thought process on IBSE practice and work on the scientific, social and language skills it requires in the classroom. This process will continue throughout the year/throughout the training program

Objectives of scientists' guidance:

- help teachers overcome their apprehensions about science,
- help them understand the scientific content,
- offer them support in preparing, implementing, and assessing the sessions—especially during the experimental phases.
- Emphasis in first training days should be on 'hands on' and getting teachers to try for themselves and enjoy the activities

Example Strategies

- a three-day "basic" training session consisting of two days at the beginning of the school year and the third day for "assessment and outlooks" during the third quarter

➔ Annex A: example of activities for a two-day course in Saint-Etienne (Pollen)

- related educational activities throughout the school year (or all in one period) where subjects are chosen based on need
- educational guidance provided by a team of trained and coordinated "resource-teachers"

➔ Annex B: example of the role of a resource-teacher in Macon (primary school)

- scientific support from trained and coordinated students, researchers or engineers

➔ Annex C: example of teaching units for scientific support

Recommendations

- Working to change IBSE practice requires time and ongoing activities in teacher training and support for a minimum period of three years. Thus, scheduling time for training over several years is an important part of the project's success and quality.
- During the Pollen project, experience showed that peer-to-peer collaboration was a very effective educational support to teachers, particularly during the second year of training. It helped improve active collaboration among teachers and communication between schools, and favoured the expansion of the project.
- In addition to this initiative, scientific guidance from science and engineering students helps relieve teachers' apprehensions and gradually confirm their command of the scientific approaches and content.
- These support methods have to be planned, prepared, coordinated and monitored. They do not replace training; rather, they provide additional support.

Establishing a Training Network

Introduction

A qualitative change in teaching practice requires time and depends on a group effort. Support and exchange systems enable teachers to share and compare their practice, their thoughts, and their individual skills. Instilling these dynamic and multi-school training networks can be a determining factor in a lasting change in teacher practice. Thus, teachers remain the primary drivers of their own careers[1].

Objectives

Motivate and mobilise teachers to work with other professionals towards mutual progress and development of skills

- by developing teachers' autonomy and their proactive approach,
- by encouraging new thought processes and collaboration,
- by valuing and disseminating their findings.

Example Strategies

- Organise discussions
- Produce tools, classroom resources or collaborate on revising these resources (courses, lessons, etc.)
- Participate in joint projects or theme-based projects (ex.: "Calendars, mirrors, the sky and cultures")
- Write learning activities for science classes in groups, teach classes in pairs, assess them in groups
- Encourage descriptions and analyses of classroom practice as an exercise in formative assessment, and produce feedback reports on what happened in class
- Analyse the methods used in class and their effect on how the pupils learned (for example, make a recording of discussions between pupils to assess their comprehension of the concepts being worked on)
- Provide assessment frameworks to overcome any problems teachers encounter and to uphold the project's dynamic
- Give teachers access to a system of material and educational resources
- Value teachers' and pupils' initiatives to promote public events in schools (expositions, forums, school newspapers, articles, blogs, etc.)

Recommendations

- Success of development processes depends upon teachers' mid-term and long-term will and capacity of conscious engagement in the transformation process[2]. It has been observed that training, support and resources are not enough to make substantial, lasting changes. Therefore, an atmosphere of trust, teacher autonomy, time for group reflection and professional collaboration must be sought. Peer support from other teachers and the school principal are vital to long term success in sustaining change in the classroom. It is important to constantly engage with school principals so they support the project ideals.
- In a Seed City, it is possible as well as desirable to create a training network, which will help advance science education by building collective expertise. Ideally it would be optimal to link in to an existing training network with established infrastructure.

1 M.Gather Thurler, J.P. Bronckart, *Transformer l'école (Changing Schools)*, De Boeck, 2004. In this book, the author discusses the "learning organisation"

2 M.Gather Thurler, J.P Bronckart, *Transformer l'école (Changing Schools)*, De Boeck, 2004.

Giving Teachers Access to Resources

Introduction

IBSE can be more easily implemented when teachers are given access to lesson plans that explain the different stages of learning on a subject, and when materials necessary for the development of every class session are provided. This requires planning and adapting the course curricula.

Objectives

- Offer all teachers lesson plans and kits of materials aligned with IBSE. Encourage teachers to use everyday materials with low capital cost that are highly accessible to children at school and at home.
- Include these courses in a curriculum that covers the school year and primary education.

Example Strategies

- Create a study schedule for every academic year. Scheduling in the Pollen project met the following criteria:
  - the themes chosen referred to the French national curricula
  - every year was composed of five periods of about seven weeks between each school holiday (this is the time considered optimal for exploring one subject); this provides an opportunity to identify five major scientific themes per year throughout the pupils' education (water, air/astronomy, human body, living world, technology).

  ➔ Annex D: Pollen curriculum 2008-2009 (the year a new national curriculum was applied).

- lesson plans were chosen by the coordination team and teachers and/or schools.
- Provide teachers with resource kits for the courses and the materials they require. The budget for a set of 35 kits for the entire academic year is about 3,000 euros, according to the lesson plans.

  ➔ Annex F: sample budget for a few kits.

- Material maintenance. The annual refurbishing budget for the kits is about 10% of the total cost of the materials, or 300 Euros/year for a full set of kits.

Recommendations

- Teachers must be involved in the curriculum development and course selection processes.
- It is important to consider teachers' comments concerning the use of materials so that they can be improved.
- To fully optimise loaning of the kits to schools, a rotation schedule can be established and sent to teachers at the beginning of the year. The schedule indicates the period at which every subject can be tackled, and specifies the dates during which materials can be borrowed and returned. Also, to help track when materials need to be restocked between periods, each kit has a tracking sheet that teachers use at the end of every period to mark materials that are missing and to write their comments concerning their use, so that the kit contents can be improved.

  ➔ Annex E: sample tracking sheet and list of materials.

- Make sure to anticipate and plan for the time needed to put the teaching kits together. It is difficult to gauge how much time is required because there are several tasks to do, for example:
  - search for lesson plans on the Pollen website,
  - find documentary resources (books, films, videos, photos, sound recordings, etc.)
  - order materials from suppliers
  - retrieve materials from the stockroom and manage deliveries
  - label the kits
  - print out lesson plans
  - fill the kits
- Whenever possible try to use materials already in a school and work with a teacher to adapt them. For example, it initially took several weeks (5 to 6) to prepare and design the courses (using already available resources), two weeks to order the materials, and two weeks to put the kits together. On top of this, deliveries could take four to six weeks (or even twice as long during school holidays).

Project Assessment

Introduction

The purpose of assessment is to measure results. It is crucial because it helps improve the project's organisation and further the knowledge acquired by teachers and pupils. In an IBSE project, at least three dimensions must be assessed:

- the processes put into place to reach an objective,
- the actual changes in science teaching practices,
- student learning.

Thus, assessing teaching practices or student learning pertains to different assessment methods, objectives and tools.

Moreover, two types of assessment - formative and summative - should be considered for each of these dimensions. They also have different purposes and implementation methods. For example, when evaluating teaching practices, either a formative or a summative rubric can be used to observe classes. In this respect, a recent observation of teaching practice in science and technology conducted at several pilot centres in France showed that command of an inquiry-based process is directly correlated with the type of guidance teachers received and for how long.

Objectives

- Define IBSE practice in terms of the education programme's objectives to improve the implementation strategies.
- Introduce IBSE strategies and formative assessment tools for formative teacher self-assessment.
- Introduce strategies, tools, and formative evaluation activities into the classroom to enhance learning.
- Design a project assessment system that accounts for its different dimensions (teacher training, resources, assessment, policy management, and establishment of training networks).

Example Strategies

- Provide access to lesson plans[3] that have clear teaching objectives aligned with the national curricula and resources for student formative assessment.
- Put teaching self-assessment practices into place by providing teachers with a formative chart.
- Define teaching practice using summative charts to measure differences between actual and recommended practices.
- Offer evaluation activities at the beginning and end of courses to assess pupils' knowledge acquisition.
- Encourage teachers to keep a reflective diary throughout the project which will be very beneficial to them and to the project co-ordinators in assessing a shift in their teaching practice.

3 A lesson plan is a teaching document that contains a series of activities to progressively teach a science subject.

Recommendations

- Before proceeding to measure the project's impact, for example, on the pupils' comprehension, you must know whether the project's implementation complies with the accepted model. In the first stages of the project, therefore, evaluation is based on data mainly collected by observing the teachers' and pupils' activities, interviews with teachers, administrators and pupils, the teacher's preparatory classroom activities, and the pupils' science notebook[4].
- "Only after it becomes apparent that IBSE has been an integral part of the pupils' practice for a sufficient amount of time can you assess the outcome of what they have learned. Otherwise, you run the risk of drawing the wrong empirical conclusions, which can lead to faulty decision-making."[5]
- Formative student assessment requires a clear definition of the teaching objectives ultimately being sought in terms of knowledge and skills. Consequently, it is of the utmost importance to help teachers determine and adopt these objectives.
- Formative and summative assessments not only differ in terms of their objectives, but also in terms of when they should be used and the tools they require. Mixing them together compromises their objectives.
- Any sort of evaluation must strictly define the following four aspects[6]:
  - A conceptual framework (for example, what is being defined as "knowledge", "skill" or "IBSE")
  - Objectives to evaluate (for example, the knowledge acquisition that has to be functionally explained and verified or the accepted definition of Inquiry-Based Science Education)
  - A selection of data sources (an activity, questions, the experiment notebook, an observation, etc.) and tools to organise the data (a chart, a form, etc.)
  - Interpretation of the results of the evaluation to draw conclusions from it (define the level expected, parts to improve, etc.)

4 IAP, «Report of working group on international collaboration in the evaluation of Inquiry Based Science Education (IBSE) programs,» 2006.

5 Idem

6 R. Shavelson, M. A. Ruiz-Primo, M. Li, and C. Cuauhtemoc, «Evaluating new approaches to assessing learning,» National Center for Research on Evaluation, Standard and Student testing, California University, Los Angeles CSE-R-604, 2003. And NRC, «Knowing what students know: the science and design of educational assessment,» Washington D.C.: NAP, 2001

Coordinating a Local Support Network

Introduction

An educational project such as establishing a Seed City necessarily becomes part of a specific local context (city, district…). Therefore, this context must be carefully examined and associated with the Seed City project, for example, through a number of community partnerships.

Objectives

To articulate the competencies of the local community that supports work being done in the classrooms and/or schools.

Example Strategies

- Set up an extended steering committee and invite representatives of the interested organisations to inform them of and mobilise them around school initiatives
- Get science higher-learning institutions involved in the classroom support activities
- Organise cultural activities related to the subject of the lesson being taught in class (for example, plan a visit to a mill during the lesson on gears)
- Encourage parents to participate in the science activities and share their know-how
- Organise actions between the partners
- Promote the project within the community
- Organize meetings with local companies to determine the results they expect from the program
- Talk to the national science promotional organization and ask for their support, particularly in promoting the project and disseminating its findings

Recommendations

- As soon as the project begins, local scientific and cultural organisations that may potentially become involved in the project should be assessed.
- In order for potential partners to be receptive to requests, the project has to be sufficiently clear and complete. Otherwise, potential partners may not clearly perceive how they can get involved in the project and what rolls they can assume.
- It is recommended that partnerships with scientific institutions be part of the ASTEP system (Supporting teachers through the involvement of scientists in primary education). More information can be found at: www.astep.fr (See Annex C).

Project Management

Introduction

Given the number and variety of the project's participants and the range of resources at play, a clearly identified coordination system must be put in place to manage the project and determine its directives.

Objectives

- To determine and implement the directives for the project dictated by the steering committee.
- To plan, develop, evaluate, and adapt the project's actions within its different dimensions.
- To make sure the project runs well on a day to day basis and is coordinated with all its partners.

Example Strategies

- Steering the Project

  Many bodies can steer the project:
  - The core steering committee

    Contains representatives from the main participants in the field[7]. It has decision-making power and control over setting up the project, monitoring it and steering it (number of classes, geographic areas, budget, etc.). It meets on a regular basis.
  - Local coordinating committee

    It contains a coordinator, the main contact for all the partners, schools and teachers involved in the project, and a trainer from the national education administration whose primary role is to train the teachers and monitor the classes participating in the project.
- Day-to-day Project Coordination
  - plan meetings (coordination, informational, institutional meetings)
  - write "required" documents (activity reports, emails to schools, meeting preparation, minutes, etc.)
  - manage educational materials (ordering, restocking, etc.)
  - manage the teams (partners, apprentices, guides, pupils, etc.)
  - participate in training: design, preparation and implementation
  - help produce resources
  - organise communication campaigns (newspaper, science fairs, brochure, website, planning classroom visits, welcoming delegations, etc.)
- In the Pollen project, local coordination required, as an average, a total of 1.6 full-time equivalent (FTE) for 50 schools throughout the year. Students and National Education staff helped with materials maintenance tasks. This is the minimum workforce estimated to get a project off the ground; for a strong growth of the pilot centre, this number should be increased.

7 IA (Inspection Académique) (Academic Inspection Office), EMSE (Ecole des Mines de Saint-Étienne), towns, city.

Recommendations

- The Beginning of the Project: quite often, a project results from an idea or initiative of a small group of people who have discussed it and had a chance to:
  - visit another Seed City site, see how it works, understand how it is implemented locally;
  - meet and talk with teachers (locally and elsewhere), visit classrooms (attend classes);
  - conduct a local assessment, find key actors in science education, identify prior actions undertaken in this area, identify the teachers' needs: what they lack, their problems, how to solve them.
- Structuring the Project: a Seed City project depends on structural elements such as materials, course activities, training, scientific partnerships, etc.

As the ideas develop, the project should be designed with cognisance of all the partners that will be involved, although the original group initiates proposals. Therefore, it is compulsory to:

- explain the project's objectives to the partners
- establish the limits of the area in which the project will be implemented, and how it will be implemented (corps of volunteers, sector, etc.)
- schedule the project's rollout phases depending on how long it is and on the local limitations, and draw up a timetable for actions
- determine a list of actions to carry out and their content
- plan for locations to store the materials, train the instructors
- forecast the project budget (number of positions, operating costs, spending for materials, travel, etc.)
- define each person's duties and commitments
- draw up a collective agreement that will contract the project in terms of objectives, implementation methods, resources allocated and partner commitments.

Appendix A
Pollen course: Two-day Basic Training

Objectives

- introduce teachers to the science inquiry process by giving them an inquiry simulation exercise
- start a dialogue on the relationship between scientific skills and language skills
- provide classroom resources (lesson plans, experiment notebook, etc.) and closely study a subject suggested in the Pollen course curriculum.

Day 1	Day 2
Welcome and presentation of the objectives and the coursework as it pertains to the project Trainees are given a **simulation exercise** on the **inquiry-based** approach for their level Share feedback on the exercise	**Documentary reading** in science: What are its characteristics? What is its role in inquiry-based education? Documentary research exercise on one of the courses chosen from the Pollen curriculum
Discussion on the experiment notebook: How should the notebook be designed? How should it be used in the classroom? Discussion about building language skills (oral and written) Analysis of the notebook contents (status of the entries, types of language, structure of the process, etc.)	**Scientific and academic suppor**t in the Pollen system Roles of the scientific and academic resources The system put into place The products and communication tools

Day 1- Morning
Start of the Course

Inquiry simulation exercise: "coffee"
(the idea for this exercise was taken from the École des Mines de Nantes)

Teachers are asked to put themselves in an inquiry-based learning situation at an adult level on a subject they will not be teaching in their classes because the concepts are not part of the primary school curriculum. The purpose of this exercise is to put the teachers at their pupils' place when they are trying to answer a question and devise an experimental process based on their predictions.

The chosen simulation exercise resembles an informal activity and if the experimentation is conducted correctly, it leads to intriguing and productive exploration.

Directions (written):
"You are given two glasses: one with hot coffee and one with milk at room temperature. Think of a procedure that would produce the hottest white coffee possible after 10 minutes.

You can use neither an isothermal system nor a heat-conveying system. [Note: This restriction limits the number of ideas]. A thermometer will be put in the mixture to take the temperature at T=10 min."

Hold a discussion to make any clarifications about the vocabulary used in the directions (heat-conveying, isothermal, etc.) since it may be an issue for some of the teachers. Explain the terms (5 to 10 minutes).

Materials needed:
drinking cups, glasses, cups, coffee, milk at room temperature, spoons, thermometers, stopwatches, large-format paper, markers, kettle.

Working method:
groups of 4 teachers.

Additional directions:
"While doing research, each group should keep a record of the actions (movements), thoughts, and language skills (oral and written) used by its members."

Teachers can be given time to explore and examine the materials before the exercise begins.

1/ Writing a Protocol (20 min.)

An experimental protocol is an accurate description of an experiment's conditions and procedure that produces results that can be used. If it is well written (complete), any experimenter can obtain the same results.

Therefore, it contains:

- the group's question (depending on the directions it receives, the group formulates a question and an experimental process based on its predictions)
- a list of materials
- conditions for using the materials
- the sequence of steps in the experiment
- conditions for taking measurements (if applicable)

2. Presenting the Protocols (15 min.)

Verify that the groups follow the directions (no heat-conveying system, etc.)

3. Experiment 1 (20 min.)

Each group makes its mixture according to its protocol.

4. Announcing and Comparing the Results (20 min.)

Discussion about how to compare the results.

This is a very important step: it helps teachers understand the importance of clearly identifying the factors involved in the experience and the need to accurately formulate the question and the conditions for the experiment (for example, the quantities of coffee and milk, the temperature of the milk, the number of drinking cups, the material the containers are made from, how to measure temperature, etc.) in obtaining comparable results. It is essentially about being able to determine experimental findings that are reliable and reproducible.

5. Writing a New Protocol based on the experimental conditions discussed and then defined as a group (15 min.).

For example, it was decided to take two identical drinking cups, the same quantity of water and milk, the milk being at room temperature and the coffee (one teaspoon of instant coffee mixed with water from the kettle) close to boiling point. The group is given the following materials:

Materials per group: 2 identical drinking cups, ½ glass of hot coffee, ½ glass of milk at room temperature, 1 spoon, 1 thermometer, 1 stopwatch, 1 piece of large-format paper, 1 marker.

6. Experiment 2 (20 min.)

Each group makes a mixture of hot coffee and milk at room temperature using its own protocol.

7. Announcing and Comparing the Results (15 min.)

Analysing and interpreting the results obtained.

Finding an explanation

It is not a matter of explaining everything, but rather of building an initial understanding of a phenomenon that, like all natural phenomena, is complex. For example, teachers understand that the characteristics of the mixing processes (in the beginning, at the end, quickly, slowly), the materials the containers are made from, and the general experimental conditions, can have an impact on results. Thus, they understand that it is useful to figure out which factors have an impact on the results. They also understand that it is crucial to clearly identify the question to be answered before conceiving the process.

8. Collectively Establishing a Finding that will be formulated as accurately as possible (this is important for vocabulary and syntax (organising the remarks)) (10 min.)

This activity will assess teachers' comprehension level based on the observations they make, the initial interpretation of the results they discussed, and what they learned in general from this exercise in terms of skills (methodology, measuring, language skills, etc.)

In terms of knowledge, the instructor has done substantial research on the possible causes of the observed results.
For example, he knows that the speed at which the liquid's temperature decreases depends on at least two factors:

- the difference in temperature between the liquid and the environment, and
- the size of the contact area between the liquid and the environment.

9. Assessment of the inquiry exercise just completed (20 to 30 min.)

Discussion on how it proceeded: what skills could adults acquire?

Think of how to apply this exercise done with adults to a classroom with pupils. This is based on what the teachers experienced, their comments and their questions.

Examples of subjects that can be discussed:

- The initial directions: were they formulated in terms of a challenge, a question or a problem?
- The hands-on exercise in itself : how does the inquiry process gradually come about ?
    - each person takes on the problem, making predictions or hypotheses based on their naive ideas (how do we use these ideas and make them evolve?);
    - a protocol is conceived (in this case, an experimental protocol) in order to validate predictions;
    - factors are identified;
    - conclusions and knowledge are built along the way.
- Dealing with procedural mistakes: what to do if mistakes are made during the process and comparable results cannot be achieved? (For example, if the thermometer is inserted in the coffee after 10 minutes but before it is mixed, the temperature reading is wrong.) The experiment would have to be redone and verified.
- Using a measuring instrument: accuracy of measurements and control of experimental conditions are important parameters to work on in class.
- Potential roles within work groups to help students do collaborative work: materials supervisor, secretary, spokesperson, experimenter.
- Comparing the results: what if the results are challenged? How do we help pupils interpret the results?
- Oral and written language (review the group notes): what do we write? When? What does this writing account for? How do we organise these entries? What oral exercises do we do?
- Including a study topic in a class or school curriculum: how much time does a study topic require?
- How do we conclude an inquiry process? How do we progressively structure knowledge? In the "coffee" experiment, how do we go on to achieve an understanding? (The instructor suggests resources to those who want them.)

Day 1- Afternoon
The Experiment Notebook

Personal thoughts
A few minutes for individual writing: "I think the experiment notebook is…"

Group Discussion
Return to the morning's activities: what is the link between the inquiry conducted and building language skills? What problems arose and what were the perceived advantages?

Make connections between the problems that arose when using the notebook in class, the problems posed, and the solutions suggested by the teachers.

Group work to further discuss some of the questions that were asked in the larger group.

For example,

- Can something be written at every step of the process? What purposes does the writing serve? What forms and types of writing are done in science class? How do you structure entries with different statuses? What materials should be chosen for the pupils (notebook, large-format paper, binder)?
- What types of oral exercises are done in science lessons (small group discussions, entire class discussions, debates)? What purposes does oral work serve (relates, describes, prepares for written work, persuades, etc.)? How does the teacher guide oral work throughout a lesson? What is his/her role (to encourage, help reword a remark, help make an observation more precise, give a pupil an indication of the right direction, suggest a response, help structure an argument…)?
- What is a group summary? How do you create one based on the pupils' suggestions and using their comprehension to come to a conclusion that does not contradict established knowledge? How do you conclude an oral lesson and a written lesson? Can there be a provisional finding? How do you deal with errors and mistakes? Are we sure of what all the pupils have learned and understood? How can we be sure?

Draw up a summary table using the group work/**Discussion**

Notebook Analysis

Group work: Analysis of a few sample notebooks (by level) brought in by the teachers or the instructor (a template analysis chart can be provided).

Watch a video taken in a classroom where the experiment notebook is being used.

Group discussion: Teachers talk and make connections between their analysis of the video and the notebook analysis they did in groups.

Overview

Do we have answers to the original questions on the experiment notebooks?

Day 2 – Morning

Reading and documentary research done in the courses used for the Pollen curriculum

Group discussion and group work on a lesson plan

- Discuss and evaluate the use of reading documentary materials in inquiry-based science education: in what context? How do we manage this activity? At what age? With which tools (texts, encyclopaedias, manuals, Internet, etc.)? And what strategy do we use? Demonstration of what makes documentary texts different from literary texts using texts about the living world (animals and plants).

- Using a lesson from the Pollen curriculum (for example, the lesson on animal classification), documentary research on the Internet is conducted with the instructor's help (websites are chosen beforehand) based on questions the teachers ask after reading the lesson.

Day 2 – Afternoon

Scientific and Educational Guidance in the Pollen Process

Group discussion on the guide's role
What is the definition of a guide? What is its objective? What methods might it use?
Are there differences between educational guidance and scientific guidance?
How can we clearly organise these guidances?

Group work
Write a charter that contracts the teacher's and the guide's respective roles.
Summarise a few guidelines for the teachers involved in the project.
List the teachers' expectations or requests (start of the guidance plan) in the project's local context and according to the number of available guides.
Establish how teachers will communicate among themselves and with the coordinating body (i.e. by e-mail), so that this guidance can be regularly evaluated and monitored.

The Seed City's Products and Promotion

Presentation by the coordinator on the opportunities for exchanging information between the European classes in Pollen and the potential tools for promoting and distributing the products created by the Seed City.

The available communication tools are the (annual) interactive expo called *La Vogue des sciences*, the newspaper called *Journal des Butineurs de sciences* (for classes, teachers and parents), and the Pollen website.

Information on the project's scientific cafés and other theme-based places, that offer teachers the opportunity to exchange their ideas and to pool their skills and experience.

Teachers share ideas on how to meet and work based on their needs and preferences.

Review of the course and outlooks for the year

For example, the following can be discussed: contents of the next training course, guidance strategies, different ways of exchanging ideas, parameters for analysing practice, expected products, scheduled events.

End of the course

Appendix B
The Role of a Resource-Teacher

A resource-teacher mainly provides educational support to the teacher he/she is guiding.

The resource-teacher with a day off from teaching

He agrees to:

1. gain a clear understanding of the definition of inquiry-based science education;
2. Produce and try out learning units in the classe, including language skills. Describe the methods used after these teaching exercises to structure the language skills learned (for example, work on specific vocabulary);
3. help teachers plan and formulate general learning objectives at a school level, and specific learning objectives at a grade level. Encourage and/or provide guidance for the development of science and technology projects at a school-level and at a grade level by helping the teachers without supplanting them;
4. Help colleagues, either by providing them guidance before the lesson, or by bringing support in the class;
5. invite teachers to share the results of their work during training events (educational events, group work, continuing education courses)
6. help establish an assessment protocol that assesses children's acquired knowledge in the scientific disciplines, their progress in language skills, and their attitude towards science. Take part in this evaluation and allow volunteer teachers to assess the evolution of their science teaching practice;
7. contribute to the organization of to the school's science room, if there is one: become familiar with the materials and what can be done with them, improve the teaching kits if they are missing anything or present problems when being used.

What the resource-teacher does not do: Monopolise decision-taking concerning science teaching at the school, play the role of "specialist", replace his colleagues.

His role	
Regarding the pupils in his class	• Implement inquiry-based science with pupils in the class.
Regarding the pupils in other classes in his school	• Supervise the groups. • Come in as an extra teacher (the regular teacher stays in charge of the class).
Regarding the teachers in his school	• Pass on information. • Encourage discussion and sharing of teaching experiences in the school. • Ask teachers to come into their colleagues' classrooms as an extra adult figure. • Help teachers set up the scientific process. • Help organise activities in the school, science room, materials, science notebooks, projects, etc.
Regarding the system	• Develop the teaching kits. • Revise some of the lessons. • Give feedback on classroom practice.

The resource-teacher without a day off from teaching

He agrees to:

1. gain a clear understanding of an actual inquiry process;
2. Produce and try out learning units in the classe, including language skills. Describe the methods used after these teaching exercises to structure the language skills learned;
3. help teachers plan and formulate general learning objectives at a school level, and specific learning objectives at a grade level;
4. invite teachers to share the results of their work during training events (educational events, group work, continuing education courses)
5. assesses children's acquired knowledge in the scientific disciplines, their progress in language skills, and their attitude towards science.

What the resource-teacher does not do: Monopolise decision-taking in a colleague's science classroom (when filling in for him/her), claim to be the "only specialist" authorised to teach science in his school.

His role	
Regarding the pupils in his class	• Implement inquiry-based science with pupils in the class.
Regarding the teachers in his school	• Pass on information. • Encourage sharing of teaching experiences.
Regarding the the system	• Revise some of the lessons. • Learn which practices are being used in the classroom.

Appendix C
Teaching Units for Scientific Guidance

Introduction

The establishment of an "ASTEP[8]" TU (Teaching Unit) at the undergraduate, graduate and PhD levels is an opportunity to introduce science or engineering students to pedagogy and science teaching in an academic context, on the one hand, and on the other hand to help teachers implement activities in science and technology in the classroom.

Three examples of ASTEP TUs already in place will be presented in this document.

Objectives of the TUs

- provide students with the opportunity to experience science teaching in the primary school;
- contribute to the diffusion of the University's scientific culture;
- unite science students around a community project;
- help develop science and technology education in an academic setting;
- enhance science and engineering students' discovery of teaching careers.

Who is it for?

These TUs are for science and technology or engineering students, from the undergraduate level to the PhD level.

How?

- TUs are based on three strategies:
  - Discover the inquiry process: simulation exercises, observations in primary school classrooms or with class videos, learn about the education system and programmes, guidance training, etc.
  - Guidance: joint teaching in the classroom with primary school teachers.
  - Review and recognition: building a dossier and academic audition.
- University recognition for students: 3 to 6 ECTS credits (European Credit Transfer System), depending on the chosen number of hours.
- Mentors managed by the scientific institution supervise the guides.
- Flexibility of the TUs: open, optional or required, depending on major.
- Partnership with the local educational authorities: if possible, it is preferable that a representative of the national education system and a representative from the scientific institution coordinate the guides and the primary school teachers in terms of putting them in contact and monitoring them.

Expected Benefits

For students :

- enhance their scientific knowledge by using it differently;
- discover the teaching careers and proffessions;
- facilitate professional orientation;
- make scienctific discourse accessible to children and teachers;
- give a more real and accessible image of science and of scientists;
- have an enriching citizen experience.

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8 ASTEP: Supporting teachers through the involvement of scientists in primary education.

For the teaching and research organisms:

- have a positive impact on the teaching practice at the primary school and on the motivation of futur scientists;
- involve students in community projects;
- develop science communication and pedagogy skills in scientists.

For the primary classes:

- reinforce primary school teachers' skills and autonomy for practicing science and technology, overcoming their eventual apprehensions and consolidating their mastery of scientific contents and procedures;
- do inquiry-based scientific activities, sharing ideas with the teacher and the guide;
- change children's representations of scientists and their jobs, making them more realistic;
- introduce children to a living, accessible and comprehensible science.

Three examples of units for scientific guidance (modalities and description)

ASTEP Partner	Université de Nancy	École des mines de Nantes	Muséum National d'Histoire Naturelle de Paris
Name of the unit	*La main à la pâte*. Science teaching at the primary school.	Societal Commitment Project.	Scientific guidance.
Modalities	This Unit (validated for three ECTS – European Credit Transfer and Accumulation System) is meant for: • engineering school or science faculty students that wish to participate in the improvement of the public's comprehension of science and techniques (it is one of the missions of teachers and researchers); • students who consider a teaching career in the elementary school.	• Every student - engineer of the *École des mines de Nantes* must participate in the development of a Societal Commitment Project, under the form of an activity integrated within a personal development project. • He carries out this activity throughout his four years of training. • For some of these projects, engineering students guide science classes at the primary school.	• Since the year 2000, and through the program *La main à la pâte* acknowledged by the National Ministry of Education, this guidance module is integrated to the training proposed to the doctoral students (1st or 2nd year) by the Doctoral School of the National Museum of Natural History. • It must be validated in order to defend the doctoral dissertation.
Description and validation of the accompaniment action	• Students will first discover the science teaching techniques, the schools and the children through one or several class observation visits. Then, they will elaborate, together with the school teacher, a pedagogical sequence (several class sessions) that they will write in detail. • They will then intervene at the schools once a week during several weeks in order to participate in science teaching. • The teaching unit ends with a final synthesis and a presentation in which every student confronts and shares ideas with his/her classmates concerning their projects.	• A general information meeting is offered to students in September, in order to raise their awareness about the class guidance activities and the implications of science teaching at the elementary school level. • A meeting is summoned with the students who have chosen to engage in a guidance and the school teachers, in order to go through the essential components of a good guidance. • Next are the sessions of class guidance. • The project is monitored by the guidance coordinator and the person responsible of the domain at the Nantes School of Mines. • At the end of the project, an oral presentation before a jury is organized for final assessment.	• First, an information meeting and a training meeting on the module to be worked on are organized for the doctoral students. Then a meeting between school teachers and doctoral students takes place. • Each student is assigned a teacher to accompany at an elementary school class in Paris (this implies preparing and following 8 to 12 class sessions – cycles 1, 2, or 3 – of about 1h, in collaboration with the teacher). • An intermediate meeting is planned, as well as a meeting to prepare the report, and an individual interview for synthesising and assessing the accompaniment. • Finally, a synthesis report is to be submitted: validation of the module is achieved through its approval by the director of the doctoral school.

For further information (http://www.astep.fr)

Many establishments of higher education have already put in place an ASTEP teaching unit for their science students. The Internet site (www.astep.fr) presents a synthesis and a large amount of documentation on the organization and the contents of the teaching units.

Appendix D

Sample curriculum (Saint-Étienne Seed city, 2008-2009)

Nursery school 1st year	Nursery school 2nd year	Nursery school 3rd year	K1	K2	K3	K4	K5
WATER							
Water transport Water workshops		Water, snow, ice, ice cubes = water	Changes of state water/ice Temperature		Water quality		Water cycle Fusion Solidification Vaporisation
HYGIENE AND RESPECT FOR THE ENVIRONMENT				THE HUMAN BODY			
5 sens			Waste		Nutrition and digestion		Respiration and circulation
THE AIR						EARTH AND SKY	
	The wind, air in movement Breath, air in movement		Is air made of matter?			Shadows and light Earthquakes and volcanoes	Day/night The Moon The seasons
ANIMALS AND VEGETABLES							
Sowing and seeds	Flower plantations (bulbs and seeds)	Animal locomotion and nutrition (stick insects and snails)	Seed or object?	Birth, growth and reproduction (stick insects) Diets	Studying an environment: the forest	Needs and reproduction of vegetables	Classification of animals Human reproduction
Throughout the year							
TECHNOLOGY							
Modelling clay	Construction games and technical objects	Properties of substances and materials: magnets	Electricity I: Simple circuit	Make things roll	Electricity II: Energy	Levers	Transmission of movement (pulleys and gears)

Appendix E

Sample tracking sheet and list of materials

Mixtures and solutions		Period 1		Period 2		Period 3	Period 4		Period 5	
P: provided R: returned		P	R	P	R	R	P	R	P	R
Material:	**Amt**									
strainers	7									
griddle	1									
distillation flask	1									
test tube holder	1									
saucepan	1									
food-colouring	1									
plates	14									
sponges	2									
coffee filters	yes									
gauze	yes									
cotton	yes									
funnels	yes									
thick wire netting	yes									
thin wire netting	yes									
coal	yes									
module	yes									
Not provided:										
cut-up plastic bottles										
gravel, sand, salt										
paper-towels, gloves										

Annex F : Sample budget for a few kits of pedagogical material

The budget for a set of kits (35 kits) is about 3000€.

Investment on the annual replenishment of the kits represents about 10% of the total price of the material, in other words, 300 Euros/year for a set of kits.

A few examples:

- **« Seed or Object » kit, K1:**
  around 25€ (seeds, potting compost, planting pots, cotton, plastic spoons, spray…).
- **« Little Engineer» kit, Nursery school 2nd year:**
  around 140€ (two CELDA construction game boxes)
- **« Respiration, Circulation » kit, K5:**
  around 90€ (scale-model, stethoscopes, lime water, pipe, straws, flask, DVD on the human body…).
- **« Electricity Cycle 3 » kit, K3:**
  around 45€ (wires, bulbs, motors, propellers, switches).