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D3.1 Innovative methods in learning of science and technology
National findings and international comparison

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INTRODUCTION

More than an introduction this is meant to be a sort of very quick guide to the reading of quite a number of innovations in science education practice each being a condensation of a very extended and in deep experience made on the field by teachers and students together.

The collection of Innovative Practices as a pivotal step in the KIS project
In the sequence of the steps planned in the project, the definition of a common set of quality criteria (WP2) guided the selection of a number of representative innovative practices proposed by the ten partners of the consortium (WP3). The collected innovations will be the starting point of a work of adaptation and implementation that teachers in different countries will start at the beginning of the school year 2010/2011 and will continue for the following school year.
The main aim of this WP3 was therefore to collect about 80 innovative practices where some key aspects of innovation in science education (Inquiry Based Learning but also attention to gender and cultural differences) were included in order to give to all partners the possibility of making an informed choice of the innovations to implement in the light of their own country needs and adaptability of the innovations to the national/regional situation.

The collection of Innovative Methods/Practices: how the process was organized
The collection of the innovative practices has been accomplished following some *a priori* selection criteria related to the quality criteria explored on WP2 and to other common criteria agreed among partners, first of all a common definition of what could be considered an 'educational innovation' and of what are the characteristics of an innovation that is both 'sustainable' and 'transferable'.
From the definition of innovation proposed in the project (the *conception, adoption and implementation of significant new services, ideas or ways of doing things in order to improve or reform educational services, ideas ...)* we arrived to a new definition proposed and discussed in the Berlin meeting:
'*A good practice is innovative if it aims to change and/or improve the learning/teaching regular context: the innovation should address one of the problem nationally perceived as important and should be in contents – and/or in approaches to contents – and in teaching/learning methodologies. Every innovation is relative to a cultural context and a good innovation should present successful results concerning the problem addressed.*'
'An innovation is sustainable if it could be implemented for several years by a 'regular' classroom (or school) with 'regular', but motivated, teachers, without special extra requirements (in terms of resources, time, teachers developments, etc.)'
'An innovation is transferable if the core of innovation and the problems addressed are clearly described, the critical points are highlighted, and if it is flexible enough to be adapted to different contexts.'
A 'format' for the collection of the innovative practices was proposed, (together with a format for the national report on the 'state of Science Education'). Both have been experimented before the second meeting in Berlin where, discussing the examples proposed by different countries, a definite format has been approved.
Once approved the format in the final version each partner started to collect and describe national innovative practices intending to cover different ages, subjects and topics, as well as teaching and learning styles and methods. Priority was generally given to innovations which had been tried out for longer periods in different contexts.
Partners in different countries used different ways and methods to localize and choose the innovations.
A common feature that influenced the selection was the possibility to interact easily with the authors. Quick responses to the request of information, documentation, clarification and good will to cooperate are in fact very important in the phase of collecting the innovations, but they will be of the utmost importance in the following phase of adaptation and implementation. At the same time a high flexibility of the proposal as concerns time necessary to get meaningful results or the kind of approach to meet different students' needs is equally essential and this has been another parameter that oriented the selection. The idea that innovations connected with science education research should be based upon

sound theoretical premises or be the object of a careful evaluation oriented the preliminary choice in many countries towards universities or education research journals.
In some cases the request of the documentation concerning possible innovations was sent to Universities where research in science education was known to be active, to teachers training centres and associations as well as to personal contacts. Alternatively the pre-selection was conducted through journals, Internet searches, as well as through visits to local schools or student teachers centres.
In other instances partners addressed to educational institutions that helped to survey the situation of the country as regards innovations sending a request of information to the local institutions.
Some partners considered activities supported or planned by the Ministry of Education or other educational institutions as a starting point to get a first list of innovations. This list was reduced often with the help of experts in the field of science education according to the general criteria of good quality, transferability and valid documentation. Other partners excluded or limited to a minimum this kind of activities because the idea was to take into account mainly innovations coming out from the 'bottom', from the teachers.
A typical sequence of the different phases of the process of collecting innovations is summarized in the following:
Contacting the responsible person of the innovative practices by phone or e-mail: explaining goal and outline of KidsINNscience, asking for permission of describing and adapting the practice. Most persons agreed and were interviewed about their innovative practice (according to the template for description). If teaching materials were not published (in print or online), documentation was asked for and made available by the authors.
The innovative practice is described according to the template. The responsible person answers open questions by phone or e-mail, comment on and approve the description which was sent to RM3.
In this phase RM3 acted as a 'critical friend', looking not only at the clarity, completeness, and correctness of the given information, but trying also to improve the understandability and transferability of the innovations.
The draft was therefore revised according to comments of RM3. If necessary the responsible was contacted again for questions, in any case sending the revised draft to them for transparency.
The documentation was translated and worked through with the proponents by telephone call and interviews checking the final version with the authors. Several rounds of revision of first information about the innovative practices were carried out with people involved in the innovation to different extents and often an approval of contact persons/institutions for use of the innovative practices within KidsINNscience was obtained.
The differences in the procedure of collection are related to the position and the experience in the field of the partners: those with longer experience in science education research have easier contacts with the national research groups and were more concerned with publications in research journals while partners more active in Research and Education Cooperation projects have more open contacts with projects work, University or Museums proposals, and partners with a curriculum development responsibility had difficulties in finding innovations limited in space and time. These differences among partners seem to have influenced the collection of practices more than the country differences.

What this collection tells us about differences and trends in science education practices

An idea of the distribution of the innovations in science education practices (ISEP) among themes and subjects treated and school levels can be drawn from a comparative analysis of the templates. The results have been summarized in the table below. Since the same innovation can deal with more than a subject the overall total is more than the number of ISEP's collected.

Country	**ID**	**IS**	**Ph**	**Ch**	**LS**	**ES/A**	**H/E/SD**	**O**	**PP**	**Pr**	**LoS**	**US**
Austria	3	4	1	1			2		1	3	1	3
Brasil	2		3	2	1		4			1	3	4
Germany	2	2	2	2		1				3	1	4
Italy	3		3	1	4	2	2	1	2	2	3	2
Mexico		2			1		4	1	1	3	4	
Netherlands		4					2	1		1	1	3
Slovenia		4	2	3	1			1	1		3	6
Spain		1	3	1	2	1	4			1	3	4
Switzerland		4	4	1	3		3	2		2	6	1
U. K.	2	4		1	1	1	1	2	1	4	4	
Total	**12**	**25**	**18**	**12**	**13**	**5**	**22**	**8**	**6**	**20**	**29**	**27**

Table I. Distribution of themes and school levels across the ISEP's
ID Interdisciplinary **IS** Integrated Science **Ph** Physics **Ch** Chemistry **LS** Life Science
ES/A Earth Science/Astronomy **H/E/SD** Health, Environment, Sustainable Development **O** Others
PP Pre-primary **Pr** Primary **LoS** Lower Secondary **US** Upper Secondary

As shown in the table above, many of the ISEP's deal with Health or Environment issues or with Education for Sustainable Development. These themes act as motivating agents for the students who are involved in activities that concern their everyday life or the understanding of some socially relevant decisions that diverse communities have to take. This is usually the starting point for the development of a scientific attitude and knowledge.

Another relevant group is that of interdisciplinary or integrated science. Here the need for overcome the artificial division among disciplines that is supposed to be one of the main causes of the disaffection of the students towards scientific disciplines as well as the idea that to understand complex systems like the natural ones one has to use scientific knowledge in an integrated way is the common starting point of these innovations. At the same time an integration between scientific and social competences is considered relevant for giving the students a more correct idea of how scientific knowledge can be used and a sense of authenticity to the learning of the disciplines.

Among subjects there is a slight predominance of Physics. This could be due, among other causes, like the personal contacts of the partners or the more involving relations with the research communities of reference, to the fact that teachers were indirectly or directly motivated to reorganize and improve their teaching activities with more attractive and appealing inputs because of the poor results of some European countries in international surveys like the OCSE-PISA and because of the low number of students enrolling in these subjects since several years ago.

In the collection there are also some instances dealing more with method than with the subject or age level. The lack of constraints in these cases can be an advantage because it gives a great flexibility to the proposal, although some teachers could be more at ease with more precise indications especially when they have to decide whether to engage in a task which is different in kind from their previous experience.

As regards school levels, thanks to a sort of self-balancing process among partners, the distribution is rather uniform considering pre-primary and primary school together. Comparing the type of innovations proposed at different school levels, it appears that in lower grades creativity and play, raising questions vs performing experiments prevail.

Considering now the approaches, Table II shows that the Inquiry or Problem Based Science Learning and Teaching is the more widely diffused together with that based on practical work or hands-on activities. They

Country	IBL/PBL	H/PW	GI	C/M	EI	ICT	REC	O
Austria	2	4	2					
Brasil	3	2		2	3	2	4	4
Germany	4	4				4	3	
Italy	4	5		4	2		4	2
Mexico	5	3		1	2		4	
Netherlands	2	2	1	2			1	1
Slovenia	2	4	2	1		2	3	4
Spain	5	1	1	2		1	1	4
Switzerland	3	3	1	2			4	1
U. K.	2	4		1	1	1	4	4
Total	**32**	**32**	**7**	**15**	**8**	**10**	**28**	**20**

Table II. Distribution of approaches across the ISEP's
IBL/PBL Inquiry , Problem Based Learning **H/PW** Hands on/ practical work **GI** Gender issues
C /M cultural /multicultural issues **EI** Equity issues (disabilities/ SPU) **ICT** Information and Communication Technology Skills **REC** Research Education Cooperation **O** (Communication, representation skills)

both stem out of a widely diffused demand of a more involving context where students can be active rather than passive and design and perform activities that will result in acquiring new knowledge. While the situation of a hands-on activity or that of practical work is rather clear and well defined, the inquiry based label can be given to settings that result quite different. We must bear in mind that activities with the same name acquire different features in different contexts or kinds of interaction. Therefore the same term assumes a different meaning (experiment, hands-on, group work, model, IBL, ..) depending on the situation. In fact the context of the majority of the ISEP's collected suggests that the kind of interaction developed is only partially comparable from one to another. This must also be considered in the phase of adaptation and implementation in different countries where the resulting situation could be significantly different from that of the original proposal.
Another quite frequent setting, especially in the ISEP's coming from countries with a tradition of contacts between industry or research institutions and schools is that, labelled as REC, which results from a cooperation between these and single classes or schools. The idea in these cases is to give students the opportunity of experiencing how scientists work making them to participate in some kind of activity related to real life situations in the field of research.
As it can be seen from Table II, ISEP's relating to gender issues are relatively few, the distribution among countries being non uniform. This could be a consequence of the fact that in some countries this kind of problem is nearly absent (for instance, in Italy or Spain there is no problem in science careers for girls and the gap between genders in Technology careers is diminishing constantly) while in others is more relevant. Among those explicitly addressed to gender issues the 'hypothesis' behind to overcome the problem is not always completely clear; are more 'girls friendly' competences (like reading, writing, cooking, ...) required?
Would a sort of 'segregation' to avoid competition be positive? Is more 'social involvement' needed? At the same time the documentation does not always allow to understand what are the results to be expected and those really obtained.
Among the ISEP's collected there is none concerning cultural minorities or immigrants, but some propose (or invite to) cultural exchanges.
As regards equity, some proposals are designed for special needs students, for vocational schools, families involvement, Science for Public Understanding.
Going back to the problems that these innovations try to solve, one of the most widely perceived is the lack of interest of students in sciences both as school subjects and future careers. Surely a number of different reasons included the social and cultural context of our societies can be among the causes of this attitude. Some of the innovations that address to this problem assume that different contents and/or learning environments could improve the situation. A largely shared opinion is that it is necessary to start from the lower ages otherwise it is too late to get meaningful changes. Taking into account students

interests instead of curricula, trying to connect science subjects to everyday life, introducing contemporary science topics more often and showing the interrelation between sciences are the guide lines of several innovations. Proposed changes in setting at low school levels include alternative use of leisure time to involve students in activities that are challenging games, exploratory, hands-on activities, group works on some problems to get a shared knowledge.
Taking into account that personal competences and social skills in schools are getting more and more important for students' and teachers' alike, other innovations work on the idea that low achievements can depend on students skills as the ability of posing research questions or on their presumptions and ideas on science that impede scientific thinking and understanding and propose innovations that could counteract this situation. On the teachers' side some innovations try to motivate teachers to address issues of science at secondary schools developing teaching materials and experiments that they could easily use.
Other innovations suppose that social/environmental problems can be faced through education and propose different activities involving families where an improvement in social behaviours of the people can be gained through the comprehension and utilization of scientific knowledge in a real life context. When the role of the local communities and families are poor parents must be involved, motivated and supported with continuous participation in the students' formative task to create a new cultural attitude with a more responsible behaviour related to environmental protection and goods consumption. On the other hand a correct attitude towards social and environmental issues is considered not only an objective in itself but as a tool to get better achievements in science.

Final conclusions and remarks

Despite the fact that science teaching and learning is a highly complex process that cannot be forced into definitions like that of 'innovative', this term conveys the idea of something new in the process or the product. From this point of view we could therefore consider as innovative a situation where students do something new like to study and work on subjects that are not ordinarily treated in the curriculum. Alternatively where students do part of their curricular studies in a new way like working in groups on a problem or learning in a different environment or posing problems and looking for solutions. Then again where students develop a new attitude towards their teachers, the subjects they study, the role of science in society. Actually these are the contexts that are described in the great majority of the proposals presented in this report where these different conditions almost always overlap. Any comparative analysis of the ISEP's through single categories is therefore limited by this situation.
The materials that have been collected in this report constitute a very rich source of reflection on the idea of innovation in the field of science education which can be drawn from the analysis of concrete examples already developed and well documented. The fact that they come from ten countries differing in educational systems, with a dissimilar tradition in the curriculum, teacher formation and type of schools, constitutes an added value of this collection. At the same time they will be the starting point of future actions that teachers in different countries with various educational problems can take basing on other colleagues' experience. The results obtained in this process of adaptation and implementation will be collected and analyzed in the following phases of the project and will further enrich the material and enlarge the basis of an up to date reflection on the idea of innovation in science education.

THE COLLECTION OF INNOVATIVE PRACTICES

What is it that bubbles, rotates and moves in the kindergarten? Science education in pre-primary

Keywords:
Pre-primary education, natural phenomena, experiments, encourage girls' performance

Problems addressed

Children, per se curious, get into contact with the inanimate and animate nature and investigate their environment. This curiosity fades by the years and this might be one reason for the lack of students in S&T careers. The author of the project faced questions such as: How can the exploratory attitude of girls and boys be kept alive? How can their interests be boosted without overcharging the children? How can natural curiosity and eagerness to learn be kept when doing the transition to school and during school career?
Studies found out that negative views on science are already formed in the pre-primary education, and therefore integration of science and technology education in the pre-primary education is discussed and planned in several countries as a response of results of PISA and TIMSS, supported by the insights of developmental psychology. The self confidence, especially of girls, should be improved from an early age. In kindergarten and in primary school there is a lack of scientific activities oriented to the development of scientific competences. Therefore the project focuses on both: implementing science education in the kindergarten on long term level as positive contacts with science at an early stage are crucial (ROCARD, 2007) and encouraging girls to participate equally in performing science experiments, observations and in raising questions.

Quality criteria

Pedagogically and **methodologically sound**: the design, learning materials, learning activities and teaching methodology take current theories about science learning into account; allows for a diversity in learning materials and teaching methods in order to meet.
Fosters **scientific competencies**: includes practical work (hands-on activities, lab-work, experiments etc.).

Innovation appraisal

From the very beginning the children participated enthusiastically as they were encouraged and motivated to act out their scientific curiosity. The pre-primary teachers, at the beginning sceptic and a little bit fearful, lost this scepticism by performing the project and came up with lot of innovative ideas and suggestions.

Relevant information in brief

Topics addressed	Nature and environment, movements and energy, life and growth, colours – all topics are integrated and follow the seasons and the festivities in the year, as milestones in the curricula
Age classes	3-6 years
Extent	Kindergarten Alpbach/Tyrol/Österreich 2 groups of kindergarten, each group 23 children
Years of experimentation	1 school-year (10 months)
Duration	1 month for each topic; fix hours 3-4 times morning circle (each 1 unit), fix hours for experimenting: 4 times a week for 1 unit, additional free hours with not limit (depending on demand of children and on action)
Main innovation promoters	Kindergarten Alpbach
Main innovation partners	---
Website	http://www.gender.schule.at/index.php?modul=suchen&suchtext=alpbach (Kindergarten Alpbach itself does not have a www)
Contact person	Ms. Spiß kindergarten.alpbach@tsn.at Kindergarten Alpbach

Curriculum relevance and connection to policy guidelines

When the project was developed (2007/2008), the knowledge of the necessity of confronting young children with science and technology topics was just an assumption of the author. Now, since 2009, the educators of the Kindergartens have to work within a national education framework. The project covers the subarea "Nature and Technique". The main aim of the project to convey key competences - identifying, raising and answering scientific questions and getting an idea of the interrelation between natural phenomena and science,… – is explicitly addressed in the national education framework. A gender sensitive approach in kindergarten as well as in school is (in theory) demanded by education policy, the use and implementation is not guaranteed in schools and/or kindergarten on a broad scale.

Description of the innovative practice

Theoretical frameworks:

Constructivist perspective and collaborative learning

Main aims, features and phases:

Children should achieve proficiency and self-competences:

Use of all senses to approach scientific issues; differentiate when observing phenomena and be able to draw conclusions from these observations and experiments. Observe, organize, predict, try out, approve and arrive at conclusions. Learn to raise questions and investigate: have fun in trying out various ways of solving problems, learn to overcome difficulties in solving questions and doing things with endurance; stay on track and not give up despite failures and disappointment. Develop abilities in handling materials and in relationships with living things.

Develop an ecological understanding of the world – develop global thinking; having fun and feeling responsible to take care of animals and plants.

Perceive the environment as a source of multiple experiences with relish and develop own ideas to achieve a better understanding of the complexity of the environment.

Social competences: Learn to work in groups and to learn from each other; develop solutions and ways to achieve them together with other children. Express own suggestions and solution, develop own ways in solving problems and investigating. Accept and perceive the different interests and abilities of the class-mates. Learn to communicate their own skills and use them to solve problems in the group.

Realize the influence of their own contribution in investigating and solving a problem

Raise questions, formulate and test hypotheses.

Special attention was given to motivate and encourage girls to perform technical experiments and to strengthen their self-esteem, e.g. by creating stimulating and gender sensitive learning environments. Role models were challenged.

Features and phases:

The main topics/themes were always integrated in the daily routine of the kindergarten. The work on the project was constant, except festivities or excursions.

In the morning, within the morning circle (gathering), the theme was approached on a general level: songs, poems, stories developed together with the children, questions on what the children already knew about the topic. There was space for the children to raise questions and to present what they had found out or done in their occupation with the respective topic – so the children also learned to talk about their findings. In the second part of the morning, the group was split in sub-groups. The children could choose out of a range of offerings. Some did experiments, investigations, others were working for some days to fulfil a task (construction of complex things,…), or were doing outdoor observations. Most of the excursions were activities for a whole day. These fixed morning circles and one unit a day were explicitly dedicated to experiments, observations, but the children always had the opportunity to go on with these experiments in the free play time as long as they were interested in. A pool of offerings was constantly available for the children.

Here an overview of the phases: Each phase took about one month. The realisation of the project during a day was divided into two parts.

The issues faced during the whole year where:

1) Above the clouds (Breath, Air, Wind)
2) Wind wheel to light (Energy)
3) Colourful Christmas trees (colours)
4) The silly Augustina (movements, equilibrium)

5) Time goes by (time, time units, clocks, numbers)
6) But it does move (rotations and wheels)
7) We are growing and growing (measurement instruments, growth-age-relation)
8) Plitsch, platsch- holidays (cycle of water, life in the water, buoyancy, aggregate phases)

Methodology used:
Broad range of methods: group working and alone, project work, outdoor and indoor investigations and observations, hands-on, multi-sensory approach and use of non-scientific language to introduce scientific concepts; gender sensitive pedagogy;

Resources needed:

- Personnel to work with groups not bigger than 6-8 children
- Sufficient material (from glass, ice cubes, balloons, candles, hammer …to light bulbs) in order that each child can experiment by him/herself. Support of the parents is useful to gather basic materials for experiments such as pipettes, cables,...
- Microscopes – the kindergarten was allowed to use the biology class of the secondary school.

Form of assessment / evaluation used:
Reflection on the process of the project in team meetings and with parents was done. As in Austrian kindergartens children do not get marks on their performance, there was no form of traditional assessment. Within the range of the daily work, there is of course an observation of the children and developmental disabilities are documented and discussed with the parents.

Information available

Material is available in German. Some material gives inputs and impulses, other give more detailed information on experiments and guidance on the realisation of parts of the project. Material as songs, poems, working sheets can be provided. In some cases copyright has to be clarified. The information can be prepared and provided in a flexible way, depending on what „phases" should be adapted and tried out. E.g.: General descriptions of phase "Time goes by" is 1,5 pages, but can be extended. The author of the project is flexible to make the material available according to the needs of adaptation/of the partner who wants to implement the project.

Critical features for sustainability

The implementation of the project during the whole year was not a problem. The variety of offerings and activities (songs and poems, excursions, experiments,…) supported to keep the enthusiasm of the children are rather complex. This complexity, the willingness of the educator to integrate the questions and interests raised by the children and the flexibility of being creative and use different means and methods, as well as try out experiments is crucial for a sustainable implementation.

Critical features for transferability

It is necessary that the teachers are aware of the fact that they need basic knowledge of scientific issues or the willingness to learn on their own. Whether teachers are trained in science education, may vary from country to country. Flexibility in addressing the different age groups on the language level and on the level of expectations is necessary: older children (~6 years) were able to connect phenomena and concepts and were very engaged in work on solutions together, the smaller ones were astonished. The general idea of the project is highly transferable as the contents can flexibly be adapted and not all of them have to be implemented.

Potatoes don't grow on trees

Keywords:
Pre-primary school, biology education, hands-on activities, biodiversity, cultural diversity in eating habits

Problems addressed

The importance of a biology education conceived as knowledge and competences that can be used in everyday life has not yet become established in Italian schools. Biology is often reduced to sheer theoretical discipline, full of nomenclatures and definitions, difficult to understand and apply in different contexts. What's missing at school are practical experiences in which students get actively involved and encouraged to apply different work methods.

Quality criteria

Pedagogically and **methodologically sound**: allows for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests.
Fosters **scientific competencies:** offers inquiry based learning activities and stimulate collaborative work.
Supports **teacher participation** and **professional development:** teachers are involved in designing or adapting the innovation to their own specific situation.

Innovation appraisal

Cooperation among children was seen to be effective and productive especially in relation to "doing", 'observing' and 'hands-on' work. The documentation collected (observations, recordings of conversations, drawings and hand-work) shows how children took part in the experiences with passion and interest. Sometimes the approach to discussion started with some effort, however most discussions have been productive and a source of inspiration for everybody.

Relevant information in brief

Topics addressed	diversity in potatoes
Age classes	3-7 years old
Extent	Local: a section of a pre-primary school (about 30 children)
Years of experimentation	1
Duration	About 5 months for a few hours each week (the activity in the vegetable garden lasts about 3 months)
Main innovation promoters	Research Group in *Teaching Biology* of the University of Milano-Bicocca
Main innovation partners	MIUR (Ministry of Education, University and Research)
Website	
Contact person	Annastella Gambini, professor of *Biology Education*, University of Milano-Bicocca: annastella.gambini@unimib.it

Curriculum relevance and connection to policy guidelines

The 2007 New Curricular National Indications highlight the central role played by experience and by the experimental/laboratory dimension that, starting from nursery school, should be carried on with continuity and consistency through primary and secondary school. Moreover, the importance of creating opportunities to make very young children experience at first hand direct contact with *living objects* is reiterated.

Description of the innovative practice

A large number of potatoes (about 300) of different quality (different in shape, size, colour) and provenance (Egyptian, grown by local farmers, bought in different place, and so on) are found by children in a large room (the gym hall) and are used as a stimulus for their curiosity about the diversity of one component of their common diet.

Theoretical framework:
It is important to immerse children from the beginning into an educational context that places them in front of the great topics of biology, such as for example, diversity among living creatures. In this way, an attitude of respect, conservation and informed choices will be fostered in the future.
Also, working in direct contact with living organisms encourages a positive relationship with living things and contributes to improving self-knowledge.

Main aims, features and phases:
In addition to learning some aspects of the discipline, such as genetic biodiversity, the biological characteristics of tubers, the plant's development and growth etc., the experience aims to transform an everyday object, the "common potato", into a cultural object on which to reflect, discuss together and organize other experiences. By going back from the part to the organism, we suggest making a vegetable garden where it would be possible to observe the life cycle of the whole plant.

The stages of the experience proposed are:
1 <u>Discussion</u>: the teacher gathers the initial knowledge that children have about potatoes.
2 <u>Familiarisation</u>: children are shown about 300 potatoes (arranged on the floor in a large room) of different qualities and provenance. Through free play and exploration, children spot the differences among potatoes; later on, they choose one of them for the subsequent activities.
3 <u>Drawing and discussion</u>: children make up a name for their chosen potato, make a drawing of it and comment on it. The teacher leads a discussion on potatoes to help children become aware of their diversity.
4 <u>Assembling the vegetable garden</u>: potatoes are interred to observe the plants' development and growth (different growth rate, different number of flowers, different roots, etc).
5 <u>Other activities</u>: during the making of stencils, dolls and puppets, the preparation of "gnocchi" etc., children are helped to recognise diversity in indirect ways: by dividing potatoes into groups, looking at them inside and outside, breaking them, peeling them…

Methodology used:
<u>Discussion</u>: the teacher leads the comparison of the different hypotheses, viewpoints and the attainment of a common and shared solution.
<u>Direct contact with the objects of the study</u>: in the first stage, it takes place as a free exploration of the material, without precise instructions. In the second stage, the exploration is led by the teacher.
<u>Reviewing</u>: some time after the activity, all the children's products are used to remember the work done and to help children reflect on what has been done. This "transforms" the experience into a cultural product.

Resources needed:
People involved: Two teachers for each section; an experienced farmer (or gardener or experienced parent) who gives children guidance on how to prepare the soil, how to plant potatoes etc. One teacher (or external observer) for monitoring and collecting the documentation necessary to evaluate the experience.

Materials: Tools to take care of the vegetable garden; materials for creative activities and for making the various products (posters, booklets etc.); photographic camera, voice recorder.

Spaces: Indoor spaces: hall/gym for familiarization; classroom for other activities. Outdoor spaces: small area of the garden to be transformed into a kitchen garden.

Added value of an adaptation
If different classrooms/schools or countries use this proposal an added value would be provided by the electronic exchange of documentation among the schools, which would enable participants to compare different experiences and draw examples of cultural diversity. For example, it could prove interesting to discover different qualities of potatoes in different countries, as well as the different uses of them as food. If such an exchange between classes is proposed it is crucial to consider the electronic exchange (of materials, impressions, suggestions…) and the production of material that can be shared (significant photographs, synthesis of the experiences etc.).

Form of assessment / evaluation used:
During the activity, documentation (i.e. photos, recording, drawings, posters, booklets and other products made by the children) would be collected for the evaluation. Such documentation is useful to evaluate both children's progress and the effectiveness of the proposal, in order to plan effectively for the various stages and possible subsequent works.

Information available

All the information to carry out the experience can be found in two articles one in English and one in Italian:
A. Gambini (2009): Potatoes don't grow on trees. *Roots*, 6(2), October, pp. 18-20;
A. Gambini (2008): Biologia a scuola. *Bambini*, n° 10, November, p. 40-47.

Critical features for sustainability

A space to grow potatoes and a gym or a large room for the initial activity.
(Basic) scientific preparation of teachers (stem structure, photosynthesis, biodiversity, adaptations, etc.).

Critical features for transferability

None.

Kids (and parents) in science

Keywords:
Pre-primary school, parents involvement, gender issues, social issues.

Problems addressed
Lack of scientific laboratory activities in kindergarten level; lack of teachers' confidence with science phenomena; lack of parents (especially mothers) scientific competences and interests.

Innovation appraisal
The innovation was received very well by teachers, pupils and parents. Evidence is based on interviews, sheets of observation, workshop participation, and quality of the communication of science phenomena made by pupils in final science festival events.

Quality criteria
Pedagogically and **methodologically sound**: allow for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests, and take gender and cultural issues into account .
Fosters **scientific competencies:** includes practical work and offers inquiry based learning activities, .
Socially relevant: promote public understanding of science and use resources and teaching contexts from outside the school.

Relevant information in brief

Topics addressed	The topics were 'Light, Colour and Vision' and 'Water', but also others could be used
Age classes	4-6 years old from different social conditions
Extent	Local . In total approximately 100 full classes in 6 years.
Years of experimentation	6 years (2001-2006)
Duration	3 hours weekly for one month/or 20-30 hours in one year
Main innovation promoters	Municipal educational authority: Assessorato all'Educazione del Comune di Napoli; Local Science Museum
Main innovation partners	Science Education research group, Università degli Studi di Napoli Federico II
Website	
Contact person	Emilio Balzano, Naples University: balzano@na.infn.it

Curriculum relevance and connection to policy guidelines
At pre-primary school level science activities are optional in Italy. International recommendations (Standards NSES USA, How People learn; Taking Science to School...) have been taken into account as well as the National Indications for primary and pre-primary schools and the ISS (Teaching Experimental Science) National Plan. The proposal originated from a possibility offered by the Local authority of a collaboration between schools, university, and the science museum in Naples and in a first phase of the project the activities were carried out at different primary school levels.

Description of the innovative practice
Theoretical frameworks: The innovation can be placed in the frames of Research and Education; Collaboration and construction of a community of practices. It pays particular attention to the affective dimension of learning (parents' involvement; small group activities...) and of the relationships between art-science, science-language and science-technology. Artefacts, lights, lasers, videos and computers are used for to fulfil these aims. The language of children, and parents, is enriched through asking them to name colours, to build phrases to interpret phenomena, etc.

Main aims, features and phases: The innovation is based on the integration of lab activities, involving external researchers, in ordinary class activities. Among these there is free exploration of

the phenomenology of every day experiences, painting, playing games led by teachers, etc. Workshops with parents and visits to science museums are part of the innovation.
The main aim was to involve pupils, teachers and parents in a 'discovery game'. Once a topic was chosen the researchers proposed simple but effective problematic situations (games with mirrors, coloured shadows, water mirrors, coloured boxes where the children could enter and see objects under different coloured lights,....) and ask pupils to find rules and explanations with little guidance from their teachers. The overarching goal was the development of logical and critical thinking, centred on the phenomena observed, through continuous argumentation and discussion .

Having chosen a suitable topic, the researchers prepared the situations and the activities where the pupils were invited to work and discuss together. Teachers guided the activities and the following discussions, with the scientific support of the researchers. Teachers have also been invited to share experiences with other teachers in order to gain competences on how to organise their work. Parents are invited to support the scientific logical development of their children making some simple experiment at home together. With this aim workshops have been proposed for the parents (a large majority being mothers from a very poor part of Naples) in order to explain the aims of the project and to improve the feeling of self-esteem when science at home is involved. Everyday examples have been proposed in order to improve the mothers' ability to reasoning and discussing scientific issues (makeup colours, discothèque changing colours, car mirrors, possible playing situation in the bath tub ....).

Methodology used:
The main methodology used with children was to play and to reason together on the experiences they have undergone. The aim was never to lead them to the accurate scientific law or explanation but to use physical and mental experiences, image schemas, perception, categorisation, emotions, reasoning, drawing inferences, to share scientific arguments and develop critical thinking skills and attitudes. Teachers were trained not to offer answers but mainly to put questions; they were also trained to understand the science involved in order to improve their self-.confidence Also the principals were involved, and a final event where pupils presented to the public, mainly parents, their 'science discoveries' was prepared every year.
The approach was interdisciplinary and strategies to build competences on 'metacognition' (for pupils, teachers and parents) and on critical thinking were used.

Resources needed: The project requires the involvement of 2 teachers per class (if a full time day is provided), the creation of a network of schools and he crucial support of the external researchers involved in some class activities. The material needed is mainly composed of every day objects plus some lab apparatus. Videos and videoclips were also proposed and the internet was used in order to exchange the materials and the documentation of the activities between schools and for the dissemination of the initiative and to provide a continuous interaction with parents.

Form of assessment / evaluation used:
Students activities, discussions and presentations have been recorded, and teachers and parents have been invited to discuss the progress made by pupils.

Information available:
Materials addressed to students, parents and teachers 60 pages + links (part of the information is already available in English).

Critical features for sustainability
This approach requires real support (with direct involvement of researchers at school) in the first years and continuous maintenance afterwards.

Critical features for transferability
The possibility and interest for teachers professional development in the following correlated fields: scientific contents, methodological approach, use of ICT.

Multimodal[1] Explanation on Nervous System in Childhood Education

Keywords:
Pre-primary education, models, inquiry based learning, multimodal explanations

Problems addressed

Failure to incorporate science into early childhood education; students are rarely asked to pose questions and multimodal explanations.
Low kindergarten teachers interest in science education.
Lack of innovative and successful practices that motivate teachers to address issues of science in early childhood education

Quality criteria

Pedagogically and **methodologically** sound: the pedagogic basis/background is clearly described and learning activities are consistent; the design, learning materials, learning activities and teaching methodology take current theories about science learning into account; motivation / interest in science is stimulated.
Fosters **scientific competencies**: fosters scientific literacy (identify scientific issues, explain phenomena scientifically, use scientific evidence). Stimulates argumentation and critical thinking. Stimulates collaborative work
Consider developments in **science education** and **science education research**: The innovation contributes to research on science education and makes implicit and explicit reference to SE research.

Innovation appraisal

In the innovation a qualitative analysis of the results was performed in terms of construction of explanations and arguments, and we found very positive results. Teachers who were involved in the innovation have increased their motivation to teach science topics. This is notable because after the conclusion of this innovation the teachers called for more materials and resources for science education.

Relevant information in short

Topics addressed	Nervous system
Age classes	5 to 6 years old
Extent	National, several classes in different parts of the country
Years of experimentation	3 years
Duration	17 sessions of one hour
Main innovation promoters	National research project of CONACYT and Cinvestav
Main innovation partners	Research institutes
Website	
Contact person	Adrianna Gómez, agomez@cinvestav.mx

Curriculum relevance and connection to policy guidelines

The innovation is part of the official curriculum, relates to the knowledge of the human body. The innovation supports communication skills; the development of scientific explanations is part of the competence included in the curriculum.

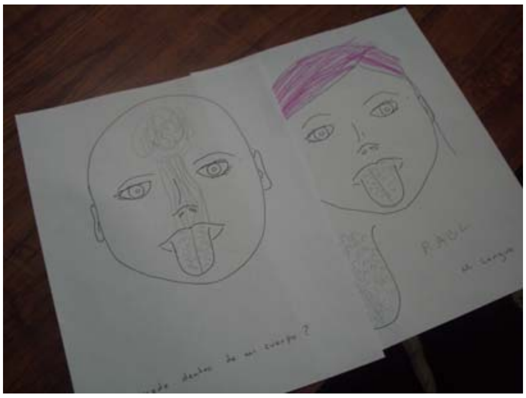
Description of the innovative practice

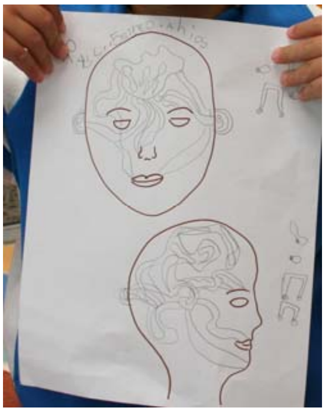
Theoretical frame: Based on collaborative learning among students and teachers. It has applied a theoretical framework of distributed cognition in which cognitive tasks are attained using collaboration with others and external representations.

Main aims, features and phases:

Aims:
The aim is to construct explanations of the nervous system using evidence obtained through experimentation and creating abstract entities to explain (Modelling).

Phases: The activities are conducted in three phases. The first phase is to carry out sensory experiences, games and experiments related to the five senses. Second a group discussion to recover evidence of what happened and to explain. A key question is what happens inside the body ... to feel, learn, react, etc..? This question allows children to invent abstract entities to explain (eg. running little wireless that carried information from the senses to the brain). The third phase is to make a representation of the model (with various semiotic media), then children argue and discuss, in small groups or whole class, around why this explanatory model is good.
Activities are performed that allow generating explanations of the 5 senses, finally there are activities to integrate the entire body and the students produces a three-dimensional model. During the development of the representations (drawings or 3D models) children choose the materials used to represent abstract entities. The students have to say why they choose a specific material and what it represents.





Methodology used: The activities are conducted in a regular classroom. The collaboration between students and with their teachers are very important.

Resources needed: The regular teacher can carry out the activities. The materials needed to make the drawings and 3D models are diverse but accessible: sheets of paper, clay, Styrofoam balls, colours, yarn, bottle caps, etc.

Form of assessment / evaluation used: There are co-evaluation tools.

Information available

There is a chapter of a book describing all the activities and a research paper that describes how to create a system of distributed cognition in the classroom. Both are in Spanish.

Gómez, A. (2009) El estudio de los seres vivos en la Educación Básica. Enseñanza del sistema nervioso desde un enfoque para la evolución de los modelos escolares (A study of living beings in Basic Education. Nervous system teaching focused in the evolution of school models). Universidad Autónoma de Nuevo León, Mexico.

Gómez, A. (2009). Un análisis desde la cognición distribuida en preescolar: el uso de dibujos y maquetas en la construcción de explicaciones sobre órganos de los sentidos y sistema nervioso (An analysis from distributed cognition in preschool: the use of drawings and 3D models in the construction of sense organs and nervous system explanations) *Revista Mexicana de Investigación Educativa*, 14(41): 403-430.

Critical features for sustainability

Innovation has been implemented in regular classrooms by teachers using information available in the chapter of the book.

Critical features for transferability

It requires that teachers support students in constructing explanations and arguments, which implies a certain methodology of work in the classroom.

[1] In this innovation multimodal refers to the use of different semiotics resources to explain a phenomena, for example to explain: How we can hear? The children use drawings, oral communication, and also gesticulation.

Thematic projects in kindergarten

Keywords:
Pre-primary, holistic approach, early science education, creativity, variety of learning methods

Problems addressed

In national context children in kindergarten are often left out of science education practice.
This elimination leads inevitably to the low interest in science and technology that we observe in general today and to the absence of scientific literacy for citizenship.

Quality criteria

Fosters **scientific competencies:** includes core competences; offers inquiry based learning activities; uses ICT skills.
Pedagogically and **methodologically sound**: uses a variety of teaching and learning .
Supports **teacher participation** and **professional development**: teachers are involved in designing their own lessons.

Innovation appraisal

Parents have been asked to participate in several meetings where also evaluation of the yearly project has been carried out with positive assessment results. Children have been asked to evaluate the project, but since they are rather young, only on a like-dislike basis. The innovation is fully supported by the teachers of the institution. The institution deals with the project on a yearly basis. All teachers are included and are accepting and supporting the project.

Relevant information in brief

Topics addressed	Holistic approach to natural sciences: geology, environmental sciences, basic of astronomy, physics and chemistry
Age classes	2.5-6 years
Extent	Local 300-400 children / Full classes / Complete institution
Years of experimentation	This is the third year of executing the innovation. The experimentation has started in early 2000.
Duration	The minimum time needed for experimenting the core of the innovation, e.g. 3 hours weekly (any three hours) for one month.
Main innovation promoters	The Ministry of Education/Local educational authority/research institutes/science foundations/school teachers/City authority of Ljubljana
Main innovation partners	Research institute/Ministry of education
Website	www.vrtec-trnovo.si
Contact person	dr. Špela Stres, prof. dr. Borut Likar, Suzana Antič - spela.stres@ijs.si, borut.likar@ijs.si

Curriculum relevance and connection to policy guidelines

The innovation is part of the compulsory curriculum, since all children of this age need to be faced with certain scientific concepts. However, scientific issues are not in the pre-primary school teaching habit. The importance of this practice is its inter-disciplinarity and the fact that it does not deal with disconnected problems, but rather with a story, connecting all the issues in question.

Description of the innovative practice

In this institution all children are included in the yearlong project.
The project is treated as strictly formal way of education, which is carried out in a informal way, through vivid and dedicated participation of teachers and students. When in-formal ways are considered, we have to mention that also Natural Sciences Museum and Research institute are involved.

Theoretical frameworks: The approach is aimed to develop the kids' competencies in a holistic way which enable the child to gain knowledge, experience and develop specific competencies. The theoretical frame and approaches are as follows: (1) setting and testing the hypothesis, (2) learning process based on sources finding, (3) "hands on" experimental approach, (4) simulation of different "real life" situations, (5) creative approach, (6) project and team work

Main aims, features and phases: Research topics in several different fields are addressed through a story of a puppet who comes to visit the nursery for the whole year. The puppet is animated by the nursery teachers. The sequence of contents proposed is:
Year 1: national history and geology
Year 2: environmental activities and basics of astronomy/ earth/ sun system/ space
Year 3: history (Indians, Columbus...) and natural sciences (physics and chemistry through oceanology)
Children follow the development of the story and are actively involved therein. Eg. (1) A Doll from the planet XY has come to the nursery, because her planet is full of garbage. Issues of environmental activities and basics of astronomy and space are opened up through various activities throughout the year. Several problems are presented to the children through discussions with the doll and children participate vividly in discussions and plan their activities to help the Doll, who in the end leaves the Earth with a rocket that has been made involving different scientists through a simple competition within the kindergarten.
Through the story children have come to know the biology of the nearby fields and forests, becoming aware of Nature and ecology. Moreover they have learned a lot about planets. Similar other puppets related stories have been provided.

Methodology used: Children learn through playing and taking care of somebody in need (the puppet); they learn facts and problems of Earth and Space/physics, chemistry/history etc, which they try to understand and solve.

Resources needed: The innovation is organized as a project: it involves ICT; outdoor/indoor; group work. Space inside the institution and a place in the outside where common events can be held is needed.

Form of assessment/evaluation used: Evaluation is performed within the kindergarten, involving the parents and the social environment of the school. The praxis and feedback on the level of kindergarten is showing very positive results. But as the kindergarten has not agreed upon observable competencies on a more general level, there is no clear and wide accepted benchmarking strategy available. Therefore the theoretical frame is being developed within research projects in the mentioned kindergarten, in particular by the kindergarten headmistress.

Information available

The innovation offers (copyright by inventors) written materials, videos and requires internet. Minimum 10-20 pages to be translated.

Critical features for sustainability

The innovative practice has been implemented in regular classroom, with average teachers and as a part of regular courses. Regular weekly coordination meetings of all the staff in the kindergarten is necessary and is carried out. No extra teacher education is necessary.

Critical features for transferability

The innovation is flexible enough to be adapted in different contexts.
The added value of an adaptation would be the teachers’ professional development on methodological issues, science contents and ability to collaborate among themselves.
Outdoor facilities in beginning, intermediate and final events are crucial and space for them should be provided.
The story of the puppet should be adapted so that it fits the basic culture of the country.

Using the Tough Spot (Builder's) Tray in kindergarten

Keywords:
Early years, play, exploration, materials, tools

Problems addressed

Managing the use of messy materials within the early year's classroom; allowing materials from the environment to be experienced within a more easily controlled environment.
Encouraging young children to begin to communicate their observations and questions, particularly those speaking English as a second language.

Quality criteria

Pedagogically and **methodologically sound**: allow for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests; take gender- and (multi)cultural issues into account; Include all pupils, including those with special educational and physical needs.
Fosters **scientific competencies**: includes practical work (hands-on activities, lab-work, experiments etc.); includes decision-making activities.
Supports **teacher participation** and **professional development:** teachers are involved in designing or adapting the innovation to their own specific situation; Innovation has a clear teacher manual.

Innovation appraisal

None available

Relevant information in brief

Topics addressed	Many topics are possible, within the field of materials and their properties
Age classes	Three to five year olds
Extent	The innovation has been operating in English nurseries for several years, as a variation of the more traditional sand tray or water tray.
Years of experimentation	Several years
Duration	The tough spot tray would remain as a constant part of the nursery environment, being flexible enough for a great variety of uses. A topic could easily be changed each week or could go on for up to six weeks.
Main innovation promoters	A book
Main innovation partners	School teachers and teacher advisers.
Website	
Contact person	John Meadows, meadowjj@lsbu.ac.uk

Curriculum relevance and connection to policy guidelines

The tough spot builder's tray has become a normal part of many early years' classrooms, alongside the more common water and sand trays. It encourages children to investigate a range of materials in wet or dry form and is especially good for mixtures of materials whose properties change as the mixing takes place. An example of this would be with soapy liquids, where films and bubbles can be formed by mixing the various materials within the tray. Links to the Early Years Foundation Stage curriculum in England
http://www.teachernet.gov.uk/teachingandlearning/eyfs/

Description of the innovative practice

The children are presented with a builder's tray filled with a variety of materials. For example, it could be filled with ice and cold liquids, with models of dinosaurs encased inside the ice cubes and many different shapes of ice used to encourage children to identify and play with the shapes, feeling the changes as the ice warms up and begins to melt. Many other materials could be used, objects with different textures, etc. This stresses the importance of sensory perception for young children as a stimulus to developing their verbal language skills and their science vocabulary.

Theoretical frame: The importance for young children to have hands-on experience of materials in a play and collaborative setting to encourage language development and the early stages of sorting and classifying materials. Early years and Piaget's stages of development theories of learning.

Main aims, features and phases: To encourage children to explore materials and talk to each other and to teachers about what they sense and how they relate this to the everyday world. The tray can be used with wet or dry, warm or cold materials and the mixing of materials helps children to explore changes as well as properties of materials.

Methodology used: Indoor activity in an area of classroom which can easily be cleaned and where the materials are enclosed.
Children are expected to explore the materials independently or in small groups and talk about their experiences to each other and to teachers and teaching assistants.
They would be encouraged to raise questions and propose explanations.

Resources needed: Builders tray. There is a book associated with the use of this equipment which provides ideas for a variety of different materials in the "Tough Spot" tray and pedagogic guidance for teachers and nursery assistants in supporting children and assessing their learning. Bromley, H (2002), 50 exciting ways to use a Builder's Tray, Lawrence Educational Publishers, West Midlands: UK)

Form of assessment / evaluation used:
Formative assessment by collecting examples of what children do to help teachers identify when knowledge, skills, understanding and attitudes have been achieved by individual or groups of children in order to plan next steps in children's learning.

Information available

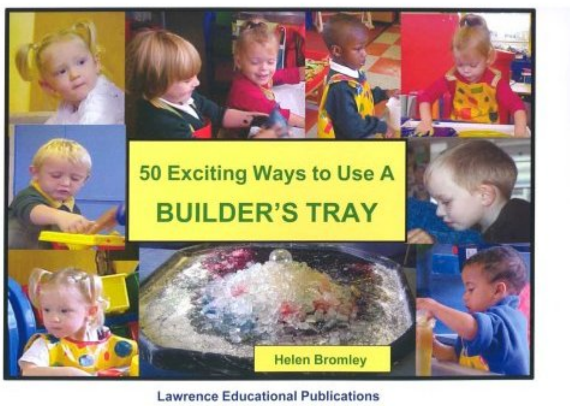
See book- Bromley, H (2002), 50 exciting ways to use a Builder's Tray, Lawrence Educational Publishers, West Midlands: UK) about 100 pages in English, but split into 50 short explanations of activities and materials. The translations would need to be negotiated with the author and publisher.

Critical features for sustainability

The innovative practice has been implemented in regular classroom with average teachers for 8 years.

Critical features for transferability

Teachers' professional development on methodological issues or on science content; the innovation is flexible enough to be adapted in different contexts.



Posing the question "WHY" to reach comprehension. Science learning and language in primary school

Keywords:
Primary school, biology and physics, hands-on/mind-on, children questions

Problems addressed

Children should not be presented with knowledge by formulae; they should create their own understanding and knowledge by experiences and experiments and by using their own language.
Language and technical terms are not taken into account as a necessary part in learning scientific phenomena in primary school.
All human beings, especially kids, are curious in nature. This chance should be taken to improve their scientific competences and understandings.
Children are intelligent and they can get challenged by complex scientific issues with adequate methods.

Quality criteria

Pedagogically and **methodologically sound**: The design, learning materials, learning activities and teaching methodology take current theories about science learning into account.
Fosters **scientific competencies:** offers inquiry based learning activities; stimulates argumentation and critical thinking.

Innovation appraisal

Children had to choose between various modules ("learning studios") – the demand was very high!
The feedback of the pupils to the project was very positive, also of parents – it was evaluated in discussions and meetings with parents.

Relevant information in brief

Topics addressed	Earthworm and different aggregate states: science experiments in primary school.
Age classes	Primary school, 1st and 2nd degree, 6 to 9 years
Extent	Local 20 pupils divided into three groups, within an optional subject,
Years of experimentation	one time
Duration	One school year, 2007/2008, 36 hours in total, 2 hours (blocked)
Main innovation promoters	IMST3 promoted by Austrian Federal Ministry for Education, Arts and Culture
Main innovation partners	---
Website	http://imst.uni-klu.ac.at/ http://imst.uni-klu.ac.at/imst-wiki/images/1/19/1442_Langfassung_Kerschbaumer.pdf http://imst.uni-klu.ac.at/imst-wiki/index.php/Zum_Verstehen_kommen http://iserver.softtechnics.com/bsr/vsemmersdorf/index.htm
Contact person	Dr. Maria Kernbichler, Heide Kerschbaumer Email: vs.emmersdorf@noeschule.at VS Emmersdorf

Curriculum relevance and connection to policy guidelines

Science as a subject is part of the compulsory curriculum. In the Innovative Practice description, an explicit connection to the pedagogical part of the curriculum is given. Interesting core areas (e.g. different phenomena) were chosen (by pupils and teachers) in the field "different aggregate state" and are partly an additional part to the compulsory content. The methods used in this practice are innovative.
"Science learning and language" is part of a big national initiative called IMST programme (Innovationen machen Schulen Top!) of the Austrian Federal Ministry for Education, Arts and Culture to improve the education in different subjects, especially science and technology. IMST works in four programmes

(thematic/regional network, gender network, culture of examination and stocks for education- and school-development) and evaluates education, school development and the education system.

Description of the innovative practice

Theoretical frameworks:

Inquiry Learning; Constructivism; Active learning; Cognitive Learning

Main aims, features and phases:

Children should create their own scientific knowledge and understanding of scientific phenomena by experiments and experiences. The focus is on letting them find their ways of formulating and describing phenomena, of answering the question "why?" and of raising questions of their own and with their own language. Children are encouraged to use their own language to understand phenomena better this way. They are confronted with phenomena without being given explanations beforehand.

Surrounding conditions:
Children should do the experiments on their own and should have enough free-space to repeat them if necessary. Many questions come up after experiments – enough time should be calculated for this process.

The start of the project was by observing earthworms in the earthworm-hutch, followed by experiments on heat, flame and ice. From here, the main question of the project arose: How do small pieces, molecules and atoms behave in different aggregate state?
Experiments on colours and surface tension were done. In prime time, the topic "plants and its function for the earth" and "where do plants get their nourishment from" were treated with experiments.

Each theme was taught in the same procedure:
1st phase: Teacher gives incentives to experiments and provides the basic conditions in order that children experiment by themselves. By observing phenomena and doing experiments, questions were formulated by the children and then treated in discussion, methodologically based on the socratic method.
2nd phase: pupils make experiments on their own and try to find solutions on the issues; hypotheses are formulated by the pupils before or after the experiment; further experiments follow, discussions about "how" and "why", with special focus on the question "why?"
3rd phase: within the conversations about their questions and findings, in some cases technical terms were offered, but not with the aim of making pupils know and learn them. Skilled or highly interested pupils appreciated knowing these terms.
4th phase (voluntarily): The documentation included some photos and was published on the school-web-page. A power-point presentation at a big school-festivity gave parents and other visitors an insight in this project with the aim to encourage parents to talk with their kids about scientific issues in daily life.

Methodology used: logic-genetic– socratic–examplary learning (Wagenschein Martin) ("the pupil is confronted with the unsolved problem equally as mankind was before having done research on it"), indoor and outdoor, single-, partner- and group-work; hands-on experiments followed by minds-on; to find the own way to describe scientific phenomena.

Resources needed:

The resources needed depend on the experiments - basic materials for experiments are sufficient (e.g. loupe, magnet…).

Form of assessment / evaluation used:

Evaluation of pupils´ assessment was done by observation of pupils learning process and behaviour, the teacher realized by questions or comments that pupils could connect the treated issues with their previous and spontaneous knowledge.
Weeks and months after the project pupils were interviewed about the content treated in the project (not just the results, also the process of the experiments was evaluated). Nearly 100% of the children could explain the experiments in detail and give explanations to scientific phenomena. This

shows that the questioning of "why is it this way" was very successfully. About 30% of the pupils could remember the right scientific technical terms.

Information available

The innovative practice is didactically and pedagogically well founded in theory. Experiments of each theme are explained and presented with photos of the project. Many examples of special situations during the lessons are given and the followed education-process explained. The interview-guideline for the evaluation is also available.
Description available in German; pages to translate: ~13 pages

Critical features for sustainability

The project has been implemented in the classes of the 1st and 2nd degree of the whole primary school, the attendance was voluntarily. The themes chosen based on the interest, wishes and questions of the children, the basis for the experiments needed to answer the respective scientific phenomena was provided by the teachers. The teachers are average teachers, but engaged teachers. As the topic came up from the children their interest and motivation is absolutely given which is important for sustainability. Time and space are critical features for sustainability (see below).

Critical features for transferability

Teachers must be willing to listen to the interests and questions of children and must be flexible to build the sub-topics of the project on the questions raised by the pupils. They should be willing to learn about one theme if they are not very experienced.
Not all parts have to be implemented. Only one theme of the topic can be chosen or just some experiments of one theme can be implemented. Materials shouldn't be a problem for transferability as just basic ones are needed (e.g. paper clip, bottles, candles, water). One critical feature is time and space: at least double teaching units and a sufficient variety of materials, experiments and e.g. fix corners for experiments are necessary to give pupils time to approach a theme on their own way, to find formulations and answers to the question "why?" and to argue. According to the author of the project, it can be carried out over a long period of a whole school year or in blocked form such as a course of some weeks. Another piece of advice: if the teacher comes up with his/her explanation before giving the children the chance to raise questions, argue and formulate on their own, the project does not work.

Sunny side up

Keywords:
Primary school, interdisciplinary, physics, questions raised by pupils

Problems addressed

- The teacher was dissatisfied with the traditional ways of presenting scientific concepts and the fact that projects were singular and not interrelated with other subjects and teachers;
- lack of scientific activities in primary school;
- lack of pupils´ ability of posing research questions;
- lack of interdisciplinary and of team-teaching and cooperation between teachers and between teachers and parents – possibility of life long learning for all persons participating;
- Cooperative learning has to be boosted in primary school;

Quality criteria

Scientifically sound: raises awareness of the Nature of Science.
Pedagogically and **methodologically sound:** the design, learning materials, learning activities and teaching methodology are clearly described and consistent with the pedagogical basis.
Socially relevant: promotes public understanding of science.

Innovation appraisal

During the project: power-point-presentations gave an insight into whether pupils understood the contents.
At the end of the project: Interviews with teachers and parents. Both were highly motivated by the enthusiastic pupils and by the fact that they would like their children to experience nature the way they could do in their childhood. They liked to support the whole project (with material, expertise, work) and regard it as a good way for self-development and competence-development of their pupils. The conclusion is that the aim was absolutely achieved.
The commitment, enthusiasm and active contribution of the pupils were given during the whole project. The implementation of the project in the whole primary school was positive regarding the constant scientific curiosity and the performance of the pupils.

Relevant information in brief

Topics addressed	the sun and its relation to the earth: raindrops, sun and water, the cycle of water, light/shadow, time of day/time of year etc. Integrating science topics with other subjects.
Age classes	Primary school, all classes 1st to 4th degree, 6 - 10 years
Extent	Local, the whole primary school, all classes 1st to 4th degree, ~ 100 pupils
Years of experimentation	3 years, now 4th year
Duration	~half to two thirds of a school year, intense and less intense phases (flexible). At least 25 to 30 units of science education, plus units of other subjects (interdisciplinary work).
Main innovation promoters	http://imst.uni-klu.ac.at/
Main innovation partners	---
Website	http://imst.uni-klu.ac.at/imst-wiki/index.php/Sonne_-_Wasser_-_Wetter_-_fast_die_ganze_Physik_in_einem_Regentropfen www.cosmi.at further information (Science on Stage, Teaching Science in Europe):
Contact person	Dir. Ida Regl, ida.regl@vs-lichtenberg.at Volksschule Lichtenberg

Curriculum relevance and connection to policy guidelines

Science as a subject is part of the compulsory curriculum and the way it is educated / implemented is innovative. In the Innovative Practice description, an explicit connection to the pedagogically part of the

curriculum is given. Interesting core areas (e.g. different phenomena) were chosen (by pupils and teachers) in the field "sun and earth" and are partly an additional part to the compulsory content. This means that the scientific content of the project exceeds the normal curriculum in some aspects.
The fact that 'innovation in science education is nearly exclusively linked to school', and ' that participation of local community and cities should be promoted in science education renewal (Rocard, 2006) was addressed by encouraging the local community to support the project on small scale (parents contributing their know-how, material,…) and on large scale (the whole city supported the planning, implementation and realization of a Children Planets Path). The Children-planets-path was an extra module developed which resulted out of the whole project.

Description of the innovative practice

The Innovative practice consists out of two modules (module one: „ Sun – sunny views "– Sun and earth; module two: Raindrops keep falling – Sun, Weather, Water; The entire physics in one raindrop;) which can be implemented separately or one after another within two years.

Theoretical frameworks:

Due to the range of methods used, the theoretical framework is quite broad. Communities of learner; participative methodologies; constructivism; Active Learning; Cooperative Learning; Interdisciplinary; Inquiry based learning.

Main aims, features and phases:

The whole project focuses on the sun, its relation to the earth, weather, air, water, human beings and to life in general. The four modules are planned and implemented in a way that various fields of science education are focused each year: astronomy, physics, chemistry, biology. 1st Module: Sun, sunny views. 2nd Module: Raindrops keep falling. 3rd Module: Life, young researchers investigating life. 4th Module: Feed, on the trail of nutrition. Additional Module: Children Planet Path.

The main aims were to boost pupils´ ability to raise questions and to encourage responsible and global thinking, also by helping them to perceive the interrelation between already known phenomena and new ones and on the basis of themes and issues selected and treated (global thinking, climate change, astronomy as a change of perspective, astronautics and achievements of our times). In this interdisciplinary approach the cooperation between teachers, parents and external supporters is an important aim. As side-aims the improvement of the teachers´ way of teaching science and getting into contact with experts are defined. Pupils should learn to observe and protocol the observations.
Pre-phase: presentation of the idea of the project within the team of teachers and to the parents.
1st phase: investigation of pupils´ preliminary concepts and ideas, knowledge and resources of information (books, videos,…) and interests within the general topic Sun or Raindrops (depending on the chosen module) and the subtopics sun, planets, earth, air, water, gravitation, environment. All teachers ask their pupils what they consider especially interesting within the topic, collect the questions and fields of interest raised by the pupils. The teacher (in some cases together with the pupils) decides on the issues that will be treated intensely and worked on.
2nd phase: realisation of the project is flexible, depending on the decision taken in 1st phase.
Some classes did science diaries, observing and documenting the weather. Others did experiments. In all classes it was essential to focus on the pupils´ perception of their environment and not to answer their questions but to let them find out and encourage them to use various means to find answers.

Module one: "Sun–sunny views"– Sun and earth

The focus in module 1 "Sun – sunny views" is on astronomy and physics, but also taking into account other fields of science and non-science education, such as music, painting, dancing. The main topics in this module are sun, space, gravitation, magnetism, air and vacuum.
Chosen themes in the 1st phase: light/shadow, time of day/time of year, feasible/non-feasible light, absorption/reflection, sun- and planets' path, drawing force/centrifugal force, magnetism/gravitation and air/vacuum, sun-energy.

Special Highlights:
Meditation: "Sun and Rainbow"; meditation for one hour at the festivity equinox.

Action Day "Ticket to the sun": project day prepared together with parents. Pupils go on a journey to the sun (small groups go on a trip to the sun with special tickets and folders made by the pupils and parents) and visit 5 stations out of a 22. They experiment, read, observe, construct, find out.
Imaginary journey: an expert from an observatory explained planets and constellations.
Festivity: midwinter, equinox – to lighten the religious and cultural aspect of the sun.

Module two: Raindrops keep falling – Sun, Weather, Water; The entire physics in one raindrop
The focus is on physics, taking into account other fields of science and non-science education, such as music, painting, dancing.

Special Highlights:
Meditation: one hour, "travelling to indigene people with drums", listening to the water,…
Dancing Performance: One class prepared a "water" – dance with the music "Moldau" of Friedrich Smetana and presented it to the parents.
Action Day "A trip of a drop": project day prepared together with parents. Pupils go on a raintrip (with a Rain-trip T-shirt painted by the pupils) and visit 5 stations out of a 21. They experiment, read, observe, construct, find out.
Musical Plipf, Plopf, Plum: musical about the cycle of the water, music part realized by the local music school, texts written by pupils, decoration realized by a mother.

Methodology used:
Inquiry based learning, outdoor, single, partner and group work, interdisciplinary group working, learner oriented (not book oriented); logic-genetic learning and storyline method (especially with interdisciplinary working), schedule work (e.g. very useful for tasks of observations)

Resources needed: The resources needed depend on the themes and topics treated. Basic materials for performing experiments should be sufficient (e.g. loupe, magnet), additional material could be achieved on low cost level. Support of parents in recruiting of experts and providing material is positive.

Form of assessment / evaluation used:
Different forms of assessment were used: puzzle, quiz, oral and written summaries, reports in the research-diary, observation of the pupils´ improvement in raising questions.

Information available

Pool of general information and links as a base for working on the themes is provided by the author of the project (most of the information already in English).
The description contains general information and sources for the teachers to get background information, many pictures and instructions of experiments with general background information and inputs for homework and observations or further activities done by the pupils as well as worksheets are available .
Sunny-views: ~25 pages to be translated from German.
Raindrops: Wind and air: 12 pages (pure text ~5 pages); Water: 5 pages (pure text ~ 2 pages); ppt presentation of global perspective of water and water consumption (11 slides, partly focussing on situation in Austria, partly global situation); Action day Raindrop: 7 pages (pure text ~ 4 pages)
Water – see, listen, feel and estimate: 2 pages (pure text ~1 page)

Critical features for sustainability

The project has been implemented in the whole primary school, in all regular classes. The intensity of the realisation of the project was flexible, based on the interests, ages and possibilities of pupils and the decision of teachers. The teachers are average teachers, but engaged teachers and willing to work together. Parents, teachers and pupils worked together which is vital for the sustainability of the project.
Recommendation of the author: An implementation along the whole school year could be positive in order to be able to do prolonged observation. Then even more interdisciplinary project work could be done between the subjects, the knowledge gained by the pupils can be even more properly embedded. To achieve suitable findings and results, it is necessary to use at least 25 to 30 units of science education, plus units of other subjects (interdisciplinary work). Contents treated in the project should be in the field of interest of all and

within the curriculum. Interdisciplinary work supports the multisensory understanding of complex issues and should be made possible to guarantee sustainability.

Critical features for transferability

Teachers must be willing to listen to the interests and questions of children and must be flexible to build the sub-topics of the project on the questions raised by the pupils; and to learn about one theme if necessary, and to be flexible in using adequate methods.
Not all parts have to be implemented. E.g. the musical in module raindrops might be difficult to be realized if there is no music support or no engagement of parents.
According to the teacher training it might be that the teacher does not feel sufficiently prepared in the scienfitic topics, to learn about the topic step by step by oneself might be very time consuming and challenging. The availability of material should be assured and one should think about the possibility of using and organising low-cost-material. (The author of the project can give good information and support in these points.)

Apple, apple, apple

Keywords:
Primary school, interdisciplinary (geography, physics, biology), apple, practical work and hands on

Problems addressed

-In science teaching, there is little hands-on and practical work in primary school.
- Pupils are not used to taking responsibility for their own work
- Self-esteem through focussing on the children's horizon and questions has to be fostered; pupils often do not grow up in a social-skills-boosting surrounding; family-life has less value than in former times, they have to learn to work in groups and with partners.

Quality criteria

Pedagogically and **methodologically sound:** Allows for diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests
Fosters **scientific competences**: includes practical work (hands-on activities, lab-work, experiments etc.), stimulates self- directed collaborative work,
Socially relevant: Uses resources and teaching contexts from outside the school, promotes global citizenship

Innovation appraisal

No structured evaluation of the project, but very positive feedback was given by parents and teachers.

Relevant information in brief

Topics addressed	Interdisciplinary science teaching on the topic "apple"
Age classes	7-9 years old pupils, 2nd-3rd degree of primary school
Extent	Local - 2 classes (2nd and 3rd degree of primary school), 41 pupils
Years of experimentation	One year
Duration	intensive work for 3 weeks, 3 months accompanying activities
Main innovation promoters	Generation innovation Bmvit (Federal Ministry for Transport, Innovation and Technology)
Main innovation partners	Boku Wien (University of Natural Resources and Applied Life Sciences, Vienna) Fruit-plant-company Medianauten (www.medianauten.at) Rainforest of Austrians (www.regenwald.at)
Website	http://www.generationinnovation.at/fileadmin/document_browser/scripts/frontend/index.php?filter=2 http://www.schulzentrum-antonigasse.at/vs/
Contact person	Mag. Andrea Salber, Dipl.-Päd. Petra Kröpfl, Dipl.-Päd.Andrea, PrskavecSchool-center Antonigasse; Vienna

Curriculum relevance and connection to policy guidelines

Some contents of this innovative practice are part of the compulsory curriculum, some are an expansion. As the curricula in Austria are open and contain a free space for optional contents, taught additional themes are expected. The interdisciplinary approach offers an explicit connection to the pedagogical part of the curriculum. As a pedagogical and content connection is given, this innovative practice is well founded in the curriculum. Furthermore the object apple is an often used theme for the kindergarten and consequently well known to the pupils. They can embed the new and more scientific contents in their already existing knowledge and deepen and broaden their understanding.
This innovative practice is part of the national programme "Generation Innovation". This initiative from the ministries BMVIT (Federal Ministry for Transport, Innovation and Technology) and BMUKK (Austrian Federal

Ministry for Education, Arts and Culture) supports the dialogue between the younger generation and scientists and innovators within the various fields of natural sciences and technique and technology. It addresses all ages of students and their parents in order to change the image of science and researchers.

Description of the innovative practice

Theoretical frameworks:

Constructivism; Interdisciplinarity; Communities of learners; Active Learning

Main aims, features and phases:

aims

-Holistic learning on the object apple
-Focus on the research- and experiment-interest of every child
-Strengthening of personal competences (autonomous problem-solving and capacity for teamwork) and social skills (interdisciplinary-, age-heterogenic- and group-learning)

Features

Creation of $12m^2$ research-corner in which experiments were realized.
Workbook "apple-portfolio" contains contributions (e.g. worksheets) of other subjects (Geography, Music, German language, Arts and Crafts) and instructions for experiments following the same scheme:

1) question that has to be answered by the pupils by performing an experiment, or an observation based on the experiment;
2) indication on what is needed;
3) lab protocol:
    a) What do you think will happen?; b) my observation; c) my explanation; d) sketch on the experiment and result to be done by the pupils
4) plan of the research diary
In the workbook six descriptions of experiments are included.

Phases

Children came up with questions based on which they were invited to investigate, sometimes also at home. They were encouraged to find out for themselves what and why questions are interesting to explore. Mainly the teachers tried to settle this attitude by: the charity idea, the appreciation of the apple, creativity in different recipes,… All over the project there was an interdisciplinary approach– also to geography and learning about other cultures (Costa Rica), music, language classes,….

1st phase: (geography and environment) children brought different apples to school: Parting from the question "Where were these apples planted?" the focus was on the earth-continents;

2nd phase: (biology) morphology and classification of apples;

3rd phase:
1) Implementation of the workbook "apple-portfolio", on which pupils worked autonomously: Pupils had to solve questions by carrying out and documenting experiments.
2) Practice (conservation and cooking), art (painting, music, creation of a radio play and a radio-reportage), read and write (the book "The apple-tree" (Der Apfelbaum) by Mira Lobe), calculation;
3) From apple to mango: fruits and their geographic appearance, environmental view, connection between Austrian trees and forest and rain forest – how can the rain forest be protected?

4th phase:
1) sale of homemade apple-mango-chutney, tried apple-and mango-pieces and different art-products; with the total revenue, the project "Rainforest of Austria in Costa Rica" was supported.
2) Pupils present their working-results to other classes in school via posters and information desks .

Additional offers:
To get an insight in apple-agriculture and further processing:
1) Excursion to an apple-tree with a forester
2) Excursion to the University of Natural Resources and Applied Life Sciences in Vienna, department nutrition technology with the topic conservation of apples.

To talk about the project and the results:
3) Excursion to the "Medianauten": creation of a radio play and a radio-reportage

Methodology used:
Indoor and outdoor; single-, partner-, group-work; experiments; autonomous learning and working; use of informal resources/excursions (university, farmers etc.).

Resources needed:
No special educated personal is needed, except for the excursions (additional offers); simple equipment for experiments (e.g. spoon, plates, fruits, plastic-bag) and exercises (e.g. coloured pencil, paper etc.) are needed.

Form of assessment / evaluation used:
Feedback discussions, puzzles and quizzes in other settings and even new contexts and transfers (for not to theorize a topic that is naturally in the practical interest of a child).

Information available

Short descriptions of all phases and of all experiments (Work-sheets) are available;
5 pages to translate; language: German

Critical features for sustainability

This project has been implemented in regular classrooms with average teachers and is part of regular courses. As for every project, teachers must be motivated and committed. The subjects/teachers for interdisciplinary work can be chosen individually, with the effect that conflicts and difficulties can be avoided. "Apple" is a known fruit and therefore promising for every primary school.

Critical features for transferability

As this project is very adaptable from very small to big and as no special material or teaching skills are needed, no critical points for transferability have to be mentioned. Excursions to universities, farmers or a radio-station might be a problem, but they are a nice expansion and deepening of this project and not a condition. Although apples are known in the whole world, the fruit can also be changed to a more regional one if wanted.

Physical Knowledge Activities for Primary Education

Keywords:
Primary education, physics concepts, alternative conceptions, problem solving, inquiry-based learning.

Problems addressed

Negative attitudes towards Sciences are identified from an early age. However, very little research is done on how to introduce physics concepts to young children considering possible relationships between physical concepts and everyday life. This innovation addresses this issue by motivating the early understanding of physics and its relations to everyday life.

Quality criteria

Pedagogically and **methodologically sound:** pedagogic basis is clearly described and learning activities are consistent; allows for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests.
Foster **scientific competencies:** includes practical work; stimulates argumentation and critical thinking together with collaborative work.
Consider **developments in science education** and **science education research:** the innovation is backed up by evidence in educational research on alternative conceptions.

Innovation appraisal

There are at least four PhD theses and numerous publications describing and evaluating the application of the teaching methodology. In general, they show that there are crucial aspects for the construction of arguments and explanations by the children: teachers' stimuli to students' participation, time for reflection and opportunities to ask questions. Positive reactions by teachers and students were also reported by authors.

Relevant information in brief

Topics addressed	15 physics activities related to air, water, light and shadows, balance, movement and energy conservation.
Age classes	7-10 years old
Extent	Local (State of São Paulo) Full classes of students are involved in the project.
Years of experimentation	Since 1991 (19 years)
Duration	Each activity lasts in average 60 to 90 minutes, depending on the teacher experience to develop group work.
Main innovation promoters	Research institutes and several public schools in São Paulo
Main innovation partners	Research Laboratory on Physics Teaching (LaPEF), Institute of Education of University of São Paulo (USP) (State of São Paulo, southeast region in Brazil)
Website	http://paje.fe.usp.br/estrutura/index_lapef.htm
Contact person	Ana Maria Pessoa de Carvalho

Curriculum relevance and connection to policy guidelines

The innovation addresses orientations of the Brazilian National Curriculum Parameters (NCP) which state that Natural Science learning is important to help students to acquire capacities such as:

- To formulate questions, diagnose and propose solutions to real problems from elements of Natural Sciences, putting into practice concepts, procedures and attitudes developed in school learning;

- To know how to use basic scientific concepts associated with energy, matter, processing, space, time, system, and life balance;

- To be capable of combining reading, observation, experimentation skills to record, collect, organize, communicate and discuss scientific facts and information;

- To be capable of working in group to collaborate and construct knowledge in a critical and collective way.

Description of the innovative practice

Theoretical frameworks:

This innovation considers teaching and learning as inseparable. It also takes into account the importance of selection of content by the teacher himself/herself (flexibility of choice), the existence of alternative conceptions, and the dependence on social-cultural background of people for scientific knowledge construction.

Main aims, features and phases:

Primary school students (7-10 years old) are encouraged to solve problematic situations, argue and write about physical phenomena. They tell their classmates and teacher what they think about a problem and, in doing so, they develop and refine their thoughts and deepen their understanding of physical phenomena. It is crucial in this methodology that students should reflect about the "hows" and "whys" of their actions. This is because when the student is preparing him/herself to tell the class and the teacher what he/she did, he/she begins to make logical connections between their actions and reactions to the objects. As soon as these relations are gradually being disconnected from the child's own actions, he/she realizes the relationships between changes in physical attributes of objects and begins to conceptualize physics concepts.

Methodology used:

The implementation of activities in the classroom consists of seven steps:

1. ***Teacher proposes the problem***. He/she divides the class into small groups, gathered around some desks where the experimental materials (such as toys like boats, paper frames, etc.) are prepared. The teacher then poses the problem to the students and distributes the rest of the material. Groups must be small to facilitate the dialogue and also allow children to have more opportunities to manipulate the material. It is important to note that the solution should not be given by the teacher.

2***. Students act on the objects to see how they react***. The teacher passes by groups verifying that the proposed problem has been understood and how students manipulate and test the materials. At this stage it is important that teachers ensure that all students have the opportunity to manipulate materials.

3. ***Students act on the object to get the desired effect***. When students are already familiar with the material, they will act to obtain the solution of the problem.

4. ***Students become aware of how it was produced the desired effect***. As soon as the students have solved the problem, the teacher organizes a discussion with the whole class. He/she asks the students to tell what they did to solve the problem. This is the time to think and speak about the activity. The material should be taken away to avoid distraction.

5. ***Pupils provide explanations about the causes of the phenomena***. The teacher's main question at this stage is "Why?". The teacher has to be attentive to question students so that they can advance in learning, because the sole description of what they did is often not enough to help them make progress in understanding.

6. ***Students write and/or draw***. Teacher asks students to write or draw on the experience. He/she can suggest that the drawings should contain what they did and to explain why they did it.

7. ***The teacher and students relate the activity and daily life***. The teacher should encourage students to make the greatest possible number of examples of this phenomenon in their daily life, valuing the diversity of experiences that each one brings to the classroom.

Resources needed:

Personnel: one teacher.
Materials: special kits (e.g. kit "ball in the basket support" needs: one rail linked with a ramp that leads with the basket support in the end of the ramp, besides one holder which prevents the ball falling out and rolling on the floor).

Form of assessment / evaluation used:
Engagement of students is the main form of assessment. But the teacher may evaluate the manner in which the students develop an understanding of the activity through argumentation and logical reasoning, construction and perception of causality relations in the phenomena, science literacy indicators and construction of moral autonomy.

Information available

The innovation is the object of funded projects. Several publications in refereed journals have discussed the innovation and its results. It has also been investigated in the context of a PhD thesis which included analyses of aspects concerning children's productive engagement and enjoyment, reading and writing abilities associated to the activities and improvement in the development of causal explanations. Besides that, there are videos on the website (http://paje.fe.usp.br/estrutura/index_lapef.htm) of the Research and Teaching of Physics Laboratory (LaPEF), at the Institute of Education-USP. Moreover, there is a book published in 1998 with the description of all activities and videos produced. Some of the videos have subtitles in English and Spanish.

Critical features for sustainability

This innovation practice has been implemented in a regular classroom since 1991 in different public schools in State of São Paulo. Teachers generally do not offer all the activities one after another. Almost always the 15 activities are divided among 4 years. This is because teachers find it helpful to the development of activities of physical knowledge as it enables integration with other curricular subjects. So, no difficulty to maintain the achievement of innovation has been found so far.

Critical features for transferability

Teacher training is needed to implement the activity and to understand the proposal at the time of assessing its effectiveness, e.g., to pick up the construction of the arguments developed by students throughout the process. A positive feature is that kits are very simple and can be modified according the materials that are available in the school. We have clarified the authors that, if their contribution is chosen by KIS, a authorisation request will be submitted for their analysis. They will then clarify the conditions for use, translation and reproduction of copyrighted materials and specify which sort of formal acknowledgement they need. As our request involves academic cooperation and does not concern any kind of profit making we do not expect any problems provided proper citation is made and adaptations are well explained.

"NATLAB"-MITMACH & EXPERIMENTIERLABOR–Laboratory for experimentation and "do it yourself" activities

Keywords:
Primary school, upper Secondary school, S&T careers, teacher training, research and Education Cooperation

Problems addressed
- No access of pupils/students to authentic places of scientists work
- Pupils have no idea of the outline of a profession / a career in S&T
- Lack of hands-on, inquiry-based science in classrooms in primary and secondary education

Quality criteria
Pedagogically and methodologically sound, the pedagogic basis/background is clearly described and learning activities are consistent
Fosters **scientific competencies**: includes practical work (hands-on activities, lab-work, experiments),
Supports **teacher participation** and **professional development**,:training opportunities are offered within and/or outside school

Innovation appraisal
- the number of visitors shows strong interest in the project, huge demand by schools
- the model of combining pre- and in-service teacher training with the visit of pupils has been honoured by three different awards (2005, Lela Award, 2006, Lela Award, 2006, Award of the Robert Bosch Foundation).

Relevant information in brief

Topics addressed	"NATLAB"–Laboratory for experimentation and "do it yourself" activities, interdisciplinary (chemistry and biology), for primary and upper secondary science education, part of the GENAU network (local learning laboratories network) and of the TuWaS! Project
Age classes	age 6-12; age 16-19, groups up to 30 persons
Extent	Regional, Berlin and Brandenburg, more than 4000 pupils, 400 pre-service and in-service teachers per year
Years of experimentation	Pilot phase: 2002, ongoing improvement (e.g. inclusion of primary education)
Duration	3h-6h teacher training, 4h – 6h per lab visit by pupils
Main innovation promoters	many different schools all over Berlin and Brandenburg, coordination office (since 2006)
Main innovation partners	Scientists from the department of the Freie University of Berlin (about 20), from other research institutions (2) and from industry (1); GenaU (Local learning laboratories network of 11 informal science laboratories)
Website	http://www.natlab.de/ , http://www.tuwas-deutschland.de/
Contact person	Dr. Petra Skiebe-Corrette

Curriculum relevance and connection to policy guidelines
All of the topics taught in NatLab are relevant to either the high school biology or chemistry curriculum, or are part of the science curriculum of primary schools.

Description of the innovative practice
The members of the GenaU network offer regular laboratory science courses for entire classes or upper school courses. In addition, there are special offers for interested and talented pupils. Teachers can attend training courses at the learning labs. In these courses, scientists provide current scientific knowledge and information on new methodical didactical developments. Three of the 11 labs are used to train students as

teachers, providing pre-service teacher training. Supported by scientists and teachers, they gather practical teaching experience from the beginning of their studies.

Theoretical frameworks:

The distinguishing feature of the REC (Research and Education Cooperation) NATLAB and all the learning laboratories in the GenaU network is that they are located in research institutions or universities. Through these labs, students can experience authentic and unique places of work. They get to know the outline of a profession or a possible career in science and technology, and of subsequent study opportunities.

Main aims, features and phases:

The main aims are: to increase pupils' interest in science, to introduce a realistic and modern picture of science, to contribute to science education and to train pre-service and in-service teachers. Publicity for the university is a side-effect leading to higher student numbers in the respective subjects.

In the laboratories of the GenaU network, pupils experiment on their own. The aim is to attract young people to science and engineering and to give new inputs to science courses at school.

Experiments are offered for primary science education like chemical tests, motion and design, microworlds, electrical circuits, colored building materials and life in a drop of water. Experiments for upper secondary education include neurobiology and behavior; evolution; photosynthesis; genetics and development electrochemistry; chemistry of polymers.

The experiments which are performed by the pupils have been developed by scientists who are experts in that particular field. The pupils are only allowed to visit the laboratory after their teachers have participated in teacher training, which is provided by the scientists who developed the experiments. During the teacher training, the teacher performs the same experiments that their students will perform. In addition, background information is given. The teacher training lasts three to six hours, depending on the topic.

Within NATLAB, three different experiments are offered, but each of the pupils only does one of these experiments. The group as a whole performs all experiments. The pupils work in groups of two or three. Each of the experiments can be done by at least two groups. The pupils not only do the hands-on experiments, but also give a short talk explaining their experiment and the results they obtained. During the visit to NatLab, the pupils are helped by university students as part of a university teacher training course. One of the aims of these courses is the early exposure of pre-service teachers to school pupils. These student teachers can assess their abilities to teach with a small group of pupils within the safe environment of the university. They also learn how exciting it is to do hands-on experiments and that performing experiments with school students is challenging but rewarding.

Methodology used:

- **Hands-on**: school visits and teacher training are centered on hands-on experiments.
- **Inquiry-based learning**: All experiments are part of a learning cycle, which starts with examining the knowledge that the pupils already have, followed by the experiment and an interpretation of the and presentation of the data.
- **Working in groups**: during their visit the pupils work in groups of two to three and there are two or three groups working on the same type of experiment. For the presentation, the groups which have performed the same experiment work together to prepare and give the presentation.
- **Practice making a presentation**: In Germany, the ability to make a presentation is an important skill that high school students should have. Presenting the results of an experiment to a group of peers allows pupils to practise this important skill.
- **Practical teaching experience for university students**: By teaching pupils in small groups, pre-service teachers gain experience in teaching and experience the differing abilities of groups of pupils from different schools. They also experience the importance of hands-on activities and inquiry-based science teaching.

Resources needed:

Coordination, part time chemistry or biology teacher, technician, laboratory and office space (provided by research institutions), basic running costs

Form of assessment / evaluation used:
Assessment of pupils and students/pre-service teachers, comparative evaluation among schools.

Information available

- information material about the setup of NATLAB, description of experiments and teacher training (German, minimum of 40 pages)
- evaluation materials for classes, teachers and students/pre-service teachers (German, 20 pages)

Critical features for sustainability

- A substantial system change can only be reached if all pupils of a region are able to visit informal science laboratories a number of times during primary and secondary education. For the region of Berlin and Brandenburg, the number of learning laboratories (11) is not sufficient
- Ongoing support by and cooperation with research institutions needed
- Participation of NATLAB in network initiatives like the project TuWas! (Do Something) since 2009, primary science education project that deals with in-service teacher training, learning materials, link to the curriculum as well as school authorities and industry, evaluation.

Critical features for transferability

- easy access and usability of the provided information and materials for setting up a similar learning laboratory
- regional research institutions needed to provide laboratory, office space and technicians, learning laboratories have to be within a reasonable distance to a number of user schools
- funding needed for basic coordination and basic running costs.

"Hypersoil"–Development of a hypermedia learning and working environment in primary schools

Keywords:
Primary school, hypermedia working environment, interdisciplinary learning

Problems addressed

Because of the one-sided, often trivial and not very scientifically based orientation on specific aspects of children life, the subject of social studies currently lacks sufficient challenge for pupils at primary schools. Only little linkable knowledge seems to be conveyed in this crucial area of learning for life. To encourage the willingness and the ability to learn right from the beginning, social studies has to increase the linking of real-life and scientific questions and should be more challenging in terms of methods and content.

Quality criteria

Pedagogically and methodologically sound: allows for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests
Supports **teacher participation** and professional development: teachers are involved in designing or adapting the innovation to their own specific situation
Considers **developments in science education** and **science education research**: science education innovation is backed up by evidence in educational research and/or educational practice.

Innovation appraisal

- Access to the website shows strong interest in the project
- Feedback of teachers and pupils with positive learning outcomes, high motivation of pupils and teachers, increase in internal cooperation at school

Relevant information in brief

Topics addressed	"Hypersoil"–soil as an example for interdisciplinary teaching and learning (biology, social studies, geology and computer science)
Age classes	age 6-10; usable also for lower secondary education
Extent	-
Years of experimentation	Pilot phase: 2001-2002, ongoing improvement and additions to the collection of teaching and learning materials
Duration	broad offer of interdisciplinary teaching/learning units, 2h – 15h
Main innovation promoters	University of Muenster, professors, students and teachers
Main innovation partners	University of Muenster, University of Dortmund, UVM NRW (multimedia university network in a state of Germany)
Website	http://hypersoil.uni-muenster.de/index.html
Contact person	PD Dr. Gesine Hellberg-Rode, University of Muenster, Institute for Biology Education

Curriculum relevance and connection to policy guidelines

The project refers to current policy guidelines, requirements in learning theory and methodological requirements: linkable knowledge that allows a transfer to new situations (conceptual knowledge and practice knowledge); interactive learning culture for life-long learning (using new media and information /communication technologies); education for sustainable development (interdisciplinary knowledge, participatory learning and innovative structures)

It can be used in pre-service teacher training (university education as well as additional pre-service training) and in educational process (e.g. preparation of teaching units). The project aims for all (in-service and pre-service) teachers that are involved in social studies at primary schools and for biology teachers in lower secondary education.

Description of the innovative practice

Theoretical frameworks:

Guided by the directives for social studies (in North Rhine-Westphalia, a state of Germany) an Internet-based hypermedia environment is developed as an example for the life-and environmentally relevant field of "soil as a basis for life". The technical basis, methodological requirements and learning theory knowledge are integrated so that they are of use for teachers as well as students for interactive processes of knowledge organization. The aim is the design and construction of a tool that allows a sound planning and organization of relevant teaching processes using multimedia resources. Regarding methodological aspects "Hypersoil" offers structured and networked knowledge made applicable by local, regional and global references. The various tasks, experiments, activities and guiding information allow for an exemplification and transferability of knowledge.

Main aims, features and phases:

Why the focus on the subject of "soil":

- soil is an important livelihood for the people and is also an important habitat for a variety of organisms
- soil is a socially and ecologically highly interesting phenomenon, which has many elements for a multidisciplinary, problem-and action-processing in the school offers
- soil plays a central role in the environmental debate, especially in the context of sustainable development

The learning and working environment consists of **four modules** that are interconnected, and are supplemented by a glossary:

1. **soil information**: basic factual and scientific nature background information are offered, together with social and ecological information (differentiated according to different areas, e.g. soil characteristics, soil development, soil animals, soil protection, soil misuse).
2. **soil workshop**: here the soil tests and experiments can be used: a woodlouse and earthworm workshop, a workshop on "soil experience and understanding", profiles for a soil-animal register and other useful materials for the design of active-learning and diversified teaching experience.
3. **soil and education**: this component includes educational and methodological contexts, curriculum reference, an overview of the lessons and suggestions for the structuring of various teaching-units with different thematic focus.
4. **media & materials:** collection of sources of academic literature, methodological themes, teaching/lecturing series, children's books, brochures, videos, CDs and other materials and interesting links on the topic of "soil".

Methodology used:

- interdisciplinary approach: through intensive collaboration between scientists and practitioners from different areas it is possible to work on the topic of a hypermedia work environment from different perspectives and to take different aspects important for the daily life of children into account
- hands-on activities (indoor and outdoor), project-work, computer skills, collaborative work

Resources needed:

Internet access, learning and working environment (soil information, soil workshop, soil and education, media and materials) .

Information available

- short description (2 pages, German)
- learning and working environment (ca. 80 internet pages, German, most have to be translated)

Critical features for sustainability

- "Hypersoil" is an offer from the university of Muenster, it can be used within the framework of the normal school lessons and of regular lesson/unit planning, within pre- or in-service teacher training
- a direct use and the application of the offers at school depends on the readiness of schools/teachers
- for schools, there are no substantial costs besides using special literature, videos and CDs (buying or renting)
- for the set-up of the practice staff for coordination and IT is necessary
-

Critical features for transferability

- transferability within a country or within German-speaking countries, easy access and usability of the provided materials, free offer with access for everybody; the variety of materials give the possibility to adapt the method to state-specific curricula, flexible, supportive materials
- translation as well as the necessary set-up of a similar national web-portal could mean serious obstacles for implementation in non-German-speaking countries.

"Water"–research on the "wet" element

Keywords:
Primary school, webquest, multidisciplinary approach, social sciences, practical work

Problems addressed

- Lack of hands-on science in classrooms in primary education
- Multi-perspective approach of scientific topics and their reference to society is widely acknowledged but only rarely used in average schools/classrooms

Quality criteria/indicators addressed

Pedagogically and methodologically sound: allows for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests.
Fosters **scientific competencies:** includes practical work (hands-on activities, lab-work, experiments), offers inquiry based learning activities
Socially relevant: promotes public understanding of science, raises the awareness of social, ethical and cultural influence and implications of science and technology.

Innovation appraisal

- survey among selected schools and teachers in primary education, positive reactions about learning outcomes, usability, motivation of learners
- the number of visitors to the website shows strong interest in the project
- increasing use of the provided materials and WebQuest since 2008

Relevant information in brief

Topics addressed	Research on different perspectives towards water for a more responsible handling of the resource
Age classes	age 9-11
Extent	national, numbers of schools and pupils unknown (survey necessary)
Years of experimentation	Application of WebQuests since 2002; example practice "Water" since 2008
Duration	about 3 weeks according to existing knowledge of pupils
Main innovation promoters	different schools all over Germany
Main innovation partners	Research institutions and organizations (providing information about different themes and experiments), Goethe Universität Frankfurt am Main (Projekt Lehr@mt, project about media competence in pre-service teacher training)
Website	http://www.schulserver.hessen.de/frankfurt/friedrich-froebel/wqwasser_mai08/einleitung.html; http://www.naturwissenschaften-entdecken.de/webquest-wasser.php
Contact person	Alexandra Merkel

Curriculum relevance and connection to policy guidelines

- All of the topics taught are relevant to and part of the science curriculum for primary schools.

Description of the innovative practice

The WebQuest "Water" takes on a multi-perspective approach and tries to make the students aware of the diversity of water. The form of a Prima(r) WebQuest (basically a reduced version of a "classical" WebQuest, with simplified terms, sources and roles of the pupils) has shown efficient results for working with a WebQuest for primary students.

As part of the Prima(r) WebQuest "Water" pupils not only learn different perspectives on the element water, in the social studies/social sciences this information is also followed up and tested using simple experiments about water, extending and supporting the cognitive argument by practical action. Such experiences can be intensified with field trips to e.g. a water works, a sewage treatment plant or other outside-school learning sites, important for the major sub-themes.

In addition to the linked websites of the WebQuest a variety of book sources in the experimental boxes is available for all groups. All kinds of basic scientific literature as well as experimental and narrative texts and books about water are presented in order to open the perspective and to enable further research. Various task-sheets with "fill in the gap"-texts, unlabeled images etc. offer pupils the opportunity to review what they have learned.

Finally, all groups design and produce a poster relevant to the sub-themes, work on a presentation according to their theme and present it with different tools such as posters and selected experiments. Using self-created worksheets the classmate's increase in knowledge and understanding of their own presentations will be checked and evaluated.

Theoretical frameworks:
- working with a WebQuest / a Prima® WebQuest
- interdisciplinarity/multidisciplinarity

Main aims, features and phases:
Water is of particular importance in the daily life of children because of its daily presence. The project allows a view from many perspectives such as science, history, politics, art, religion, mythology and others. Water appears in all areas of life and generally is the basis of life. Therefore it is important to recognize this diversity and to perceive water as something special and valuable. The different views that can be taken on water mean that there is no possibility to give a short and concise definition for water regarding all perspectives. Therefore even primary school children should be offered a wide range of interpretations of the concept of water, so that they are able to form their own view on water. This requires a multidisciplinary approach making the diversity of the water part of the teaching content and process.

Learners should acquire a number of competencies in different categories.
General competence:
- e.g. expand their technical skills in dealing with the computer, their literacy, language skills and their expertise in the preparation and presentation of content in social studies by carrying out a WebQuest from the theme "water" in small independent groups,

Science competence:
- e.g. assess the contents of the text sources and refer them to their own behavior, preparing the most relevant content for a presentation; carry out experiments, evaluate them and bring them into a context of already gathered information on the relevant subject,

Media competence:
- e.g. learn how to access the WebQuest (the Internet) and from there other links, be able to navigate within a WebQuest,

Social competence:
- e.g. work cooperatively in small groups and structure learning processes together with other pupils, work critically and constructively with their own results and those of the other groups.

Methodology used:
- **Hands-on**: experiments along the learning process, experiment(s) during final presentation, outside school visits/exploration/experiments
- **Working in groups**: pupils work collaboratively in groups of two to five, groups prepare and give a presentation with shared responsibilities among the group members
- **Practice making a presentation**: the ability to make a presentation is an important skill throughout all levels of education. Presenting the results of an experiment to a group of peers allows pupils to practise this important skill.
- **Self-evaluation:** pupils check the contents of their own presentations by using a self-created spreadsheet to evaluate the increase in the audience's knowledge

Resources needed:

- sufficient number of computer working places, Internet access, presentation hardware, various media like boards, posters, experimentation materials etc.
- possibilities for outside-school field trips

Form of assessment / evaluation used:

- internal reviews, task sheets
- self-created worksheets (by pupils) to check learning outcomes of classmates

Information available

- WebQuest "Water" (in German, multi-page website)
- collection of task sheets (in German, 5-15 pages)
- description of experiments (in German, at least 10 pages)
- evaluation materials pupils and teachers (in German, 5-10 pages)

Critical features for sustainability

- the innovative practice has been tested and evaluated by research institutions and teacher training institutions
- requires acceptance and cooperation within the school environment (long duration, effects on other school subjects etc.)
- "normal" infrastructure needed, provided by most schools, no substantial funds needed

Critical features for transferability

- easy access and usability of the provided information and materials for setting up a similar practice (if German materials can be used)
- translation of necessary materials for any other language: WebQuest "Water", collection of task sheets, description of experiments and evaluation materials for pupils
- setting up a similar WebQuest in a different language, adapting content and tasks to the local situation.

Modelling of invisibles structures

Keywords:
Pre-primary/primary school, matter complex structures, invisible structures, argumentation, modelling.

Problems addressed

Science education often asks children to observe phenomena but seldom challenges them to propose their own interpretations, and the process of 'explanation' and of 'argumentation based on evidence' is neglected in many educational practices. However to explain observable processes using invisible entities (such as cells, atoms, molecules, forces, energies,…) is a normal praxis in science and we cannot suppose that children could understand complex phenomena (as the digestive process or the photosynthesis) without having developed the capacity to imagine invisible structures and relations. Asking children to build models of what 'could happen inside' requires good teacher competence and the ability to progressively adjust fanciful models to real characteristics. But in this way children start to appreciate the modelling processes and avoid mistaking for reality what are only 'scientific' interpretations of complex phenomena.

Quality criteria

Scientifically sound: provides insight in the way scientific knowledge is constructed, asking for an appreciation of the modelling process
Fosters **scientific competencies:** offers inquiry based learning activities and stimulates argumentation and critical thinking, seeking for causal relations between observations and interpretations.
Considers **developments in science education** and **science education research:** the innovation is baked by, and contributes to, research on science education and on constructivism.

Innovation appraisal

The innovation has been carried out and developed in many schools in Italy and abroad. A portfolio of the work done by children and the recording of their discussions allows us to follow the development of children reasoning and of their cognitive abilities. The innovation has been published in International Science Education Journal and in International Science Education books.

Relevant information in brief

Topics addressed	Structure of matter: modelling of 'invisible structures' in order to explain visible phenomena.
Age classes	Pre-primary/primary/lower secondary at different levels of understanding
Extent	National: many classes and schools in different Italian regions
Years of experimentation	First experimental classes started in the '80 in Turin (project coordinated by the Turin Municipality) and have been followed by teachers training in other regions.
Duration	The school year
Main innovation promoters	Science experts and school teachers.
Main innovation partners	Italian Ministry for the University and Research – 2002/2007
Website	
Contact person	Maria Arcà, mar.arca@gmail.com Paolo Mazzoli, paolomazzoli@fastwebnet.it

Curriculum relevance and connection to policy guidelines

The innovation is part of the Italian compulsory curriculum as far as the importance for students to master their own cognitive competences is concerned. To understand and explain scientifically phenomena and facts is part of TIMMS and PISA international recommendations. All the issues explored by the children are part of the basic curriculum.

Description of the innovative practice

The innovation fosters children's research of consistent interpretations of the observed phenomena, their construction of explanatory models, and the continuous and systematic comparison between diverse models and interpretations. From pre-primary schools children could understand that 'making science' should not be limited to 'descriptions' of what has been observed, and that the process of 'explanation' and of 'argumentation based on evidence' is a relevant tool to develop scientific knowledge, often neglected in educational practices. The innovation invites students to seek for common visions and models that could explain what they are experiencing, and to propose new experiments and observations in order to check their interpretations and validate their models.

Theoretical frameworks:

Modelling is considered a key process in supporting children in scientific knowledge construction (Duschl & Erduran, 1996;Lehrer & Schauble, 2005; etc.). The basic hypotheses refer to constructivism and to a conception of science education where students have to be confronted with the dynamic, and the unexpected outcomes, of a real lab inquiry. The focus is on the comparison of ideas and on evidence based argumentations (not a brainstorming!), on the imagination needed for building models and on the research of 'counterexamples' where the models don't work.

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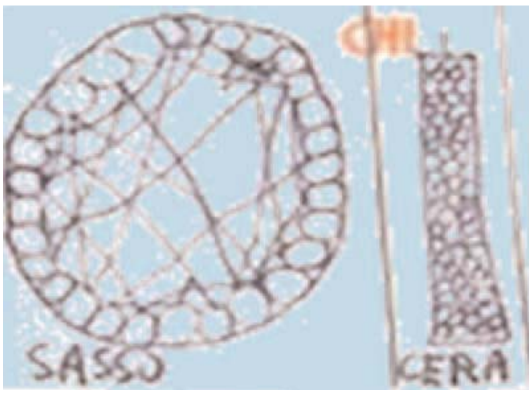
Main aims, features and phases:

One of the aims of this method is to develop, together with scientific reasoning competences, also linguistic competences – as the use of an appropriate language is essential to express questions related to facts, to imagine the consequences of possible actions, to develop cognitive abilities, mainly the ones of the 'causal' category, connecting visible facts with their invisible causes or effects. Another main aim is to explore together with children the limits of 'usual books explanations' , working on questions and on limits of the explanations (for instance, '*could we understand how toes grow using what we know about the digestive mechanism?*'). With the evolution of the proposed models, the quality of questions improve, together with the ability to use examples, metaphors, and analogies, also using 'mime' and 'drama' techniques, in order to represent the invisible processes that shape the visible phenomena.
As an example, working with water and the 'micro-structure of water' the teacher asks: '*Water is like… what? How can we imagine…. the water into a glass of water? the water composed by drops of water…, the surface of a drop of water, the inside of a drop of water (the water into a drop of water), the structure of a drop of water, the smallest particles of water into the drop,... '* The models built should explain the book statement 'liquids assume the form of the container' imagining invisible particles and invisible bonds, and the differences in bonds (or in particles) between liquids, solids, gas ...

Methodology used:

The activities start from a concrete situation – to make meat-balls, to look to the consistency of materials as powders, foams, emulsions..., to reasoning about what happens when we blend or cook things,... - . Pupils are invited to produce graphical models of the observed facts, with the explicit request "to imagine and to represent" what may happen at the invisible level.
Their ideas were collected and used to explain aspects of new and different realities.



In the left picture children linked together trying to simulate the hardness of a stone and the softness of beeswax. On the right, one of the many models they proposed for the different bonds in stones and in wax.

In a class group session children explain to their peers the graphic models they have formulated individually or in small groups. This social activity contributes to the ideas' circulation and is really useful in modifying and developing individual thinking.

Resources needed:

Teachers open to inquiry are the main resources needed, together with experts able to interpret, on the basis of their deeper knowledge, the children's attempts at explanation. A lot of 'rescued/recycled' material could be used together with minimal science lab resources such as containers, balances, heaters ….

Form of assessment/evaluation used:

Children are continuously asked to justify and to explain their thoughts and the main collective discussions are recorded in order to formative assess the thinking progress. For these children the usual text items are relatively easy.

Information available

The activities has been described in International articles and in an Italian book:

A. Acher , M. Arca, N. Sanmarti (2007) Modeling as a Teaching Learning Process for Understanding. Materials: A Case Study in Primary Education, *Science Education*, pp. 398-418;

A. Acher & M. Arcà (2006), Children's representations in modeling scientific knowledge construction, in C. Andersen, N. Scheuer, M. P. Pérez Echeverría, E. Teubal (Eds.), *Representational Systems and Practices as Learning Tools in Different Fields of Knowledge,* Sense Publishers;

E. De Giorgi, M. Arcà, L. Bassino (2006) *Dentro la materia. Una storia di atomi, molecole, particelle*, (*Inside matter. A story of atoms, molecules, particles*) Scuola Facendo Tascabili, Carocci Editore.

They are not recipes but a well established methodology. Presentations with a synthesis of the ideas and pictures of the children's products are available in English. Example of activities and questions could be found (in Italian) on the webpage www.carocci.it, and can be downloaded free of charge (you need to register for log in). The minimum overview of the innovation methodology to be translated, with practical suggestions for teachers, is 16 pages.

Critical features for sustainability

The innovative practice has been carried out with children of very different abilities and background, with average but willing teachers, not only in Italy but also in Spain and in Argentina. This working habit in some case has been extended by the teachers also to subjects others than science.

Critical features for transferability

The difficulty is to start and to convince teachers that is worth accepting the models proposed by children instead of the 'real scientific truth' , as it is presented by school books, and to convince children that their own words have more value than the 'stereotypical statements' they are accustomed to memorize. Once these initial difficulties have been overcome, teachers and children recover their autonomy and value very positively the mental and experimental inquiry ethos that has been developed.

Teachers' support and training is vital in order to help teachers to understand that the initial 'waste of time' will be compensated by the interest of children and by the accelerated learning that will follow.

As far as tools and material resources are concerned what is important is the willingness to exploit the concrete opportunities, to build problematic situations (not necessarily experimental situations), to use simple and real life materials as tools to represent, model, argue, connect, the concrete facts that occur in the class with what children think and understand.

From complex to simple systems, and backwards

Keywords:
Primary school, system thinking, urban environment, body system, school garden

Problems addressed

The innovation is an attempt to reverse the common practice of presenting in primary school simple, and simplified, biological systems where few elements, and few relations between elements, are relevant. Instead, it proposes addressing the idea of complex systems as early as possible, starting with systems that are complex but very familiar to children: the living area where the school is located. This approach address also the problem of the relatively low attention to the cognitive component of environmental learning that frequently characterizes the activities in this area[1]

Quality Criteria

Fosters **scientific competencies:** offers inquiry based learning activities, stimulates argumentation and complex systemic thinking.
Supports **teacher participation** and **professional development:** teachers are involved in designing or adapting the innovation to their own specific situation **.**
Considers **developments in science education** and **science education research:** the innovation is baked by, and contributes to, research on science education.

Innovation appraisal

Students' learning was evaluated by analysing their production, audio-taped class and group discussions, questionnaires submitted at the beginning and at the end of the school years. The appraisal of the outcomes of the project was also done: a) with the involved teachers at the end of the project and few months afterwards with a semi-structured interview to be reported in a published book, b) with the Head of the school, c) with the partners of the European Project.

Relevant information in brief

Topics addressed	School neighbourhoods exploration as starting point for a systemic approach
Age classes	9-10 year of age - 4th,5th grade
Extent	Local, 3 full classes involved. The project was carried on within the "Computer-supported Collaborative Learning Networks" European Project
Years of experimentation	2 years
Duration	About 30-40 hours for year
Main innovation promoters	European Commission/research institutes/ school institute and teachers
Main innovation partners	ISTC-CNR, Research institute
Website	
Contact person	Silvia Caravita, s.caravita@istc.cnr.it

Curriculum relevance and connection to policy guidelines

National Indications for Primary and Lower Secondary School mention the importance of promoting the construction of a systemic and dynamical approach for the interpretation of the environment and of supporting multidisciplinarity in environmental education.

Description of the innovative practice

The project was based on the assumption that the concept of ecosystem is distant from children's thinking because they have little direct experience of "natural environments", and little knowledge about the many relationships inter-linking their components. On the other hand, they have everyday experience (though tacit knowledge) of their urban neighbourhood and how they and their families are related with it in many

respects. The concept of system might be therefore more easily achieved if students are asked to confront, to re-elaborate and re-organize their knowledge about their own urban environment.
The hypothesis was that conceptualization about 'systems' should progress along the school grades, starting with an 'holistic' pre-scientific but complex view of the system and developing analytical capacity in view of achieving a refined cognitive representation of the complexity. Building models and looking for simpler situations where the models could be applied is an important component of our pedagogical strategy.
The classes of the schools involved were located in 2 different urban systems: one in a newly built area of Rome, the other one in an area near the city Centre of Bari (a town on the seaside). 2 teachers for each class have been involved on a regular basis (the teachers volunteered to participate in the project and got some credits for their in service-education activities); external researchers participated in class discussion; experts and stake holders have been interviewed by children.

Theoretical frameworks: The proposal originated from a team of researchers of the Institute of Cognitive Sciences and Technologies of CNR, who was the Italian partner in an European Project. The chosen perspective was the socio constructivist one, aiming to build a 'community of learners', proposing problem-based learning, and participative methodologies. System thinking theories were also taken into account as well as education for citizenship.

Main aims, features and phases The overarching aims were: to build self-confidence as science learners and to feel responsibility for the ways of living in environments and for using the resources that they afford.
The aims of the project during two school years were: a) to foster the development of scientific thinking and of methods for the description of the environment and for its interpretation as the resultant of many ever changing processes, involving components, structures, rules, resources, etc. ; b) to make students aware of the mechanism of decisions (where to go, how to get in contact with responsible of decisions, procedures that are usually followed) in the field of environmental design and management, starting from the school itself; c) to lead the students to conceptualize their own body as a living system.
The social and natural environment were consequently investigated in parallel and the specific aims were: to be able to identify appropriate descriptions, to find out criteria and categories of interpretation, and to model familiar phenomena. The competencies acquired where then transferred and applied to the understanding of the functioning of the human body (or of the garden around the school) facilitating the comprehension of body as organism, on one side, and deepening the interpretation of environment as ecosystem, on the other side.

In the first phase the proposed activities were the observation and description of the urban area around the school asking for the identification of the main characteristic elements of a 'system'. The attention was called on "change", on the dynamical aspects that shape the functioning of an environment, in order to go beyond the static description of the components and to stimulate systemic thinking. Different activities were proposed in order to trigger questions and inquiries about the relations between components, about the constraints, about the rules that have to be followed by the single components and by the system as a whole in order to survive.

Children's conceptualization evolved from the idea of environment as a spatial entity to a more abstract idea of setting including and structured by interrelated heterogeneous elements, which do not belong only to the category of concrete objects. Children were able to think relationships connecting physical and cultural aspects, structural and functional components, individual and social elements in the private and public sphere of life. They also became aware that multiple descriptions of the same environment are possible and legitimate.
The term "*intreccio*" (intertwined elements) made a bridge-concept preceding that of system and was easily transferred to the description of the human body. At the end of the fifth grade, during a collaborative activity between the two school classes, the following key-words were written on the board and justified with arguments as good descriptors of the knowledge covered by the overall project: relations, transformations, system, rules, links, cycle, equilibrium, exploration.
Sense of belongingness to an organized community, attention for the quality of the environment and willingness to improve it appeared as other acquisitions.

Methodology used:

- In class activity: grounding the development of the activities on the knowledge children have, on their experiential and cognitive resources; supporting them in the identification of the problem, the planning of the inquiry, the choice of the methodology and tools adequate for the target of the inquiry; giving opportunities for the emergence of diversity among findings, ideas, representations through the differentiation of tasks, group work, class discussion, use of symbolic languages; creating opportunities for transfer across knowledge domains.
- Inter-class activity: exchanges among classes in the same school who addressed the same general theme (i.e., urban environment) and pursued the same goal (i.e., to understand the "functioning" of the environment where we live) but who followed different lines of inquiry.
- Network activity: communicating with students of schools located in different urban environments and with students of different age.

Resources needed: 2 teachers for each class have been involved on a regular basis; external researchers participated in class discussion; experts and stake holders have been interviewed by children. The collaboration by the Head of the school and colleagues for flexibility in the time schedule, for supporting outdoor activities has been essential. At least one computer with ADSL line for making the sharing of written documents and communication among students a regular practice is needed

Form of assessment/evaluation used: Formative evaluation: Students' products and transcripts of audio-registered class discussions were the objects of constant analysis and reflection in the group of teachers and researchers. Students and class assessment tasks were also designed.

Information available

The innovation ask to teachers a great capability of understanding children's ideas (often hidden in their discourses), and of transforming their intuitions into problems and methodology of inquiry. This capability cannot be transformed into simple rules to follow, nevertheless descriptions of the many activities – and examples of children products – are available as well as evaluation tasks. The necessary information (about 30 pages + drawing and photos) can be retrieved and re-organized for a translation in 2010.

Critical features for sustainability

The innovative practice has been implemented in regular classroom with experienced and passionate teachers. It was part of regular class work. Communication between classes and schools in different towns or in different countries is not compulsory but give an added value and facilitate the development of the system concept.

Critical features for transferability

The success of innovation was mainly due to:

- the interest of the team of teachers in the project, receiving support from the Head of the school and having the possibility to collaborate with and trust researchers.
- the possibility of outdoors activities in the area around the school.

The communication between students living in different urban environments was an effective tool to help the children to look at things with other eyes, to enrich their observations and comments, to make them aware of differences and commonalities among life contexts.

[1](M. Rickinson, C. Lundholm, N. Hopwood - Environmental learning. Springer, 2009)

Educational Program in Biodiversity Conservation of the Caribbean Sea

Keywords:
Primary education, environmental education, biodiversity, decision making, cultural approach.

Problems addressed

Loss of biodiversity in one of the most biologically diverse region of the world: the Caribbean Sea.
Importance of educating the population about their own roles in protecting and conserving biodiversity in the world. Need to change peoples' behaviour related to environmental protection and responsible consumption.

Quality criteria

Pedagogically and **methodologically** sound: allows for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests. Takes gender- and (multi)cultural issues into account. Motivation / interest in science is stimulated.
Fosters **scientific competencies**: Stimulates argumentation and critical thinking. Includes decision-making activities.
Socially relevant: Raises the awareness of social, ethical and cultural influence and implications of science and technology. Addresses national problems in science education. Promotes actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues.

Innovation appraisal

Evaluation has not been performed, however, the innovation has been presented in local, national and international forums and exhibitions. This program is a reference in environmental education at the Caribbean Sea. Materials have been published in several languages (Spanish, English and French).

Relevant information in brief

Topics addressed	The Caribbean Sea. The specie *Strombus gigas*, Queen Conch, as a paradigmatic example. The sustainable use of resources.
Age Classes	7-12 years old.
Extent	International: conferences, trainings and exhibitions have been performed for teachers and / or Environmental educators and park rangers in Colombia, Venezuela, French Antilles, Puerto Caribbean, Brazil and Chile.
Years of experimentations	7 years.
Duration	12 hours of teacher training, 12 sessions of two hours with students.
Main innovation promoters	SEP, CONACYT, AMC, private companies such as "Xel Ha" and "Xcaret", Archipel des Sciences of French Antillas, Guadalupe Island.
Main innovation partners	Xel Ha and Xcaret, Archipel des Sciences, Mutec, Universum museum, Mexico City's Subway.
Website	http://mda.cinvestav.mx/biblioteca/strombus/
Contact person	Dalila Aldana Aranda, daladana@mda.cinvestav.mx

Curriculum relevance and connection to policy guidelines

This innovation is not integrated to the official curriculum, but it contains issues related to environmental education as one of the cross curricular themes. The innovation is part of projects with the Caribbean Fisheries Management Council, National Council of Science and Technology CONACYT, the Mexican Academy of Sciences AMC, companies Xel Ha, Xcarert and Archipel des Sciences.

Description of the innovative practice

Theoretical frame:

Learning based on solving problems; the program provides basic information to students, puts them in a problematic scenario and lets them work on the solution as a team. The themes are addressed through collaborative work and through games.

Main aims, features and phases

Aim: Raise awareness among teachers, children and the general public on natural resources conservation and use of sustainable environmental practices by using materials that have been designed in this program.
Maintain a training program for teachers and environmental educators, giving them information so that they can promote good environmental practices among their students, and the students can understand the importance of protecting and conserving biodiversity across the world and can argue and make reasoned decisions.
The innovation is based on a training program for teachers and environmental educators. Teachers participate in the workshop and carry out the activities. It is expected that trained teachers develop the activities with their students.

Activities

The innovation has three major phases: first, primary school teachers training; second, work with students on classroom; third, this mean using books, DVDs and CDs, or producing new ones? (books, DVD, CD, etc.).

The first phase: Teachers attend two workshops of six hours each. These workshops consist of 12 activities that can be implemented in a regular classroom by teachers. Teachers participating in the training sign a letter of intent confirming their agreement to carry out activities in their classroom.

The second phase: Each activity with students begins with a presentation about endangered species, why is important to preserve them, their biological characteristics, etc. Then, students play a game related to the topics covered in the initial talk. The teacher concludes proposing a problem and the students have to argue and decide actions to protect the species or ecosystem. An example of a game for one activity is a "lottery". In "biodiversity Lottery" game, there are several playing cards with different images related to one of the following issues: ecological value of species, issues related to conservation, biotechnology, solutions for conservation or fishing regulations. Participants play with different boards and they become more familiar with the topic of each board. The local consumption of shells of endangered species to use as decoration is an example of proposed problem. The students analyze the situation and propose alternative solutions.

The third phase: In this innovation there are some materials to work with the Queen Conch *Strombus gigas* (these materials are in French, English and Spanish). One of the aims of the innovation is the production of materials for each region. The materials consist of books, games, DVD and informative pamphlets. In the preparation of the material teachers, researchers of environmental science and of science education are involved.

Resources needed:

PowerPoint presentation about endangered species to support explanations**.** Printed games material.

Information available

Books for teens about Queen Conch are available in Spanish, French and English. Also there is a book available in Braille and a book available in Maya.
Cd with all information about *Strombus gigas*, Queen Conch, is available in English, French and Spanish.
Photographs of some activities are available.
Books in the Web page: http://mda.cinvestav.mx/biblioteca/strombus/

Critical features for sustainability

The innovation has developed over several years in regular classes and in culturally diverse classes. It is not part of regular school courses, so is taken as an extracurricular activity.

Critical features for transferability

The innovation has been created to meet local needs in environmental education, incorporating cultural activities in southeast Mexico. However, the innovation has been taken as a model and adapted in other regions and countries. Adapting the innovation requires the development of *ad hoc* material for activities related to endangered species of each locality and the introduction of the views of local cultures/communities.

Science Workshops for Visually-Impaired Children

Keywords:
Science workshops, visually-impaired students, special education, communities of learners, REC-Research and Education Collaboration.

Problems addressed

Science is not addressed within the current special education programs of Mexico´s Education Secretary; partly because there are no available resources that effectively serve to teach science to visually-impaired students. In particular, the problem is more acute when trying to convey topics such as microscopic structures and organization of cells, virus, fungi and similar biology topics, or visual phenomena such as light.

Quality criteria

Pedagogically and **methodologically** sound: Allow for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests. Include all pupils, including those with special educational and physical needs. Motivation / interest in science is stimulated.
Fosters **scientific competences**: Include practical work (hands on activities, lab work, experiments etc). Stimulate collaborative work.
Socially relevant: Promote changes or improvements in educational contexts. Use resources and teaching contexts from outside the school.

Innovation appraisal

The 3D materials in science method was used for several topics, mainly biology. The workshops have been offered in schools and institutes for the blind in 5 states of México (Guanajuato, Nuevo León, Michoacán, DF and Jalisco). Cinvestav have been appointed by the Education State Secretary in Guanajuato and Nuevo León to train their teachers on the method. Feedback obtained from interviews with users of the products is highly positive. Both method and materials have been successfully used for regular-vision children too.
We currently hold 8 patents, 7 in México on 3D materials and 1 provisional patent in the US on the method and materials.

Relevant information in brief

Topics addressed	Science teaching to visually-impaired students
Age classes	Elementary education, 4th to 9th grade, 9 -15 year-olds
Extent	National (currently), workshops have been offered in several cities on five states of Mexico
Years of experimentation	4 years
Duration	2 months for production of 3D models, 3 months working with group (3 times a week, 45 minutes each session)
Main innovation promoters	Secretaría de Educación del Estado de Guanajuato, Secretaría de Desarrollo Económico del Estado de Guanajuato, Consejo de Ciencia del Estado de Guanajuato (CONCYTEG), Schools and institutes for the blind, Museums, Stanford Research Institute (SRI)
Main innovation partners	CINVESTAV, UNAM, Gobierno del Estado de Guanajuato
Website	www.sientelaciencia.com
Contact person	Dr. Cristina G. Reynaga Peña, CINVESTAV Unidad Irapuato cristyreynaga@yahoo.com

Curriculum relevance and connection to policy guidelines

The program started as a special project for non-formal learning, its success is leading it to be acquired by formal education institutions, given also that most of the science topics are part of the current curriculum.

Description of the innovative practice

Theoretical frameworks: Constructivist perspective, Communities of learners.

Main aims, features and phases:

Aims:

1. Allows inclusion of visually-impaired children in science activities together with regular-vision kids.
2. Teachers have a hold of didactic materials suitable for all children.

Features**:** To plan and build the 3D-models, there was a call to university students of science and design. The students work in groups with at least one student of science and one student of design. The students made 3d prototypes of the topic, for example cell or fungi models. There was a competition and the best prototypes useful for visual-impaired students were chosen.
The university students, the teachers, researches and class students participate in class activities using the prototypes and making experiments, forming a community of learners. At the same time the university students become aware of students with different abilities.
The experiments were designed to be accessible to the visual-impaired students, for example, in the fungi topic the students made bread. They put the bread dough (with yeast) in a bottle and use a balloon in the top of this bottle, then they may feel that the balloon is inflated because the gas produced by the yeast.

Methodology used: Hands-on science workshops containing a combination of experiments and activities related to a specific science topic that can be observed without sight, in addition to comprehensive explanations on specific concepts supported with the use of three-dimensional models.

Resources needed: They are designed to take place in regular classrooms or outreach activities. When visually-impaired children are to be taught, we suggest a one-to-one work with teachers or other student not visual-impaired to guide the use of 3D materials.

Form of assessment/evaluation used: Qualitative assessment was made to recognize the improvement of motivation to science.

Information available

We have instructional DVDs showing how science activities can be performed and written instructions for the use of 3D models are currently in preparation. Both are in Spanish.

Critical features for sustainability

The DVD with experiments and activities has been recently piloted in rural schools for regular vision children of the State Education System with great success. Cinvestav is finding the venue to reproduce the 3D models since we hold only one piece of each. It is necessary have some money to support the making of prototypes (3D models) by university students (20 to 50 dollars each).

Critical features for transferability

The products were created to be Universal, inclusive and educational in all senses.
For the elaboration of the prototypes it is necessary to involve students both of science and design careers. In this project the students made the prototypes as a final project in one subject, and the university teacher evaluated part of the subject using the 3D models produced by the students. For transferability it is important to motivate the universities to participate in the project.

Science in family

Keywords:
Primary school, collaborative work, science for everyone, family development.

Problems addressed

The role of the local community and family are poor in the development of a positive student attitude to science. The family do not contribute to the development of the educational system objectives, like developing interest on science.

In the world-wide forum on education DAKAR 2000 México acquired the commitment to extend and improve the education of younger children. In order to create a new educative culture parents must be involved, motivated and supported with continuous participation in the student's formative task. Direct actions oriented to adults that interact with children would increase the integral development of the children and their families. Furthermore, this proposal tries to give an answer to the basic learning needs emphasized by UNESCO that include learning to know, to do, to coexist, and to be a key to education for peace and tolerance.

Quality criteria

Pedagogically and **methodologically** sound: motivation / interest in science is stimulated.
Fosters **scientific competences**: include practical work (hands on activities, lab work, experiments etc). Stimulate collaborative work. Fosters scientific literacy (identify scientific issues, explain phenomena scientifically, use scientific evidence).
Socially relevant: address national problems in science education, promote public understanding of science. Use resources and teaching contexts from outside the school.

Innovation appraisal

The innovation was evaluated by two questionnaires submitted at the end of the second application, one of them for parents and the other one for teachers. The first one was given to a sample composed of 1710 families.
The sample of parents represented 49% of the participants in the program, with 70% of the families participating for the first time. Their opinion about the presentation of the contents and design of the pamphlet was surveyed. With respect to the understanding of the base text explaining the subject in each pamphlet, 89% considered it easy or relatively easy, and for almost all (96%) the design of the presentation was pleasant.

Relevant information in short

Topics addressed	Topics related to physics, chemistry and biology
Age classes	9 to 12 years old, primary school
Extent	Local 5017 students, 59 schools, 290 teachers
Years of experimentation	7 years (Science 2004)
Duration	In class, 6 classes of one hour per month. In home one experiment per month (during 6 months). The experiments at home can take only one hour to several days (if the family have to see a slow process like decomposition of bread).
Main innovation promoters	State government educational authorities
Main innovation partners	Universities/Ministry of education/
Website	http://ciencia.comitenorte.org.mx/
Contact person	Adriana Elizondo, adriana_elizondo@yahoo.com

Curriculum relevance and connection to policy guidelines

The subjects that are treated in the experiments are part of the official curriculum contents. These home-made experiments do not replace the teaching of the subjects in class, because not all the students of a class participate in the project, but only those with parents made a commitment to work at home with their children.

Description of the innovative practice

Theoretical frame: Collaborative learning. The proposal is to set a problem that encourages a family to do an experiment and to solve it as a team. Each member contributes with different knowledge. In many occasions children explain the experimentation processes to their parents, giving value to the knowledge acquired at school. Collaboration and communication at home are enhanced.

Main aims, features and phases:

The aim for this innovation was to do experiments at home with easily available materials, to involve all the family and make them talk about science. First of all there is a meeting at school, and there is an invitation to the families to participate to the program. An adult member and the child must make a commitment to participate so the family may enter the program. One experiment per month is carried out for 6 months. A pamphlet is offered to the families which explains the problem and the experiment (includes the sections: Intention, what, investigates, we work together, what you learned and remember).

For example one experiment is a hand-made chromatograph used to explain some ideas related to photosynthesis: the family put some spinach leaves in alcohol and then crushed the leaves, then filter the liquid using a coffee filter. They cut strips of coffee filter and taped to a pencil and placed in a glass containing the liquid obtained from the leaves. They have to wait for 30 minutes. The filter paper strips are colored with spots that indicate the different pigments from spinach. The members of the family have to identified the pigments and relate the results whit ideas about photosynthesis in plants.

Another experiment is a "dropper" or a home-made pluviometer (device for measuring rainfall), used to investigate some ideas related to the water cycle. The family has to make a pluviometer with a glass bottle of ½ litres and a funnel. With a rule they made a scale in the glass bottle. Then they have to put the pluviometer in the rain for one hour, then register the amount of water in the glass bottle and then, using a simple formula, they must calculate the amount (in millimeters) of water that fell rain.

At the same time the children have a special logbook where the family write the results of the experiments and place evidences of the collaborative work carried out at home. The professor reviews the logbook once a month and gives feedback.

Methodology used: Experimental work is done at home with accessible home products (Glass bottles, pencil, bread, coffee filters, etc.).

Resources needed: A collaboration of at least one adult member of the family is required. The teacher's role will be: to follow, to give feedback, and give support for the families on the comprehension of outcomes and activities. Pamphlets (four sheets) with the description of the activity and a logbook to write and to discuss the results at home are required.

Form of assessment / evaluation used:

A logbook where the results and discussions are reported is used (all family members write on the logbook) for a formative evaluation. The formative evaluation is done by the teacher and the pedagogy advisor that support teachers. The teachers check if the family makes hypothesis, how they organizes procedures and results; teachers check also if the family presents illustrations or drawings to improve the understanding of their work, if they answer to the questions and analyze the information that they look for and make conclusions. The teachers also look for evidence of the active participation of the different members of the family.

Only the best works (300-400) are evaluated for second time by researchers group, they select 150 works that win educative toys in the closing ceremony where all participant families are invited.

Information available

There are pamphlets describing the experiments that can be done at home: available in Spanish. Each pamphlet has 4 sheets with illustrations and contains only one experiment (the pamphlets have some open questions for the family, but the central part is the description of the experiment to reproduce in home). 6 experiments have to be done, one every month.

There is access to the student's logbooks.

Critical features for sustainability

This innovation has been applied in regular subjects in primary schools and it has been sustainable for 7 years. It uses resources and advantages that formal education (continuity, structure), but also the informal education (free participation, qualitative participant evaluation).

Critical features for transferability

It is required to interest the parents to collaborate in a meeting that is carried out with them at the beginning of the scholastic year and then in the innovation. The teacher has to follow the activities and give support to the families in the understanding of the experiments and the results. The innovation is sufficiently flexible to adapt to other countries.

Concept-context approach in science

Keywords:
Primary school, science in every day life, concept content approach, procedural knowledge, applied knowledge

Problems addressed

The concept-context approach tries to face the problem of pupils being dissatisfied with the traditional ways of learning concepts in science. The approach is meant to deal with the problem of disintegration and fragmentary nature of science education.
The most important aim is to let pupils acquire knowledge and understanding of some important science concepts that relate to everyday life and their daily experiences. These experiences are culturally determined. Pupils acquire an understanding how science concepts relate to each other and to daily contexts and they learn to apply science concepts in other real life situations thus making science more interesting for pupils.

Quality criteria

Pedagogically end methodologically sound: Motivation / interest in science is stimulated
Socially relevant: promotes public understanding of science through a selection of real life and nearby experiences to learn and apply science concepts;
Fosters scientific competencies: especially those to do with scientific literacy (identifying problems, exploring, making a design, making a prototype, testing and evaluating, presenting results, reflecting on the results).

Innovation appraisal

The exemplary teaching materials are being tested in four schools. These first experiences lead to the conclusion that pupils are enthusiastic about this kind of learning by inquiry and design.

Relevant information in brief

Topics addressed	Science concepts such as (living) plants, sound, light and animals in contexts that are relevant for pupils. Three categories of contexts: daily life, profession, science.
Age classes	4 - 12 (year 1-8 in primary schools)
Extent	Initiated by the ministry of education; not yet broadly accepted or used; four schools are testing the exemplary teaching materials; this is monitored
Years of experimentation	2
Duration	To conduct the complete pilot 2 full years are necessary. However, for the purpose of the KIS project, we have chosen one module of five or six lessons to illustrate the essential ingredients of the programme on the topic of 'Floating and Sinking'.
Main innovation promoters	Ministry of Education; NIBI, Netherlands Institute for Bioscience; SLO, Netherlands Institute for Curriculum Development
Main innovation partners	- several primary schools - organisations for environmental education (NME)
Website	SLO - http://www.slo.nl/primair/leergebieden/wereldorientatie/natuur/ NIBI - http://www.nibi.nl/ CVBO- http://www.nibi.nl/nibidvd/Pagina's/Het%20nieuwe%20examenprogramma/De%20concept-context%20benadering.html
Contact person	Dr Marja van Graft m.vangraft@slo.nl

Curriculum relevance and connection to policy guidelines

The concept context approach is not yet part of the compulsory curriculum.
In several new exam syllabuses for subjects in secondary education (age 16-18) the approach is used in both the design process of the curriculum as well as in developing learning materials. For these subjects the concept context approach is leading in the selection of relevant concepts and contexts. This is the case in chemistry, physics and biology, but also in economics and social studies.

Description of the innovative practice

To fully implement the concept context approach as part of a longitudinal curriculum (for primary and secondary education) will take at least five years. It is important that a substantial number of schools and teachers are willing to apply the materials and textbook authors adopt the approach.
Based on the framework, aims and features, pedagogical approaches and assessment practice outlined below, the innovative practice is illustrated by the module on *Floating and Sinking*. In this module (for grades 3 and 4, first and second class of primary education) students (in groups of two) explore the idea of sinking and floating and make a list of objects which float and those that sink. Some of the objects can float *and* sink, e.g. a Lego building block. At the end of lesson 2 students are given a ball of plasticine (kind of putty) which sinks, to mould it in such a way that it will float. In lesson 3 the classroom is changed into a shipyard. Various materials are present for students to use in completing the task of building a small boat (max 20 cm length by 10 cm wide) so that it can hold as much glass marbles as possible. Students in groups will first make a paper design; these are discussed in a plenary session. In lesson 4 students will be busy using their designs to build the actual boat, lesson 5 is used to test the boat with the marbles and possible adjustments will be made, if the design does not fit the requirements. The boats are exhibited to a larger audience, e.g in an exhibition in the school hall. In this way a complete cycle of design, building, testing, adjusting and reporting is achieved.

Theoretical frameworks:

- inquiry based science
- problem based learning (design technology)
- constructivist perspective
- scientific educational frame: the innovative practice is developed to connect to 'regular' science subjects: physical geography, biology, physics, chemistry, design and technology, and covers topics such as such as soil, river, health, species, food, energy, temperature, material.

Main aims, features and phases:

An overall aim is to reduce the disintegration and fragmentary nature of science education. Another aim is to enable pupils to consider a career in vocational training or professional education in science.
The concept context approach brings pupils into contact with the relevant concepts in the world of science. For pupils this approach creates a learning environment in which science concepts are learned in a natural way by applying them in real life and recognisable experiences. The contexts can be divided in three categories: real life contexts (such as sport, holiday), work contexts (such as the work of doctors, firefighters, nurses) and scientific contexts that are relevant for pupils (such as research about influenza).

Methodology used (including for the Floating and Sinking activity):

Inquiry based learning, as well as outdoor/indoor education, project work, group work, lab work. Usually traditional classroom settings. Each lesson starts with a plenary session, after which the students work in groups of 4 or in groups of 2, depending on the task at hand. Students write the results in their logbooks, individually.

Resources needed:

All commonly available materials.
For the Floating and Sinking activity specifically: various objects in different shapes, mass, and made of different materials: milk cartons, cork, wooden blocks, washing up bowls, small amount of plasticine (3-4 cm diameter); maximum of 20 marbles; other materials (glue, scissors, paint etc.)

Form of assessment / evaluation used:

Regular assessment tests (knowledge and understanding) as well as formative evaluation.

Information available

No English materials and information available. English conference paper (8-10 pages) in progress (July 2010: Eridob conference, Braga Portugal). The Dutch lesson materials are available in pdf: a total of 20 pages of lesson materials plus introduction to the context-concept approach will need to be translated. Some of the headings and the pictures may provide an illustration of the activity.

Literature:

- Boersma, K.Th., Graft, M. van, Harteveld, A., Hullu, E. de, Oever, L. van den, & Zande, P.A.M.van der. (2005). Vernieuwd biologieonderwijs van 4 tot 18 jaar. Utrecht: Nibi.

- Boersma, K.Th., Graft, M. van, Harteveld, A., Hullu, E. de, Knecht-van Eekelen, A. de,Mazereeuw, M., Oever, L. van den, & Zande, P.A.M. van der. (2007). Leerlijn biologie van 4 tot 18 jaar. Uitwerking van de concept-contextbenadering tot doelstellingen voor het biologieonderwijs. Utrecht: Nibi.

Critical features for sustainability

The Floating and Sinking module provides information on and structure for inquiry-based learning in a simple, straightforward but effective way. It suggests the use of simple and commonly available equipment and materials.

Critical features for transferability

The topic of Floating and Sinking is recognisable and attractive to most students in the lower grades of primary schools, anywhere.

Are the silkworms worms? Learning to ask and answer questions in the first grade

Keywords:
Primary school, life cycle, IBST, collaborative working, learning to learn

Problems addressed

Lack of scientific activities in primary school oriented to the development of scientific competences, in particular identifying scientific issues (EU, 2006; PISA 2006). Cooperative learning and collective decision-making are not often related to classroom (science) practices (i. e. selecting relevant data, posing research questions, contrasting hypothesis and communicating of results). This is often the case in primary education.

Quality criteria

Scientifically sound: Provides examples and experiences that give pupils insight in the construction of scientific knowledge (make pupils participate in an experience of animal development, promoting the identification of scientific questions).
Pedagogically and methodologically sound: the design, learning materials, learning activities and teaching methodology take current theories about science learning into account.
Fosters **scientific competencies** and scientific literacy; identify scientific issues, explain phenomena scientifically, use scientific evidence; offers inquiry based learning activities (students propose their own problems to investigate, students discover their own problems and try to solve them either in group or by themselves); stimulates collaborative work (learners work as a team when analyzing an experience, reporting results and discussing them.

Innovation appraisal

The pupils are motivated and participate in the tasks. High grade of engagement in learning activities, collaborating spontaneously and sharing their knowledge.

Relevant information in brief	
Topics addressed	Investigating together the life cycle of silkworms
Age classes **Extent**	6 year old (first grade primary school) Local
Years of experimentation	1 class working together as a whole group Classic activity in science classrooms with a innovative approach, several years of successful implementation
Duration	6-8 weeks (but using only a part of the sessions)
Main innovation promoters	School teacher: María Teresa García Quintas
Main innovation partners	
Website	
Contact person	María Teresa García Quintas, maritegq@yahoo.es CEIP Pío XII, Santiago de Compostela, Spain

Curriculum relevance and connection to policy guidelines

The proposal is framed in Spanish curriculum for primary education, where the scientific disciplines are integrated in a subject called "Knowledge about the Environment", compulsory at this level.
The curriculum is structured around science issues, and the students are required to experiment and to develop knowledge. Scientific topics are structured around experiences. It follows guidelines about teaching strategies that are comprehensive and interdisciplinary. The aim of this innovation is pupils' overall development by integrating the development of scientific knowledge, communication competences and cooperation.
The innovation is connected to the EU 2006 recommendation on key competences and also to PISA 2006 guidelines for scientific competences, in particular 'learning to learn', and 'identifying scientific questions', in other words learning to pose and answer scientific questions.

Description of the innovative practice

Theoretical frameworks:

Constructivist perspective; Inquiry Based Science Teaching; Problem Based Learning.

Main aims, features and phases:

Aims for the students: learning to work collaboratively; learning to ask scientific questions; learning to communicate and share the results; "learning to learn" (to search and organize information, to use language and scientific terms, to develop thinking strategies and personal autonomy); developing empathy and interest for living being; learning how to care about living beings.

Features: learning activity designed to explore the life cycle of silkworms and their biological transformations; collaborative work of whole class.

Phases:

The teacher takes a box with about a dozen silkworms to the classroom. She introduces the project, explaining that the silkworms produce silk, handling around some silk clothes (so soft!), and also that they only eat mulberry leaves.

- Phase 1, Raising silkworms: the children are asked to take care of the little animals, by a) feeding them mulberry leaves (provided by the teacher), and b) cleaning the faeces (little black balls) from the box.
- Phase 2, Knowing silkworms: the children collect information about silkworms both from the school library and from internet, and are encouraged to ask about them at home. They also use magnifying lenses to observe them.
-Phase 3, What do we need to know?: the children are encouraged to draw a double list about the silkworms based on their observations and the information gathered a) what they already know, and b) about questions that they want to find out. Some of the questions collected in one year were: How are they supported in their legs?. Do they have eyes, mouth, teeth? Why do they eat so much? From where goes out the butterfly? How is silk gathered from them?
- Phase 4, How do they change?: Observation of how the silkworms spin cocoons attached to the box. They identify this phase of the life as being difficult, for two of the silkworms died while spinning the cocoon (see photos).
- Phase 5, Making silk: the children took one of the cocoons and put it in hot water, then they got the thread loose and unrolled the silk. They observed the 'worm' inside not yet fully formed.
- Phase 6, Feeling like cocoons: the students make paper 'cocoons' and get inside, being still for a while (see photos)
- Phase 7, Answering the questions: the pupils answer the questions collaboratively, and a poster with the answers is produced. For instance: "They eat so much because they are growing and putting weight very fast; when they turn into chrysalis they stop eating".

Methodology used:

whole course project developed in regular classroom; cooperative work; classroom as a community of learners.

Resources needed:

Regular teacher; everyday materials (box, silkworms, mulberry leaves, water, silk clothes); basic lab equipment (glass containers, magnifying glass, heater); library and internet access for consulting.

Form of assessment/evaluation used:

Formative evaluation framed by the main goal of the Spanish primary curriculum which is pupils' overall development. The levels of development, knowledge, basic aptitudes and practical skills, which the pupils gradually acquire, are assessed by the teacher at the end of the course in order to promote them to the next level.

Information available

Paper by teacher in Spanish Educational journal: García Quintas, M. T. (2009) ¿Son gusanos los "gusanos de seda"? Aula de Innovación Educativa, 186, pp 16–18.

Critical features for sustainability

This innovative practice is been successfully implemented every year in a first grade classroom, in a public primary school, as a part of the regular course, guided by the teacher. Perhaps some discussion could be raised about the pain suffered by the animals when put in hot water.

Critical features for transferability: This proposal arouses the interest of pupils through this new approach to a traditional activity. Reinterpreting the discovery process, by encouraging the students to behave like scientists, offering them the opportunity to ask questions, have an active role and find solutions independently, are reasons to achieve a high motivation and engagement. The innovation is flexible enough to be adapted and transferred to other school contexts (grades, types of schools…) and of course, countries.

Walkabout through the body in 80 pulsations: the circulatory system

Keywords:
Primary/lower secondary school, health education, nature of science, cultural and historical differences, hands-on.

Problems addressed

a) Overweight increases the risk of high blood pressure and subsequent circulatory disease. Pupils should be sensitized to this interaction at early age (Health education) (activity 6).
b) Pupils infrequently use hands-on methods to explore issues autonomously.
c) The awareness of the scientific expertise of Non-Western cultures and of ancient cultures is low. This is in spite of the fact that change over time and different cultural interpretations of observations are inherent characteristics of scientific knowledge (knowledge about science/nature of science) (activity 2).

Quality criteria

Pedagogically sound: the pedagogic basis/background is clearly described and learning activities are consistent; allows for diversity in learning materials and teaching methods in order to meet a variety of pupils' needs and interests; takes gender and (multi)cultural issues into account.
Scientific competencies: includes practical work (hands-on activities, lab-work, experiments, etc.); stimulates collaborative work.
Socially relevant: raises the awareness of social, ethical and cultural influence and implications of science and technology.

Innovation appraisal

During the course of a medical study (see Description of innovative practice below), 'many' teachers have carried out the activities using the materials provided. However, the number has not been recorded. None of the teachers involved returned the feedback questionnaire provided with the teaching materials. The researchers visiting the classes reported that the teachers liked it.
Outside the context of the medical study, 15 classes or groups of children booked this course at a school lab since 2006. About half of them chose the activity on cultural and historical differences (activity 2). The visiting classes seemed happy, but feedback has not been collected in a systematic way.

Relevant information in brief

Topics addressed	Circulatory system: ancient and recent images, heartbeat, heart capacity, pulse, blood pressure, health education: blood pressure and circulatory disease
Age classes	9-13 years old, with small adaptations according to age
Extent	Regional (Canton of Vaud), full classes involved
Years of experimentation	5 years
Duration	1-2 hours (3 activities are chosen out of 6, each activity takes 20 min)
Main innovation promoters	University of Lausanne – L'Eprouvette (Alain Kaufmann, Séverine Trouilloud, Laurianne von Bever), Ministry of Education of the Canton of Vaud (Nicolas Ryser), Institute of Social and Preventive Medicine, University of Lausanne (Arnaud Chiolero)
Main innovation partners	as above
Website	http://www.unil.ch/webdav/site/interface/shared/eprouvette/80_pulsations.pdf (in French)
Contact person	Séverine Trouilloud, University of Lausanne, severine.trouilloud@unil.ch

Curriculum relevance and connection to policy guidelines

Part of the compulsory curriculum (human body, circulatory system).

Description of the innovative practice

In 2005/06, a study on the weight and the blood pressure of Swiss school children was performed. In the Canton of Vaud, researchers of the 'Institut universitaire de medicine sociale et préventive', Lausanne, screened classes of grades 5 and 6 (11-13 years old). A set of optional hands-on and teaching materials was offered to the teachers to provide a content-specific but flexible frame when the researchers visited a class to do their examinations. For the examination, always two pupils left the classroom for 10 min. The rest of the class continued its activities. The set of several autonomous activities for the pupils allowed for a break whenever it was the pupils' turn to be examined.

Theoretical frameworks:

The scientific educational frame: connection of personal and daily life experience with content, collaborative work and multiple approaches to an issue

Main aims, features and phases:

Objectives:

- The activities help the pupils to understand the measurements taken at the doctor's or in the original study (see above)
- Pupils learn interactively about their circulatory system
- Pupils compare their personal images of the circulatory system with ancient and current concepts
- Health education: interaction of blood pressure and circulatory disease (esp. activity 6)

Organization of the learning activities: Each activity starts with experimentation, observation, questioning or measuring. A worksheet with instructions guides the pupils and supports them in analysing their results, drawing conclusions, formulating hypotheses. Further activities as extension out of school are suggested.

- The pupils work in pairs
- The pupils watch the time: the experimentation should not exceed 15-20 minutes per activity
- The pupils follow the safety rules (e.g. wash the hands before each activity, disinfect objects that will be in contact with several persons with alcohol)

The teacher's role is to watch that the organization of the activities runs smoothly (watch the time of experimentation, make sure that the pairs change activities, remind pupils to note their findings).
The number of pairs carrying out an activity simultaneously depends on the number of activities installed by the teacher. The material provided per activity has to be multiplied accordingly. Teachers are recommended to offer three activities, among them either number 1 or 2, because they provide a basic understanding of the circulatory system.

Activities:

1. The way of the blood

- Pupils individually draw the circulatory system on a work sheet and compare their drawings with each other
- Pupils outline a real size silhouette and agree on how to depict the circulatory system inside it
- Pupils place images of organs on the silhouette and label the organs' function
- Pupils compare their drawing and arrangement of organs with an information sheet

The silhouette can be used to indicate results of other activities.

2. The circulatory system through the centuries

- Pupils place images from the circulatory system in various cultures and periods along a timeline (3000 BC to 2000 AD, age not indicated): Egyptian, 2500 BC; Arabic, 16th cent.; French, 18th cent.; current Western scientific illustration
- Pupils compare the different conceptions to each other and to their personal one (if they carried out activity 1) or to what they know about the circulatory system. On the back of each illustration there is background information on the importance of the heart in this culture, the knowledge about the circulatory system at that time, and the purpose of the illustration.

3. Thu-thump, thu-thump (The heart beat)

- Pupils build a stethoscope using a funnel, wrapping film, rubber bands, and tubes
- Pupils listen to their own heartbeat and the one of their partner, looking for where it is heard best

4. Marathon of the heart

Pupils become aware of the heart's performance by carrying out small experiments:

- Pupils press a tennis ball as many times a heart contracts within a minute, i.e. 70 times
- Pupils transfer the total volume of blood (5,6 L) with a cup containing the volume the heart expels with each contraction (80 mL)
- Pupils calculate the circulatory flow rate at rest and during exercise

5. Chasing the pulse
- Pupils search where on their body they can feel their pulse
- Pupils relate pulse to their heartbeat (before and after exercising)
- Pupils compare the pulse in the arteries and the veins

6. Under pressure
- With syringes, pupils inject a fixed volume of water into tubes with different internal diameters. They measure the time it takes the liquid to pass and the force they have to exert on the piston.

Methodology used:
Pupils work in pairs, hands-on exploring

Resources needed:
A box containing most material needed for a full class can be rented or ordered online from the school lab l'éprouvette, Lausanne. For each of the 6 activities, material is available for 3 groups to be working in parallel. Rent for a week: ca. € 70.-, purchase: ca. €360.- plus postage (also possible from abroad). Contact: eprouvette@unil.ch. Consumables are provided by the teacher. The teacher may provide all the resources needed him- or herself.
Content of the box:
- wrapping paper, double-sides tape, pictures of the different organs (activity 1)
- illustrations of the circulatory system in various cultures and periods (from work sheet, in colour, enlarged, laminated) (2)
- funnels, tubes, Y-connection pieces, wrapping film, rubber bands, alcohol for disinfection, stethoscope (3)
- buckets, cups, tarp to protect the floor from water, tennis balls, stop watches (4)
- stop watches (5)
- tubes with different internal diameters (2, 3, 5 mm), connection pieces tube-syringe, syringes à 100 ml, plastic bowls to collect the water from the tubes, stop watches (6)

Consumables provided by the teacher:
- pens of various colours, pins (activity 1)
- scissors, kitchen paper (3)
- running water, PET bottles (1,5 L) (4)
- chairs (5)
- containers with 500 mL water (e.g. cut-off PET bottles of 1,5 L) (6)
- copies of the work sheets (for each activity)

Form of assessment / evaluation used:
Feedback forms about the activities and the material provided for the teachers have not been returned. There is no information on assessment in class.

Information available
A comprehensive documentation including information addressed to the teachers (objectives, scientific contents, the organization of activities in class, links to health education) and to the pupils (work sheets) is available online (in French: 42 pp. in total; 10 pp. of general interest, 2-6 pp. per activity)

Critical features for sustainability
As time is short for stimulating interaction by the teacher when pupils are carrying out the activities, we recommend allowing enough time for reflecting and discussing the outcome of the activities in class afterwards. On each work sheet, there is space for pupils to note questions and comments. These notes can be referred to in the discussion. To meet the objectives on health education, teachers should address the links between the activities to messages from health education as provided with the teaching material.

Critical features for transferability
none

explore-it – grasping technology

Keywords:
compulsory education, experimental kits, technical functional issues, online teaching material

Problems addressed

Dissatisfaction with traditional ways in presenting concepts: teachers at primary and lower secondary level rarely teach technical issues in an explorative, hands-on way. Especially at the age of 10-12 years pupils have a high capacity of learning technical-functional issues, but there is a lack of suitable, practical teaching materials. Explore-it provides learning and teaching materials for pupil activities at school, cheap experimenting kits, and supports teachers (online platform, teacher pre-service and in-service training).

Quality criteria

Pedagogically and **methodologically sound:** the pedagogic basis/background is clearly described and learning activities are consistent; allows for diversity in learning materials and teaching methods in order to meet a variety of pupils' needs and interests; motivation/interest in science is stimulated.
Fosters **scientific competencies:** includes practical work (hands-on activities, lab-work, experiments etc.); offers inquiry based learning activities; stimulates collaborative group work.
Supports **teacher training** and **development:** training opportunities are offered within and/or outside school; teachers are engaged in peer reviews and line reviews of the innovation.

Innovation appraisal

400 classes across Switzerland have successfully used the kits. Many teachers repeatedly use them. All 104 teachers involved in the pilot phase stated in a survey that they would recommend explore-it to their fellow teachers (survey was run by 'explore-it').

Relevant information in brief

Topics addressed	Magnets, electromotor; power engineering: solar, wind or hydropower; energy, motion.
Age classes	9-14 years old
Extent	National, full classes involved
Years of experimentation	4 years
Duration	20 – 30 hours or project week
Main innovation promoters	Universities of Teacher Education (Pädagogische Hochschule Wallis PHVS und Fachhochschule Nordwestschweiz PH FHNW), association explore-it
Main innovation partners	University of teacher education http://dict.leo.org/ende?lp=ende&p=5tY9AA&search=college, public and private sponsors for the provision of cheap consumables
Website	http://www.explore-it.org/ (in German, partly translated into French and English; as of fall 2010 all information in ge, fr and en; translation in Italian is planned)
Contact person	René Providoli, Pädagogische Hochschule Wallis, rene.providoli@explore-it.org

Curriculum relevance and connection to policy guidelines

Part of the compulsory curriculum, can be extended to an expansion and deepening thereof. Meets the recently formulated standards in Switzerland (project HarmoS). The pupils interact in heterogeneous groups, act self-contained and use instruments and resources interactively (OECD 2003).

Description of the innovative practice

Theoretical frameworks: Constructivist perspective, IBST-Inquiry Based Science Teaching.

The scientific educational frame: Pupils discover and develop their own theory, learning by constructing and exploring. explore-it emphasizes systematic learner actions and working with a model (Beck Gertrud et al. 1996)

Main aims, features and phases:

explore-it currently offers a selection of learning activities for the 3 topics 'From a magnet to an electric motor', 'solar power moves' and 'energy makes mobile'. For each subject, online information, consumables for the pupils, and teaching and learning materials are available.

Each topic is divided into 4 phases, each addressing a particular content (e.g. for 'energy makes mobile': gravitational and elastic potential energy, electric energy, and thermal energy; for overview and impressions, see http://www.explore-it.org/de/energie-macht-mobil.html)

Each topic is also addressing 3 different levels of learning:

1. …explore: pupils construct a given object that can be observed or can be subject to measurements. Pupils formulate their personal conception and verify it with help of the consumables (e.g. elastic potential energy: pupils build a measuring mobile which can be propelled forward with a rubber band. The distances achieved result in a graphic depiction of the elastic constant, older pupils can calculate the constant).
2. …invent: pupils construct and explore their own objects and solutions (can be extracurricular) (e.g. elastic potential energy: the pupils compete to transport a chocolate bar as far as possible using a balloon (the balloon may be cut)).
3. …and more: pupils can discover e.g. the technical use of a concept in practice by web quest (possible extension for high achievers, but not only).

Methodology used: The pupils work in pairs (one kit for two pupils). They formulate their personal questions and try to answer them with help of observation, and experimentation. But first, an object/device is constructed from scratch by the pupils themselves. This raises authentic questions about the functioning and gives pupils a profound understanding of it. The way of working continuously recalls the pupils' previous knowledge (e.g. drafting the object before construction and changing the draft according to their experiences when constructing and their observations). After the pupils set up their small experiment they reflect for what this experiment is used at a larger scale. Especially the inventing part draws on and enhances the pupils' creativity.
The teacher supports the pupils during their inquiry and discovery process. The teachers are deliberately given the autonomy (and the task) of how to embed these experiments in their class (learning objectives, number of lessons used). In-service teacher training supports the implementation in class.

Resources needed: As a teacher conducting the teaching unit: Consumables ca. 7 € per pupil. The consumables are everyday objects available at regular stores (e.g. straws, isolated wire). Teachers have the possibility of ordering the consumables needed online at cost price. The ready-made boxes will be delivered to their school. Experimental protocols and suggestions how to use the kit are provided. Ideally, the teacher takes a training of at least 3 hours.

Form of assessment/evaluation used: Formative or summative evaluation of the pupils' questions to be tested, their experimental set ups, experimental results, logbooks, conclusions drawn.

Information available

The description of activities, implementation in class, working sheets, etc. are available online: 50 pp. per topic, of which ca. 25 pp. text and ca. 25 pp. pictures (in German, partly in French and English; as of fall 2010 all material will be available in ge, fr and en); accessible only by teachers ordering consumables (see transferability below).
For training of the teachers: material could be provided (given the agreement of the financing foundation)

Critical features for sustainability

The innovative practice is implemented in regular classroom, with teachers optionally trained in-service or pre-service (at least 3h). Currently, a group of coaches is set-up to give technical support with the inventing part.

Critical features for transferability

As an offering institution, e.g. university of teacher education: Ideally an internet platform is set up and maintained, where all the resources needed by the teachers are available. Contact addresses of an educational and a technical expert who are willing to support teachers in case of questions. Teacher pre- or in-service trainings help teachers getting familiar with the issue, the kit, and the methodology.
Funding is needed to give the consumables at cost price. explore-it and their sponsors do not give the materials for free to avoid the notion that something that does not cost anything is not worth anything.
(FOR TRANSFER WITHIN KIDSINNSCIENCE: at maximum 20 classes could be provided with the kits for free.)

CCI - Children Challenge Industry

Keywords:
Primary school, gender and culture, real world context, scientists role, schools and industries.

Problems addressed

The project reduces the distance between science studied in school and real scientific practices – this project enables children to do the same things that people in industry do, using similar contexts and developing scientific competences through their problem-solving activities. It allows children to interact with real scientists, seeing that there are plenty of women working in some scientific areas and encouraging girls in school to think about career options in science and technology. In other cases, children will see that scientists come from many different cultural and geographical backgrounds.

Quality criteria

Pedagogically and **methodologically sound**: the pedagogic basis/background is clearly described and learning activities are consistent; the design, learning materials, learning activities and teaching methodology are clearly described and consistent with the pedagogical basis; takes gender- and (multi)cultural issues into account.
Fosters **scientific competencies:** fosters scientific literacy (identify scientific issues, explain phenomena scientifically, use scientific evidence); includes practical work (hands-on activities, lab-work, experiments etc.); stimulates argumentation and critical thinking.

Socially relevant: raises the awareness of social, ethical and cultural influence and implications of science and technology; promotes public understanding of science; promotes actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues.

Innovation appraisal

Each year children and teachers are questioned before and after participating in the CCI programme, to enable attitudes before and after to be compared and measured. Children are asked to provide drawings in order to add another dimension to the data collected. Of the children questioned, 99% said they had learned something new, 96% enjoyed learning about industry and 94% stated that they now enjoyed science more after taking part in the CCI activities. The National data show that girls, in particular gained a more positive attitude to science, as they became more aware of the opportunities for young people and especially women scientists in industry.

Some comments from the website:

- *86% of the pupils who remembered the CCI lessons stated that the lessons were enjoyable compared with 58% of pupils who thought that secondary school science lessons were enjoyable.*

- *The number of children who gave positive responses regarding what they thought of science (63%), was far more than the number of children who gave negative responses (36%). Nearly two thirds of those children that gave positive reasons declared that they enjoyed science because they enjoyed the lessons and/or they enjoyed the practical sessions. The main reason the pupils gave for not enjoying science was that it was boring.*

Relevant information in brief

Topics addressed	Plastics (8 to 11 year olds), Water for Industry (10 to 12 year olds), Pencils, poems and princesses, Pinch of Salt (8 to 11 year olds), Feel the Force, Medicines from Microbes, Kitchen concoctions, Healthy drinks and Tasty Toothpaste (7 to 9 year olds), Smart Bricks for Smart Plants (9 to 11 year olds).
Age classes	7 to 12 year olds.
Extent	National. The project started in North East England and now has contacts in all areas of the United Kingdom, including Wales, Scotland and Northern Ireland.
Years of experimentation	Started in 1996
Duration	The minimum time would be a unit of about 12 hours.
Main innovation promoters	Chemical Industries Association, University of York
Main innovation partners	Schools and industries.
Website	http://www.cciproject.org/;www.psep.org
Contact person	Nicky Waller nicola.waller@nepic.co.uk

Curriculum relevance and connection to policy guidelines

Some of the activities and lessons would form part of compulsory curriculum. Instead of studying the properties of water in terms of solid, liquid or gas, children could more usefully investigate the uses of water within an industrial process and in a modern context, or compare modern water processes with historical ones or with water issues, droughts and climate change in other countries.

Description of the innovative practice

A high proportion of children living in post-industrial Britain have negative attitudes to industry, describing it as dark, noisy, dirty and smoky. In 1994 a MORI poll showed that public perception of the chemical industry remained at a low level. CCI was at first local, and then expanded into a national initiative linking science in schools with science in industry. All the classroom activities have real industrial starting points, with local companies writing or emailing the children asking for their help with specific problems they are experiencing onsite, for example, how to cool water quickly.

The Children Challenging Industry (CCI) project, which began in 1996, aims to create enthusiasm for learning science amongst primary school children by providing classroom-based training for the teaching of the National Curriculum for Science. This, and liaison with local science-based manufacturing companies, enables pupils to see how the science they learn at school is used in a 'real life' context.

Theoretical frameworks:

The children are involved in trying to solve problems that arise within industrial contexts, acting like real scientists. The project aims to give them a more realistic view of modern day industry and a greater understanding of career opportunities, roles of scientists and engineers and the contribution that industry makes to our everyday lives. As such, the theory behind this is PBL- Problem Based Learning as well as some aspects of a REC -Research and Education Collaboration-.

Main aims, features and phases:

The projects started with links between industry and schools. It has now generated useful teaching and learning resources based on these initial links and it is not necessary for schools to carry out the industrial links, especially in areas where there is now little industry. An extensive range of support and training materials are provided to help participants on the programme. These include:

- advice on organising site visits and speakers from industry;
- classroom investigations with an industrial context;
- training activities for use with class teachers;
- links to other useful sources of information;
- a range of activities to allow the integration of ICT into the classroom activities.

Methodology used: A variety of activities is available from the website for example, ideas for an investigation into the thermal insulation properties of materials which could be very open-ended, or much more structured, depending on the experience of children in doing their own investigations.

Resources needed: From 2011, materials will be free from web site, but sample materials are available as a pdf document about teaching plastics, http://www.psep.org/SchoolsArea/online_docs/teaching_materials/plastics_playtime.pdf

Form of assessment / evaluation used:
Children were assessed through self-assessment, through teachers questioning them, assessing their writing and drawings. There is a five year report available as a pdf at www.cciproject.org/reports/documents/5YearOn.pdf

Information available

See above Resources. The information is in English.
Although the project which links schools with industry is carried out in the North of England, there are materials for schools who wish to carry out similar activities (online interactive materials for children and training materials for teachers) at the PSEP website www.psep.org

Critical features for sustainability

The willingness of teachers to carry out activities with children which link with Industrial ideas.

Critical features for transferability

Good communication between local Industry and schools, with a supporting organisation and research expertise from a university education department (Chemical Industry Education Centre at the University of York).

Studying science outside – the Jurassic Coast

Keywords:
Primary school, outdoor education, gender, problem-based science

Problems addressed

The study of this world heritage site allows children to experience science in the everyday world and to make links between science, art and history.
By reducing the distance between science studied in school and real scientific practices, this project enables children to do the same things that scientists do, using similar tools and developing scientific competences through their activities and discussions.

Quality criteria

Scientifically sound: correct use of scientific content/ knowledge according to the context; raise awareness of the Nature of Science; provide insight in the way scientific knowledge is constructed;
Pedagogically and **methodologically sound:** the design, learning materials, learning activities and teaching methodology are clearly described and consistent with the pedagogical basis; allow for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests; take gender- and (multi)cultural issues into account;
Fosters **scientific competencies:** includes practical work (hands-on activities, lab-work, experiments etc.); offers inquiry based learning activities; includes decision-making activities.

Innovation appraisal

The informal appraisal which appears in a short article in Primary Science Review (2008) shows that children enjoy the experience of working in the outdoor environment and can manage to raise scientific questions and link their observations to the artistic and historical aspects of the places they visit

Relevant information in brief

Topics addressed	The study of the World Heritage site of the 'Jurassic Coast' in Dorset, England, mainly biological concepts, but some physical and geological.
Age classes	8 to 11, but could also work with children up to 16 years.
Extent	Local to the Jurassic coast which stretches along the south coast of England from Devon to Dorset. – see website for up to date figures
Years of experimentation	Initiated in 2002
Duration	The minimum time would be a single visit of a couple of hours but the best way of using the site is to plan and carryout activities with a class over a period of time, looking for seasonal changes.
Main innovation promoters	Natural Science Museum has now opened a centre at Lyme Regis on the Jurassic Coast. Other educational centres provide hands on investigations and plenty of information and activities for all ages along the coast. – also the City of Bath, the Cornwall and West Devon Mining Landscape, the Jurassic Coast of Dorset and East Devon and Stonehenge and Avebury.
Main innovation partners	South West Grid for Learning, world heritage site, schools.
Website	http://content.swgfl.org.uk/jurassic/resourcepacks.htm
Contact person	John Meadows meadowjj@lsbu.ac.uk

Curriculum relevance and connection to policy guidelines

Some of the activities and lessons would form part of the compulsory National Curriculum for England and Wales. The science curriculum requires children to study and compare local and contrasting environments, so even schools more distant from the site could organise visits to compare this rich environment with their own locality.

Description of the innovative practice

The main topic is the study of the World Heritage site of the Jurassic Coast for science and environmental education. The children visit some of the sites along the 100 km coast and make observations, leading to questions. With support from adults, they turn questions into investigations and search for further information. Questions could follow observations of the colours in the cliffs and soil, the relative hardness of clays, soils, pebbles and rocks, for example, what makes the rocks red (the presence of iron?) or black (indicating lava flows?) or white (chalk – does it write on a blackboard?; where are fossils found and who found them in recent history including gender issues, for example the story of Mary Anning, woman fossil hunter.

Other questions about the living things in this environment could focus on birds and their behaviours, for example, why do the crows live in this section of cliff and the seagulls elsewhere? Art could be linked in here, with drawings, photos and paintings of birds, cliffs and flora.

Theoretical frameworks:

Much of the theoretical backing for work of this type comes from the general area of inquiry-based learning. IBL, along with ideas from social constructivism ensures an open-ended approach to the questions arising from observations and discussions between children and with teachers and researchers. The development of community of teachers and learners around the notion of the World Heritage Site and local interests is also an important issue.

Main aims, features and phases:

There are many different ways of using the Jurassic Coast and its resources within a science course. The main aim might be to link the science in classrooms with science in the outdoor environment and with the work of real scientists and collectors now and in recent history. Traditional ways in presenting concepts may be too abstract for some children, particularly younger ones or those with learning difficulties and special educational needs. The physical interactions with rocks, fossils, stones, streams, the sea, wild life as well as wind and weather provide a rich environment for children to experience their surroundings with many of their senses.

Methodology used:

ICT features through the use of CDROMs and DVDs which have been produced (in English) by staff in the regional centres; outdoor work in the environment involves observations and the raising of questions as well as some investigations into changes such as the movement of pebbles on the beaches. Indoor work in class will focus on searching for further data and information and some investigations into the materials found on the beaches. Project work and group work would allow children to follow up their interests and ideas.

Resources needed: Ideas and materials are available as work packs for pupils, PowerPoint slides for teachers and children, CDROMs and DVDs. The Sites are open to parents as well as schools and researchers. Interactive Google maps are also available to help look at the whole length of the coast and its geology, features, towns, etc**.**

An example from one unit of work: -

How will the World Heritage Site affect the environment and the people who live there?

Encourage the children to discuss whether they think World Heritage status is a good thing for the Jurassic Coast and the people who live there. Points to consider might be:

- § Increased pressure for tourism (including school visits!) and its impact
- on the coast
- § An obligation to look after the coast
- § International links
- § Financial benefits

Form of assessment / evaluation used:

The pupils are assessed through a variety of methods, including observations of their activities, questioning them about specific observations and ideas, looking at their drawings and other records of the visits and the results of their project work, which could be presented to and assessed by other pupils.

Information available

Resources are available through the Heritage Site centre as well as through educational materials such as information leaflets, CD materials for teachers of ages 5 to 11 and beyond. Adult resources are available via website, as well as teachers' resources prepared by Anjana Khatwa, educational coordinator. Guides to the Jurassic coast along with plenty of educational and historical and environmental information are available through web sites and in printed versions or as DVDs or CDs. The Jurassic resource packs website (see above) contains methodological as well as practical instructions for teachers and students. It could be adapted to fit other sites/countries.

Critical features for sustainability

Many schools and individuals and families use the resource centres along the Jurassic Coast Both Educational and Tourism help to fund the facilities available.

Critical features for transferability

Although the Jurassic Coast is unique as an environment in one part of England, there are opportunities in almost any environment to study outdoors, raising questions and using local information, history, environmental issues, etc as a stimulus for authentic science investigations. The location itself is not transferable, although similar coastal regions do occur across the world. What is transferable, with support from the contact person, is the way of working from observations and questions raised in real environments, where the answers to the questions and problems are not always predictable.

PREP: play, research, explore, practice

Keywords:
Primary school, play, hands-on, exploration, raising questions

Problems addressed

PREP stands for Play, Research, Exploration, Practice
It addresses the importance for children to explore freely the materials and resources, tools and equipment they will be using in science, before being required to use these in more formal ways. Often only the youngest children (3 to 6 year olds) are encouraged to play while older children may only have very brief amounts of time to get to know new resources.
Traditional ways in presenting concepts may be too abstract for some children, particularly younger ones or those with learning difficulties and special educational needs. Concrete objects offer a learning environment which leads to the raising of questions by the children; such questions help the teacher to assess the level of understanding of some of the children (Assessment for Learning)

Quality criteria

Pedagogically and **methodologically sound:** the design, learning materials, learning activities and teaching methodology take current theories about science learning into account; take gender- and (multi)cultural issues into account; includes all pupils, including those with special educational and physical needs.
Fosters **scientific competencies**: includes practical work (hands-on activities, lab-work, experiments etc.); includes decision-making activities.

Innovation appraisal

The PREP sessions have been trialled across the primary age range and seem to have "a positive impact on the teaching and learning of science" (p15) – "creates an environment that is conducive to maximising learning by making individuals feel safe and secure, prepared to take risks that they otherwise might not have." Lessons have been evaluated through observation, using Laever's Leuven Involvement Scale (1994).
Reference: Phethean, K. PREP: play, research, explore, practice, Primary Science 105, Nov/Dec 2008 p 12-15 Association for Science Education: Hatfield.

Relevant information in brief

Topics addressed	Science curriculum topics having as starting points 'playing situation (sound making objects, large and small magnets, mini-habitat, etc.)
Age classes	8 to 11 year olds, but could also work with children up to 16 years and in teacher training.
Extent	Local
Years of experimentation	4 years
Duration	The minimum time would be a ten minute period at the start of science lessons
Main innovation promoters	Karen Phethean
Main innovation partners	Teachers
Website	http://www.planetscience.com/wired/index.html?page=/wired/games/index.html http://www.bbc.co.uk/schools/scienceclips/ages/6_7/grouping_materials.shtml
Contact person	Karen Phethean, karen.phethean@winchester.ac.uk

Curriculum relevance and connection to policy guidelines

Some of the activities and lessons would form part of compulsory curriculum for England.

Description of the innovative practice

PREP can be used whenever children are allowed to experience new resources, materials, tools and instruments. It can begin in teacher training courses with students in groups being given a set of "sound-making" objects, including real instruments as well as resonant objects like copper tubes, rattles, instruments from other countries. It could begin with children playing with sets of large and small magnets along with samples of metal and non-metallic objects. It could even begin with children observing living creatures in a mini-habitat, such as a sand or earth-filled tray. The only proviso would be ensuring the health and safety of the children with the new objects.

Theoretical frameworks:
Constructivism includes the need for children to explore materials freely and then in more structured ways, so they can construct knowledge and understanding.
"Play allows the learner:
To create (construct) and explore a world we can master, conquering fears while practicing a range of different roles;
To develop creativity through the development and use of imagination and fine and gross motor skills;
To learn to work in groups, to share, to negotiate and to resolve conflicts;
To practise decision-making skills; to move/progress at their own pace;
To move forward along the road of self-discovery" (Phethean, K. 2008 p. 14).

Main aims, features and phases:
PREP can be a short, 10 minute free play session before beginning the main teaching.
Play – when children perceive learning to be fun and enjoyable they will be actively engaged an focused
Research – learning involves a cycle of studying, reviewing concepts and ideas, and assessing what has been learnt and what needs to be done next (target setting)
Exploration – learning involves finding out facts in a variety of ways. I may involve research and quiet study, searching for prior knowledge and understanding and for answers to question, or it can be experimental, trialling or testing ideas and conceptions.
Practice – carrying out an activity – doing; going through what you already know helps you to build upon your prior understanding.

In many lessons in the UK, teachers start with a 10 minute starter activity, often involving reviews of previous learning, or sharing ideas, and using techniques like small whiteboards and pens for each children to scribble instant responses and show them to the teacher, or talk partners, where children discuss a topic for a few seconds with a partner and then with the whole class.

Methodology used: Learning by playing, group work.

Resources needed:
Mainly just whatever practical materials are to be used by children in their science activities. Examples from the PSR article are in the context of a lesson about forces, where the children are allowed free play with the set of force-meters.

Form of assessment/evaluation used: PREP sessions have been trailed across the primary age range and teachers have reported that they seem to have a positive impact on the teaching and learning of science (Phethean, K. 2008 p. 15). The lessons have been evaluated using observation and the conclusions are that the PREP creates an environment that is conducive to maximising learning by making individuals feel safe and secure, prepared to take risks that they otherwise might not have.

Information available

Children who are about to start on a teaching sequence on Materials and Magnetism, for example, should be allowed to "play" with a collection of magnets of different sizes, shapes and strengths along with some metal objects such as nails, paper clips, ball bearings. There should be no specific instructions to the children, just leave the materials on their table or floor and ask them to use them in any way they like (as long as it is safe!).

Another example is in the study of sound – provide the learners with a collection of materials which make sounds, some real instruments, some sound-making toys, some instruments from a variety of cultural backgrounds or from different countries around the world. Again, no instructions are necessary, just that the learners use the materials to try and make sounds. After the play period, children could be encouraged to sort the sounds they make into a variety of categories, which they choose themselves.

The following websites have several simulations and games which show how play can be more structured to teach specific scientific concepts.
http://www.planet-science.com/wired/index.html?page=/wired/games/index.html
http://www.bbc.co.uk/schools/scienceclips/ages/6_7/grouping_materials.shtml

Critical features for sustainability

The innovative practice has been implemented in regular classroom with average teachers for about 4 years.

Critical features for transferability

Just persuading teachers that play is important even for older children and that the benefits of 10 minutes of exploratory play with resources that are unfamiliar to children can be long term motivation towards science as well as longer term understanding of specific concepts.

Renewable Energy

Keywords:
Lower secondary school, interdisciplinary, project work, research process, energy-forms

Problems addressed
-Lack of interest in technical and challenging themes by pupils, especially by girls;
-Teaching should have more long-term-effects as awareness raising or option making;
-Current topics should be implemented more often in school;
-Lack of knowledge and of understanding of sustainable and renewable energy-sources;

Quality criteria
Fosters **scientific competencies:** foster scientific literacy (identify scientific issues, explain phenomena scientifically, use scientific evidence); stimulate argumentation and critical thinking.
Socially relevant: promote actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues.

Innovation appraisal
Based on statements of the pupils, the teacher found out that students are more motivated and enthusiastic by themes about the future and that pupils in general show big interest in innovative products. This practice also showed that students can get inspired by technical and challenging themes if the methods are creative and students have the chance to give their own input. The point that students worked also during their spare time can be regarded as a proof of the fact that such projects are awareness raising and option making.
To measure durable change of behaviour is really difficult. A literature-research showed that students already have their archetypes and as every human being is naturally lazy, they also dislike changing their habits.
The conclusions made by the author of the project are based on personal end of project meetings with students and talks with the students.

Relevant information in brief

Topics addressed	Project-based introduction of different energy-forms with focus on sustainable renewable possibilities
Age classes	4th degree of regular secondary school, 13 – 14 years
Extent	Local, group of 8-10 pupils
Years of experimentation	1,5 years
Duration	6 months, 12 units minimum
Main innovation promoters	Bmwf (Federal Ministry of Science and Research)
Main innovation partners	Institut for research at the University of Education (pädagogische Hochschule, Mag. Emmerich Boxhofer and Dr. Clemens Seyfried)
Website	http://www.sparklingscience.at/de/projects/220-energy-twenty-one/
Contact person	Brigitta Panhuber, MBA PAB@ph-linz.at Praxishauptschule Diözese Linz

Curriculum relevance and connection to policy guidelines
This innovative practice is part of the optional curriculum as it's an optional course called "Science group" in the regular secondary school for those pupils which are really interested in this topic. The theme is connected to the compulsory curriculum and can be regarded as a deepening and expansion of knowledge and competences. Furthermore it enables an insight to research which is really important at this early stage of education. "Renewable Energy" is an interdisciplinary project – this gives an explicit connection to the pedagogic part of the curriculum.
This innovative practice is part of the national programme "Sparkling Science" of the Federal Ministry of Science and Research which promotes projects in which schoolchildren are actively involved in the research

process. Schoolchildren support scientists in scientific work and in communicating the joint research results to the public.

Description of the innovative practice

The project "Renewable Energy" aims to broaden the knowledge of students about renewable energy so that they can argue accordingly and form their own opinion about this topic. The project gives students an insight in the research process: from the formulation of research questions to possible methods to get a result. It first gives students a general insight in renewable energy and focuses in second step on the specific energy-situation of the country (in this case Austria). In the third step, students concentrate on one renewable energy-form which is quite often used and well known in the country (in this case: pellets). During step three, students learn the basics of research (questionnaire-implementation and -evaluation).

Theoretical frameworks:
Active learning, Interdisciplinary, Informal learning environments, Project-based education, Cooperative Learning, Environmental Education;

Main aims, features and phases:
Pedagogical aims: find out previous knowledge, awareness raising, creative work, critical thinking, interdisciplinary work, get an insight to research
Content aims: gain basic knowledge and technical terms; do research with focus on current and local topics; differentiation between different kinds of energy;
Features special interdisciplinary week on the topic "Energy week"
Phases
1st phase: find out students knowledge about renewable energy via questionnaire;
2nd phase INPUT:

- search for information, in addition theoretical input by the teacher about missing contents; formulation of research-questions;
- special focus on pellets: development of a questionnaire: implementation and evaluation;
- creation of a game with the focus "sun as energy-source";
- creation of flashcards about the topic "renewable energy";

3rd phase: evaluation of the project

Methodology used:
Creative techniques - Brainstorming-clustering for previous knowledge, mind-map, partner- and group work, info-poster for colleagues in school, flash-cards for new English-vocabulary, excursions to research institutions and innovative companies (e.g. biomass-electricity station, passive house, wind park etc.), presentations;

Resources needed:
Personal: the teacher needs basic knowledge about the topic, but some of the content is worked out together during the project; if excursions are wanted, experts are needed.
Materials: normal writing material like pencils, posters etc.

Form of assessment / evaluation used:
At the beginning of the project, the state of knowledge of the students was surveyed with a questionnaire. Then pupils acquired more knowledge on the topic by presentations, films, doing research in scientific literature, excursions to innovative institutions with focus on renewable energy resources etc. This base enabled pupils to do qualitative interviews with university students and teachers.
At the end of the project the gained knowledge was documented by the pupils with posters, flashcards and the creation of games for younger children. These products were evaluated by the teacher.

Information available

The whole project is well described and well documented. The methods are explained and also graphically printed, the working process is explained in details and consequently the results understandable. The description is clearly structured with an overview at the beginning and afterwards each phase explained in detail. Didactic-material like questionnaire or developed games that have been used are available as well.

~15 pages to translate. Available language: German

Critical features for sustainability

This innovative practice was implemented in one regular school in an optional course with an average but committed teacher. This project is part of the optional curriculum and therefore it is possible to work together with interested pupils but parts of it can also be implemented in regular classrooms.
According to the author of the project some expertise in the topic is necessary. Therefore it is recommendable that a teacher (e.g. teacher of physics) or a teacher who learned about renewable energy by him-/herself leads the project. Of course for the success of the project, it is necessary that the teacher is interested in the topic. The support of the head of school, budget for materials and excursions to specific institutions is important for the project.

Critical features for transferability

Since this project is process-oriented, the exact way to reach the aims was not determined at the beginning. Consequently the developed material e.g. questionnaire, results of content-research etc. can be transferred, but one wouldn't copy the main idea " process-oriented education" because they were produced during the process and are therefore a result of it. Nevertheless they can be proposed as an example.
This topic is very current but the subtopic "pellets" chosen is just interesting for countries with access to a lot of wood and more for countries with heating systems (in general countries where pellets are used). This might be a criterion chosen if using the developed material and content. If not, new material can be developed according to a different energy form.
Further points concerning adaptation are that the content, methods and input-steps can be chosen optionally. According to the author of the project, excursions to concrete institutions (for example: enterprises, wind energy converters, biomass power station, photo-voltaic panels or similar renewable energy resources) are vital. It is recommended to use creative methods and assignments of tasks in addition to boost the enjoyment of the pupils in working on the content of the project.

Health education for young people in the Web Radio AJIR

Keywords:
Lower secondary school, health education, ICT, inquiry-based learning, radio communication.

Problems addressed

Historically the hegemony of a biomedical model in the educational process has addressed health issues in schools in a prescriptive and normative way exclusively. The socio-cultural aspects of health are dealt with as a minor issue, which leads to fragmented ways of understanding health problems and dealing with them. Students are rarely motivated to address health issues in a broader way. Their vision of health is mainly restricted to biological matters.

Quality criteria

Pedagogically and **methodologically sound:** allows for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests; motivation/ interest in science is stimulated.
Fosters **scientific competencies:** Stimulates collaborative work; stimulates argumentation and critical thinking; offers inquiry based learning activities.
Socially relevant: promotes actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues; uses resources and teaching contexts from outside the school.

Innovation appraisal

Restricted to the assessment of the teacher responsible for the innovation, who reported positive reactions by teachers and students involved.

Relevant information in brief

Topics addressed	Drug addiction, tuberculosis, AIDS and HIV, diabetes, teenage pregnancy
Age classes	11-14 years old
Extent	Local Several primary schools in the city of Fortaleza – CE (State of Ceará, Northest region)
Years of experimentation	About one year (started in 2009)
Duration	Once a week with different classes
Main innovation promoters	UECE (State University of Ceará)/ PROEX
Main innovation partners	Primary school Edith Braga
Website	www.ajir.com.br www.saudeuece.ajir.com.br (both only in Portuguese)
Contact person	Prof. Raimundo Augusto M. Torres (UECE) Prof. Betânia Marta Silva Câmara

Curriculum relevance and connection to policy guidelines

The subject addressed (Health) by this innovation constitutes a cross-curriculum theme as proposed by the Brazilian Curriculum Parameters (PCN) for both Primary and Secondary Education. According to PCN health education in schools must be understood and addressed from the perspective of 'health promotion', that is, beyond biomedical and behavioral approaches, and in an inclusive way. Therefore this innovation seeks to integrate several aspects involved in health issues such as biological, social, cultural, economical, environmental and educational. Furthermore, the innovation activities encompass experiences that foster student creativeness and allow the expression of subjectivity, such as the ability to use and to understand the various languages of art, games, storytelling and ICT technologies. Health education is seen as a way to propose counter-hegemonic perspectives, pointing new ways, not only in addressing health issues, but also in configuring new pedagogical processes.

Description of the innovative practice

This innovation addresses health education using ICT in a dialogical experience of web radio. "Radio Ajir" is an online channel linked to the Practices in Collective Health Laboratory - LAPRACAS/CCS, State University of Ceará - UECE/Deanery for Extra Mural Activities - PROEX (www.uece.br). This project produces radio broadcasts about young people's health problems in ways in which education and health are presented together with culture, sports, entertainment, art, and literature, among others.

Theoretical frameworks

Although not explicit, the general line of this innovation is inquiry-based learning, since students carry out investigations around one theme. Radio is taken as a media that allows verbal expression and fosters debate and group work. ICT is recognized as generating relevant information that can promote autonomy in decision making towards health care and health education.

Main aims, features and phases

The main aim is to generate educational resources using media to promote dialogue and collaborative learning and, in this way, to contribute to the understanding of health in its broadest sense. The objective is to prepare students and community to take part in school management and also to produce significant changes in the relationships between health/education, school/community and teacher/student as they relate to local needs. The work is developed in three stages.

The first stage is preparatory: selection of the themes, research on the chosen theme, elaboration of summary discussions, questions and problems arising that the radio broadcast will address. The second stage corresponds to a radio broadcast itself, and to the online participation of students in the debate by sending supplementary questions to the radio host. The third phase is the dissemination of the information generated in the radio broadcast to the school as a whole.

Methodology used

At first, the students in a class receive a list of possible themes and, with the support of the web radio professional responsible for the broadcast, decides on a topic to be addressed in the radio show. On the same day the teacher and the class start researching about the chosen topic in the school library and in the Internet. The following day the group discusses the results and the teacher assesses students' understandings on the issue. After preparing a summary of the discussion, students present a set of questions to be sent to the radio host. During the broadcast, additional questions may be sent on line. The action in the radio studio, where an invited specialist answers the questions live, is visualized by the whole group with the support of a screen projector device. After the show, students will be responsible for preparing strategies to disseminate the information obtained, to the whole school through the making of Power Point presentations, leaflets, posters, videos, texts, etc. as well as though seminars for other classes in school. Once a month, parents and school community are invited to participate in a seminar prepared by all the groups participating in the project to disseminate even further the information.

Resources needed

Personnel: one teacher.
Material: computer and screen projector.
Other: Library, access to Internet and a space for meetings.

Form of assessment / evaluation used

There is not a specific moment for evaluation, but the teacher should observe students' participation and the development of critical knowledge.

Information available

Videos of the interviews with specialists can be found at the radio's web page (only in Portuguese). Abstract papers describing different aspects of the experience are available (in Portuguese) at http://www.uece.br/semanauniversitaria/anais/

Critical features for sustainability

No significant difficulties to maintain the innovation have been found so far. The only pre-requisite is the availability of a computer, Internet and data show at schools. Special training for teachers is not mandatory. The proposed innovation is used in regular courses on basic education. A school trying this innovation should keep track with the web radio coordinators.

Critical features for transferability

The existence of a collaborative link between a given web radio (which might be interested in broadcasting shows about young people health issues) and the school is the main critical feature for transferability. Except for that, the innovation is flexible enough to be adapted in different contexts. Alternatively, it is possible to seek for more widely available media such as internet based communication facilities (e.g. chat rooms, forums, blogs etc.), university (cable) television channel, communal radio and TV networks.

Literature and science teaching

Keywords:
Primary and lower secondary school, science language, literary language, cultural influence on science teaching.

Problems addressed

The innovation seeks to promote the teaching and learning of science concepts through the use of literary texts in science lessons. The perspective adopted brings together science and literature, scientific language and literary language and language and knowledge construction. The proposal addresses the contextualization of science contents, students' motivations for the study of science, the contribution of science teaching to promote reading skills and interdisciplinary approaches in school.

Quality criteria

Scientifically sound: raise awareness of the Nature of Science.
Pedagogically and **methodologically sound:** allows for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests.
Considers **developments in science education and science education research:** the innovation contributes to national research on science education.

Innovation appraisal

The innovation was proposed by an experienced science teacher and developed as part of her teaching activities. Later, it was investigated in the context of a PhD study carried out by this teacher herself. Several teaching activities based upon the innovation proposal have been implemented in Pre-Schools and Elementary School classes in several schools. Results indicate efficacy, as demonstrated by students' interest and good performance in the proposed activities and by teachers' positive appraisals. The innovation has also been successfully incorporated in Initial and In-service Biology Teacher Training Courses. Teachers have made suggestions concerning implementation and adaptation aspects that made it possible for the innovation to be conducted in classes of older students and in other disciplines. The innovation has also been analysed by undergraduate students in the context of small scale research exercises and of teaching practice activities.

Relevant information in brief

Topics addressed	Botany
Age classes	Late Primary school 6th to 9th grade (11-14 year olds) and, later, Primary School 1st to 5th grades (6-10 year olds) and pre-school (4-5 year olds).
Extent	City of Macaé, in Rio de Janeiro State 10 classes (approximately 300 students) from 10 Primary School classes in 4 schools in the state of Rio de Janeiro. 10 courses in Initial Biology Teacher Training Courses in Rio de Janeiro (approximately 100 students). 5 In-service teacher training courses (approximately 50 practicing teachers).
Years of experimentation	8 years
Duration	The innovation can be implemented in as a teaching unit and its length is variable (average 4 weeks).
Main innovation promoters	School teachers and university lecturers
Main innovation partners	School Coordination and University (Universidade Federal Fluminense, Rio de Janeiro, Brazil)
Website	-
Contact person	Simone Rocha Salomão (simonesalomao@uol.com.br)

Curriculum relevance and connection to policy guidelines

The innovation is an optional activity. It may be used in regular or special classes, with the whole group or smaller ones. It is suggested as a methodological strategy to promote science learning in as much as the work with literature allows addressing historical and epistemological aspects, often neglected by traditional approaches in science teaching. It matches the Brazilian Curriculum Guidelines in terms of theoretical and methodological orientations contained in these documents, for example, the contextualization of teaching contents, the students' active participation in their dynamics of learning and the conception of science as a human activity, determined by social and historical factors. The innovation seeks to enrich the school science curriculum as it articulates cultural aspects in school and contributes for students' cultural development. The innovation promotes teachers' professional development because it stimulates the reading of literary texts and helps them establish relationships between the literary plot, science contents and pedagogical activities. In this way, it helps teachers to construct new knowledge about science contents as well as to develop autonomy as readers and as researchers.

Description of the innovative practice

Theoretical frameworks:

The innovation is theoretically based upon socio-cultural approaches and language studies. It is based upon Bakhtinian categories such as social language, discourse genres, authoritative discourse, and internally persuasive discourse, amongst others. The innovation makes specific reference to science education research and explores relationships between science and language, between language and science teaching and between science teaching and culture.

Methodology used:

The innovation is implemented in four main steps:

1. Teacher's selection of one or more literary texts, not only dealing with science related topics but also addressing aspects of students' experiential context. It is possible to work with a single text or with several texts in order to explore wider or complementary aspects of the curricular topic. In the Brazilian case, a play written by Machado de Assis, a 19th century Brazilian writer, called "Lição de Botânica" (Botany Lessons) was chosen because of (a) his importance in the Brazilian literature and (b) the explicit reference to botany contents and to issues such as the role of the scientist and to gender issues.
2. Teacher's planning of two groups of activities: (a) development of literary aspects of the literary text – e.g. group readings, formulation of questions, dramatization and (b) development of the science content aspects related to the literary e.g. text production, construction of biological models, analysis of biological specimens, interviews with specialists etc.
3. Implementation of activities (2) with the group(s) of students.
4. Formative and summative evaluation of the innovation.

Resources needed:

Personnel: one science teacher who may work together with other teachers responsible for different school subjects.
Materials: National or international literature texts that address biological or scientific themes. Other school resources can include games, videos, biological collections etc.

Forms of assessment / evaluation used:

Evaluation is made in terms of (i) enthusiasm and participation in the activities, (ii) elaboration of new meanings by the students as expressed by (oral, written, visual) textual production and (iii) better understanding of concepts and related phenomena as revealed by the quality of explanations.

Information available

This innovation was the research object of a PhD thesis, in 2005. Since then, several academic papers have been published both in journals and conference proceedings. Undergraduate essays have also addressed this innovation as their research topic. All of them are written in Portuguese, except the abstracts both in the PhD thesis and in the papers.

Critical features for sustainability

No difficulties have been found that may hinder the success of this innovation so far. The success of this innovation depends on teacher motivation and his/her creative planning of activities. Teachers should feel free to choose the text – both literary and scientific ones - according to their perception of students' needs, age and interests. Topics chosen should be articulated with related curriculum contents and educational resources available.

Critical features for transferability

The innovation is flexible enough to be implemented in different contexts, since literary texts selection is made by the teacher. There should be special care about identifying relevant national literature texts that address biological concepts (as, in the Brazilian case, for Botany) in each country adapting this innovation. Special teacher training is not needed.

Science Blogs

Keywords:
Secondary school, Science Technology and Society, education for sustainable development youth culture and identity, blogs.

Problems addressed

One of the difficulties associated with science learning is building strong connections between school culture and knowledge and youth culture (students' interests and practices). This innovation seeks to promote a critical reflection about the influences of scientific discourses which circulate in the Internet in students' lives, in particular, through a discussion about the ways such discourses concern relationships between science and issues such as politics, consumerism, prejudice, social and environmental impacts.

Quality criteria

Socially relevant: raises the awareness of social, ethical and cultural influence and implications of science and technology; promotes actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues;
Fosters **scientific competencies:** stimulates collaborative work; uses ICT-skills)
Consider **developments in science education** and **science education research**:

Innovation appraisal

This innovation is part of an on-going PhD thesis research which investigates strategies to implement a new science curriculum, based upon post-critical educational theories, in an urban secondary school and that involves the construction of blogs by secondary school students. So far, students have been highly motivated by the proposed activities as a whole. They report that the amount of text produced in the blog activity has been much larger than it would have been on paper. Teachers involved in coordinating the innovation have noted a high intensification of scientific language appropriation and of understanding of scientific inquiry and of scientific concepts. Authorship and quality of texts have been improved. So far, student development can be perceived in the increased potential for critical debate on the presence and impacts of science and technology in everyday life and for changing attitudes regarding actions toward environment preservation.

Relevant information in brief

Topics addressed	Biomechanics and body culture; Chemistry (chemical reactions) and consumerism: cosmetics and garments; Impacts of telecommunication (electromagnetism) in daily life.
Age classes	13-14 years old
Extent	Local. City of São Paulo (State of São Paulo – SE region). 8 regular classes (35 students each) divided in groups of 3-4 students.
Years of experimentation	2 years
Duration	3 months to one year
Main innovation promoters	FEUSP (University of São Paulo)
Main innovation partners	School teachers
Website	http://remexo9b7.blogspot.com
Contact person	Mônica Fogaça (m.fogaca@uol.com.br)

Curriculum relevance and connection to policy guidelines

The innovation addresses demands present in the Brazilian Curriculum Guidelines (PCN and DCNEM) for acknowledging students' culture, interest and forms of expression as relevant points to be addressed and highlighted in science class. It seeks to bring together school culture/knowledge and youth culture, taking techno-culture (mainly practices of expression of young people interest and practices through Internet) as a means to do it.

Description of the innovative practice

This innovation articulates aspects of science knowledge and environmental education through the development of blogs designed by students in order to analyze different techno-scientific issues in contemporary society.

Theoretical frameworks:
Post-critical pedagogy mainly, but also Cultural Studies (Stuart Hall), Sociology of Science (Boaventura Sousa Santos) and discourse analysis (Jay Lemke).

Main aims, features and phases:
The objective of the project is to diagnose, influence and describe transformations of students' identities and attitudes toward scientific, technological and environmental everyday life issues (cruelty to animals, exercise and fitness, fashion and textile industry, impact of telecommunication). The construction of blogs about these issues is the main feature. By these activities, students should learn to read critically how social-scientific issues appear in the techno-culture and the effects of such culture in society.

Methodology used:

a) Mapping youth culture in the community: involves the development of group dynamics, reading and writing activities etc. in order to survey themes that are part of students' daily lives and that are coherent with educational objectives.
b) Raising students' interests in the chosen themes through the exploration of media texts that are present in the students' daily lives (e.g. movie, internet site, songs etc.)
c) Organisation of research activities: working in groups students will define questions to guide their investigation of a given subject aiming its publication in the form of a blog.
d) Mastering the tools needed for blog construction with the help of the teacher and ICT technician and beginning of postage in the blogs.
e) Development of research in textbooks, internet, literature, media texts and of labwork experiments.
f) Planning and making individual portfolios with data collected, conclusions reached and criticism about the inference making process as well as about the theme.
g) Continuous production of postage in the blogs.
h) Selection of a topic related to the nature of media discourse to be problematised (e.g. rhetoric of mass media communication and information reliability; use of imagery)
i) Exchanging information through the contents of colleague's blogs in a constructive and respectful way.
j) Students' self-assessment of their own learning; regular exams at school level.

Resources needed:
Personnel: one teacher, one ICT technician for backup.
Material: Internet Access; one computer for each group of four students approximately.

Form of assessment / evaluation used:
Students' participation in the debates and engagement in the proposed activities. Continuous evaluation of the texts written by the students in terms of quality and awareness and domain of scientific concepts. The main indicator that may be observed by the teacher is the evolving capacity of the student to deconstruct the dominant representations of the nature of science, of technology and of the identities of cultural groups.

Information available

Paper in Portuguese in the proceedings of a Brazilian conference on educational research (average length: 10 pages).

Critical features for sustainability

Access to internet and to library resources. Teacher motivation.

Critical features for transferability

The main features are related to (a) use of technology: reliability of Internet links; access to fully functional computers; support of an ICT technician; (b) teacher education: motivation to learn about ICT and blog construction; interest about and knowledge of local and general youth cultures and attitudes; ability to promote a dialogical work environment with students; (c) curriculum flexibility: selection of science themes should address relevant issues in youth culture; blogs should not be used to "impose" the scientific perspective or language but to "give voice" to the students.

"Carbon dioxide"–an example from the project Science Experience Days (Naturwissenschaftliche Erlebnistage)

Keywords:
Secondary school, hands-on, REC-Research and Education Cooperation, web platform

Problems addressed

- lack of hands-on, inquiry-based science in primary and lower secondary education
- only few independent science-related activities / experimental research activities in primary and lower secondary education
- lack of target-oriented cooperation between schools and industry and the lack of awareness of schools about such existing cooperations.

Quality criteria

Pedagogically and **methodologically** sound: design, learning materials, learning activities and teaching methodology are clearly described and consistent with the pedagogical basis.
Fosters **scientific competencies**: includes practical work (hands-on activities, lab-work, experiments), offers inquiry based learning activities
Supports teacher participation and **professional development**: stimulates peer reviews and visits to classes of other teachers inside and outside school(s) to give each other professional feedback.

Innovation appraisal

- the number of participants/ web-site visitors shows strong interest in the project
- more than 20 "special" schools permanently involved in the network "Science Experience Days"
- networking activities on the platform "lo-net2"

Relevant information in brief

Topics addressed	"Carbon dioxide"–an example from the platform Science Experience Days (Naturwissenschaftliche Erlebnistage), interdisciplinary (Chemistry, Biology)
Age classes	Lower secondary education: age 11-14
Extent	Regional (Baden-Wuerttemberg), groups up to 30 pupils
Years of experimentation	Pilot phase: 2003, ongoing increase of education units and partners in industry and research institutions
Duration	Compulsory part: 3h – 4h, optional part: 4h-8h according to depth
Main innovation promoters	"Science Experience Days" organization, many different schools all over Baden-Wuerttemberg
Main innovation partners	Chemical Associations Baden-Wurttemberg (Chemie-Verbaende Baden-Wuerttemberg), Ministry of Culture, Youth and Sports Baden-Wurttemberg
Website	http://www.nawitage.de/
Contact person	Maja Jeretin-Kopf, Dr. Tobias Pacher

Curriculum relevance and connection to policy guidelines

The topics are relevant to either the primary and the secondary biology or chemistry curriculum; they are part of the science curriculum of the state/region Baden-Wuerttemberg.

Description of the innovative practice

Within the platform "Science Experience Days" pupils should be motivated by different learning conditions: the platform supports the identification and the contact for cooperation partners for schools (e.g. research institutions, industry), the presentation can be held at a special school from the network and the participation/cooperation of students and researchers from teacher training institutions will be arranged. All project ideas have been revised by relevant industrial enterprises to current procedures and terminology used in the industry.

The materials of this practice should enable pupils and students to carry out scientific projects independently to a large extent. In this education unit, students explore mineral water and the contained carbonic acid / carbon dioxide in practical experiments. They start with "closely guided" work orders that contain detailed instructions for the experiments and go on to increasingly more open forms of work. The work-book includes a compulsory part that should be followed completely and an optional part. The latter encourages an in-depth study of the topic, for example by doing a demonstration experiment for the whole class or by doing an online survey among fellow classmates – also from other cooperating schools.

Main aims, features and phases:

The instructions for the experiment of this education unit come from the series "project idea" (from the platform "Science Experience Days") and offer assistance for the processing of tasks. It includes experiments and research tasks. The students can deal with the problems individually or in groups, but group work should be preferred.

Learners should acquire a number of competencies; pupils / students should:

- expand their scientific knowledge and methodological skills
- determine an indicator of the degree of acidity of mineral water and examine the behaviour of carbon dioxide in solution in water
- research on the Internet and document their learning outcomes
- plan and perform their own experiments according to the methods acquired during the first part of the education unit
- create and perform an online survey
- present the tests/experiments and test/experiment results

The compulsory part deals with a number of given questions and experiments as well as research questions to be solved with the help of the Internet and documentation. Within the optional part learners become teachers as they present their experiments as hands-on, collaborative experiments for all, create and test a survey using the guided platform "lo-net2" and are given further tasks in a collection of questions and problems that should be solved individually or at home.

Methodology used:

- **Hands-on**: pupils activities are centred on hands-on experiments
- **Inquiry-based learning**: All experiments are part of a learning cycle, which starts with examining the knowledge that the pupils already have, followed by the experiment and an interpretation of and presentation of data/results
- **Working in groups**: collaborative experiments and tasks through most of the educational unit

Resources needed:

- basic laboratory equipment, basic chemicals, sufficient for a suitable number of pupils or groups of pupils, suitable number of computer working places, Internet access

Form of assessment/evaluation used:

- survey among pupils/groups of pupils/schools about achievement in terms of knowledge and competencies

Information available

- working material, description of experiments (German, 10 pages)
- templates for expert folders, working plans, documentation and research, experimental works, technical works (German, available on the web-site of "Science Experience Days", http://www.nawitage.de/

Critical features for sustainability

For a successful and broadly based link between industry, research institutions and schools a platform like "Science Experience Days" and "lo-net2" is necessary. Such a platform has to be maintained and basic staff for coordination should be available. Single education units like the one described here can also be tried at classroom level (without these platforms).

Critical features for transferability

- easy access and usability of the provided information and materials, simple and clear documentation (only in German)

- web-site and materials well structured but not available in English
- funding needed for the setting-up and maintenance of a platform and basic staff for a coordination between schools and industry/research institutions

A minimum aquarium

Keywords:
Inquiry Based Science Learning, ecology, lower/upper secondary school, update scientific practice.

Problems addressed

Low interest in science and technology; lack of Inquiry Based Learning and Teaching and predominance of rote learning in Italian schools (TIMMS and PISA data); naive images of science; distance of the teaching proposals from actual scientific practices.

Quality criteria

Scientifically sound: provides insight in the way scientific knowledge is constructed ,using the same living organisms than the research labs.
Pedagogically and **methodologically sound**: learning materials and activities take current theories about science learning into account.
Fosters **scientific competences** and literacy: identifies scientific issues, explains phenomena scientifically, uses scientific evidence; includes hands-on activities and experiments , stimulates collaborative work.

Innovation appraisal

The proposal was launched within the National Educational Plan for Experimental Sciences Teaching (ISS), and the evaluation carried out through teachers log books and national monitoring was positive.

Relevant information in brief

Topics addressed	An aquarium is at the centre of a multidisciplinary/interdisciplinary approach, where biology, physics and chemistry are integrated
Age classes	11 – 15 year old. Lower and upper Secondary school
Extent	National. Full classes involved
Years of experimentation	The experimentation started in 2006 and it is still running
Duration	10/20 hours for minimum 2 months (in order to follow the life cycle)
Main innovation promoters	ANISN - Italian Teachers Associations for Natural Science teaching –
Main innovation partners	ISS Educational Plan, Italian Ministry of Education
Website	www.openscience.it
Contact person	anna.pascucci@gmail.com

Curriculum relevance and connection to policy guidelines

The innovation is part of the compulsory curriculum for Lower Secondary school and it is included in the Italian Natural Science Teachers association (ANISN) guidelines. The activity was planned and set up for didactic purpose in a joint program where teachers and scientists are intended to work in collaboration. It was also launched and disseminated within the National ISS (Teaching Experimental Sciences) Plan. The educational activity is planned to be implemented in the classroom although the stages of the experience and the fact of working with living organisms allow for close cooperation with Museums and Research institutes that could enrich the experience.

Description of the innovative practice

Theoretical frameworks: The proposal is based on the constructivist perspective and on the IBST - Inquiry Based Science Teaching - methodology. The main idea is to propose the same organisms and steps of observations used by research labs in order to give the feeling of 'true research' and to have updated data and information.

Main aims, features and phases: The proposal is to use a simple aquarium – the simplest one – as a model of the relations between living organisms and their environment. The setting up of an aquarium allows students: to identify the biotic and abiotic components necessary for the reconstruction of an environment suitable for the organisms chosen; to formulate questions and hypotheses to explain facts and phenomena and to organize successfully the observation, identifying the more effective tools; to identify the role that different elements have in an ecosystem, and find connections between them; to classify organisms and to observe the reproduction of the organisms in the aquarium. The aquarium is a freshwater aquarium and the few organisms are chosen because of their "educational characteristics". The fish chosen have different characteristics (viviparous/oviparous) and are the same as those used in real research labs. Using the aquarium students can identify the links between different parts of the aquarium-system, observe various organisms and their relationships, observe the fish breeding, and make hypotheses about the mechanisms regulating the balance in the environment and the factors allowing life. Also physical phenomena – such as light refraction and reflection, floating and pressure - and chemical phenomena as pH, salt solution and concentration - are examined.

Methodology used: The students themselves take care of the aquarium that is permanently in the classroom. They observe, discuss together and with the teacher about the events, often unexpected. They ask questions, discuss problems coming from the observation of aquarium-system and look for solutions. The way of working recall continuously the prior knowledge of the children, allowing them to compare what they know from common sense knowledge with scientific knowledge. The students are asked to take responsibility for this small 'environment' and to reflect on what this responsibility means in broader terms.

Resources needed: The activity requires: an aquarium with a lamp and temperature regulator, aquatic plants, the suggested fishes, a stereomicroscope, an optical microscope.

Added value of an adaptation: The exchange of observations, pictures and questions between classes in different countries could help students in reflecting on the importance of environmental conditions and on cultural diversity.

Form of assessment/evaluation used: The evaluation proposed is a formative one where the logbooks of the groups of students are assessed. Also competence items have been prepared for summative tests.

Information available

A full description on how to set up the aquarium and how to present and conduct the activity with the students is available in Italian, including PPT, pictures and working sheets addressed both to students and teachers. The minimum to translate is between 10-20 pages. Part of them have been already translated in English: http://www.openscience.it/opendanioeng.htm. Indications for further reading are available in all languages (Lorenz writings).

Critical features for sustainability

The innovative practice has been implemented in many regular classrooms as part of regular courses, the teachers have been trained in national training courses, but also in e-learning courses using the available materials.

Critical features for transferability

The cost of the aquarium is low but not so low - about 600 euro -. Students and teachers need to have the willingness to learn by trial and error what a living system means.

Evolution “on display”: using a Museum to approach evolutionary issues

Keywords:
Biological evolution, bio-lab in museums, framing concepts on evolution, meaningful learning, epistemological obstacles

Problems addressed

The knowledge of evolutionary phenomena is entrusted to scientific teaching, which, in Italy (and not only in Italy) faces many difficulties: few available hours and tools, few opportunities for teacher training, and few possibilities for integrative curricular experiences. In the last few years biological evolution has occupied continuously less space in our curriculum. Added to this is the difficulty of the theory itself (Mayr, 2004, points out that actually we should consider evolution inclusive of five theories): the comprehension of biological evolution requires not only basic scientific knowledge about the organization of living beings, but also a good mastery of the concept of species, classification criteria, some principle of genetics, and understanding of the nature of science. Moreover, the comprehension of evolution is made more difficult by a number of conceptual and epistemological obstacles (like finalism and determinism) caused by social representations, common education and cultural, philosophical, religious and logical problems.

Quality criteria/indicators addressed

Scientifically sound: Provide insight in the way scientific knowledge is constructed taking into account the conceptual obstacles that prevent the passage from common sense to scientific understanding.
Foster **scientific competencies** and scientific literacy: identifies scientific issues, explains phenomena scientifically, uses scientific evidence; stimulates argumentation and critical thinking.
Socially relevant: Use resources and teaching contexts from outside the school.

Innovation appraisal

This innovative teaching and learning strategy was very well received by teachers and students. They have appreciated particularly the museum context/setting with exhibits and biological specimens, the laboratory and creative activities, the interactive and informal approach.

Relevant information in brief

Topics addressed	Evolution Theory and meaningful learning
Age classes	Primary, secondary, high School
Extent	Local. Number of classes/groups of students involved: 60
Years of experimentation	Two years
Duration	Primary School: 2 visits (approx. 8 hours) in Museum; Lower Secondary School: 3 visits (approx 12 hours) in Museum + work in class; Higher secondary school: 2-3 visits (approx. 10-12 hours) in Museum + work in class
Main innovation promoters	Italian Ministry of Education. Culture Bureau of Rome Municipality.
Main innovation partners	ANMS - Scientific Museums National Association.
Website	www.museodizoologia.it
Contact person	Elisabetta Falchetti, Zoological Museum of Rome; elisabettamaria.falchetti@comune.roma.it

Curriculum relevance and connection to policy guidelines

Evolution is the main topic of Biological curricula in the Secondary School and some preliminary issues are also introduced in the primary school. This innovative proposal is explicitly connected with the National ISS (Teaching Experimental Sciences) Plan of the Italian Ministry of Education, and with PISA suggestions as far as the methodological approach is concerned.

Description of the innovative practice

The themes of this educational proposal were selected taking into account the conceptual obstacles that prevent the passage from common sense to scientific understanding: (1) the difficulty with the concept of geological time; 2) the impossibility of verifying evolutionary changes in organisms and environments; 3) the connection (in a non finalist way) of shapes and structures of living beings to the environment; 4) perceiving the diversity of living beings and their different forms of organization; 5) explaining the origins of diversity.
The following "framing concepts" about evolution have been proposed:
1) living forms and natural environments change and have mutated repeatedly over time. This assumption is necessary to understand evolution and "accept" that all living beings evolve and to explain the origin and history of life on Earth;
2) the environment interacts with living beings; the elements of the environment are "agents", "factors,". This assumption is necessary to understand adaptation and natural selection;
3) diversity is an emerging property of living beings at different levels of life organization. This concept is necessary to understand diversity as the basis and the result of evolutionary processes (new species and adaptations), and the potential to apply new vital strategies;
4) genetic diversity exists; the genetic code is universal and explains "unity in diversity". These assumptions can support the understanding of the common origin of living beings and their evolution by natural selection.

The museum context facilitates the understanding of the evolutionary issues because the design of the modern exhibits is inspired by evolution: in fact specimens and natural objects are exposed following standards that emphasize the diversity of life and the relationships between living beings and their environments. For example, many exhibitions show different specimens belonging to the same species to facilitate the comprehension of intra-specific diversity by the comparison of individual traits, as other exhibitions display different levels of taxonomic-interspecific biodiversity. The "dioramas" reproduce natural environments to emphasize the diversity of biotic communities (ecological diversity). Other exhibits show adaptations to illustrate influence of ecological factors and natural selection.

Theoretical frameworks: 1) It is difficult to gain *meaningful learning* on the evolutionary theory (this is confirmed by the fact that, even after schooling, the tendency to provide teleological or Lamarckian explanations for evolutionary processes persists); in this innovative practice learning is the result of a conceptual change and meaning is achieved only if new knowledge is connected to pre-existing knowledge. As a consequence, the educational strategies are constructive and active, based on revision and improvement of personal conceptual frameworks, by means of personal inquiry and involvement, practical experiences, social cultural exchange. 2) The proposal aims at creating a basis and laying foundations on which to build new knowledge and give a sense to the evolutionary concepts, rather than explain (directly) the formal contents/assumptions of the theory. 3) The "laboratory" was conceived not only as a space where experiments could be done, but also as an experimental procedure and a model for reasoning (inquiry based and problems posing learning), as it is in real scientific work/research. 4) Biological museums are considered "learning environments" that facilitate understanding of scientific concepts (Giordan, 1984), because they can interest, motivate, stimulate personal inquiry and reflection and help visitors to form ideas. 5) The study of evolution "by examples" is advisable; it was found, in fact, that reasoning over observable and concrete cases stimulates interest and questions and facilitates comprehension.

Main aims, features and phases: main aims are 1) to support the scholastic formal approach to evolution with laboratory practices, observations of specimens and museum exhibits; 2) to stimulate students' and teachers' interest in this fundamental theory; 3) to improve collaboration between Museum and School.

Features and phases: planning of the didactic aims and strategies and of the objectives of research; planning and realization of exhibits in the Museum with particular specimens and laboratory spaces, integrated by two exhibits dedicated to Charles Darwin and one exhibit showing the modern research in evolutionary biology in the Museum; contact with teachers; training of museum educators; experimentation with "pilot classes"; experimentation with the interested Schools; analysis of the questionnaires and proofs of the students.
This innovation has had both aspects of curricular innovation and research on scientific teaching in Schools and Museums.

Methodology used: In a large room of the Zoological Museum, the four framing concepts (see above) were presented in four displays each composed by exhibits and laboratory spaces for practical experiences. In each exhibition the students observed biological specimens, simulated

scientific research and discussed in working groups. For example, to reflect on the change of life forms over time, an exhibit was created with fossil specimens and a small paleontological laboratory, complete with a reproduction of a paleontological dig. Here students simulated the practical work, observations, research questions and the way of thinking of paleontologists. The dig helped to imagine paleo-environments, extinctions and change in living organisms. Fossils gave an example of the diversity in life forms and a confirmation of extinction and change. Diagrams, drawings, tracings/moulds were realized to reconstruct shapes and paleo-environments. In the exhibit dedicated to biodiversity students observed, compared and described differences and similarities of the specimens, and traced hypothesis on evolutionary relationships. Particular attention was given to "not visible" biodiversity. Through microscopic observation, students discovered similarities and the sharing of some fundamental characteristics (for example the common cell organization in all living organisms) in macro and micro living beings, but also differences in the same organism (for example cell diversity) and among different species. This experience stimulated reflections on common origin and relatedness but also diversity and its origin. Various species of small mammals were available to allow students to plan and create freely their own exhibit to illustrate cases of biodiversity; this exercise stimulated students to note similitude or differences and to explain them in terms of adaptation to life environments.
Interactions between museum educators and teachers were integrated into the process. Dialogue and guided discussions were developed to start from participants' previous knowledge and ideas about evolution. These moments represented a point of strength of the experience, because they revealed misconceptions and ideas that could hinder understanding and learning. Rather than as "informers," the educators acted as "organizers" of the cognitive processes of the students, stimulating them to recall their knowledge, to examine their languages and definitions, inviting them to observe and experiment, suggesting strategies to change their points of view from common sense to scientific.

Resources needed: one teacher for every classmuseum educators/experts; fossil specimens (or models/reproductions) and set for simulation of paleontological researches (1° framework concept); a variety of biological specimens to facilitate discussion about relationships between morphological shapes and functions (2° concept; we used some Insects, because they show original, extremely efficient and easily observable adaptations, e.g. exoskeleton, wings, mouth apparatus) and about taxonomic biodiversity (3° concept; we used many invertebrate and vertebrate specimens); moreover simple lab instruments as microscopy, stereomicroscopy to observe biodiversity in microscopic/little organisms (3° concept) and chromosomes (4° concept; we used cellules of roots of onion in mitosis); only for the high school, kit for DNA extraction (4° concept).

Added value of an adaptation: It would be very interesting to compare "misconceptions" or "naïve/common ideas" of the students about the evolution and the effects of the museum teaching experiences in different countries.

Form of assessment/evaluation used: Questionnaire pre-post every experience and final test to check changing of ideas; analysis of the conversations.

Information available

Materials addressed to students and prepared for teachers in Italian; 10 pages minimum to translate; for the teachers an article, available in English, explains all the aspects, topics, didactic strategies of this innovation (E. Falchetti, "Communicating biological evolution through the Museum in the year of Darwin 2009: an experimental study on themes and methods", in press).

Critical features for sustainability

This innovative practice has been implemented in many regular classrooms as a part of regular courses and in "pilot classes".

Critical features for transferability

The innovation is flexible enough to be adapted in different contexts, focusing on only 1 or 2 of the concepts proposed. All naturalistic/biological Museums have and display a great variety of animal collections and they generally collaborate with Schools in the scientific teaching. If there are not Museums it is possible to reconstruct the setting/context in Schools and organize similar experiences and observations using natural specimens or models (see resources needed).

The “parallel globe”: perceiving ourselves on a spherical Earth

Keywords
Lower secondary school, astronomical basic knowledge, perception vs knowledge, initial conceptions, relativity of interpretations.

Problems addressed
The innovation reacts to the lack of scientific competences in basic astronomical concepts and against the widespread rote learning of astronomical facts. It takes account of extended dissatisfaction with traditional ways of presenting astronomical concepts (like planet Earth in space and the gravitational field; day and night; seasons; …) where standard representations - as geographical maps and standard globes often identical all around the world – are used. It is part of the general problem "grasping the complexity of real life" because main astronomical ideas are important to understand National History and literature as well as are part of our everyday life and environment. The topic has also some intercultural values.

Quality criteria
Scientifically sound: proposes a more effective presentation of the same scientific content/ knowledge in different contexts;
Fosters **scientific competencies:** offers inquiry based learning activities stressing the relativity of the interpretations.
Considers **developments in science education** and **science education research:** the innovation is baked by, and contributes to, research on science education.

Innovation appraisal
Teachers and students (8-18 y) as well as adults are all very interested in astronomical topics. The topic (what we know about Earth in space vs our everyday perception) has been appreciated by many students, teachers, adults groups in many countries for emotional as well as cognitive reasons. The use of the model (the parallel globe) to help with the visualization of the Earth from different perspectives has been considered very efficient.

Relevant information in brief

Topics addressed	Earth and Sun: the local and the global point of view; motion and light/shadows.
Age classes	8-18
Extent	International (EUROPE, SOUTH AMERICA) National and Local Number of classes/groups of students involved: hundreds of students
Years of experimentation	from 1985
Duration	From a minimum of 2 hours to 8-10 depending on the age of students and on the activities proposed
Main innovation promoters	N. Lanciano Uniroma1; the MCE group of "Pedagogia del cielo" (Sky pedagogy); E. Giordano, Univ. of Milano-Bicocca; some expert teachers (L. Fucili, O. Tomasetti, P. Bonelli Majorino, P. Catalani, L. Corbo)
Main innovation partners	Museums /Ministry of education within the ISS (Teaching Experimental Sciences) Plan
Website	http://didascienze.formazione.unimib.it/Lanciano/il_mappamondo_parallelo.htm
Contact person	Nicoletta Lanciano, nicoletta.Lanciano@uniroma1.it; Enrica Giordano, enrica.giordano@unimib.it

Curriculum relevance and connection to policy guidelines
The national curriculum for compulsory school (6-14 year old) includes as an important topic ‘Earth in space’ while motion and light are part of physics teaching. It is unusual to teach the latter ones starting from or referring to astronomy. The parallel globe is a very stimulating object to use in summer/outside stages for

formal and informal learning (e.g. orienteering). Many PISA and TIMSS items refer to night and day, seasons, etc.

Description of the innovative practice

The innovation proposes to free the common 'earth globe' from its support and to place it outside, under the Sun's rays, with its axis parallel to the Earth axis as oriented on the local Horizon i.e. pointing to the Polar Star, inclined on the horizontal local plane of an angle equal to the latitude, with the local geographic position on the higher position (see the picture) and the site http://didascienze.formazione.unimib.it/Lanciano /strumento_flessibile.htm.

In this way the globe represents exactly the local situation and ourselves with the Earth. The horizontal plane under our feet is seen like part of the tangent plane to the spherical Earth at the observer point, and can be used to reflect upon. Many other phenomena occurring on the real Earth can be recognized on the model (in which part of the globe is day or night; where is midday; where the sun is setting and where it is rising; etc.)

The "parallel globe"

Theoretical frameworks: The Constructivist perspective and the IBST-Inquiry Based Science Teaching are the main points of reference about the teaching/learning methodology. Research and education collaboration about Pedagogical Content Knowledge and the importance of modelling in science and understanding are also relevant.

Main aims, features and phases:

Aims: Learning how to connect what we see from our local point of view about the Earth, Sun and the sky with what is represented in standard maps/globes and is usually taught about Earth in the solar system (always represented from an external perspective). Geographical maps usually on the walls of the classroom erroneously suggest that North is "up"; traditional globes erroneously suggest that the Earth's axis has the same inclination on different local horizons; etc.

Learning to connect observations/representations through different media (bidimensional drawings, 3-dimensional objects; static and animated models; simulations; …)/interpretation in different "systems of reference", avoiding initial conceptions concerning flat/round Earth.

Methodology used: The innovation is based on the integration of field observations and data collection (about day/night cycle in different seasons and in different points on the planet; about local solar noon, the sun position and the shadow of a gnomon; meridians on the Earth/globe, the North/South direction and the use of models) with "expert" knowledge presented in books, astronomical websites; etc.

Outdoor observation with simple instruments and models have to be shared with groups of students; models help to visualize objects and phenomena on a time/distance scale otherwise impossible to manage; discussions with peers help students to understand that different interpretations are possible about the same observations and to respect different ideas; reading about history (in particular Giordano Bruno and Galileo for Italian students) can demonstrate how science can pass through big changes of paradigms and show the connection between Science and Society. ICT can help to construct communities of learners under the same sky but looking at it from different points of the Earth. The globe in the sun will show what is happening at the same time in different locations: what time is in Mexico when in Italy we are at noon, if it is early morning or evening, what is the height of the Sun on their horizon, what pole is lit up, …

Resources needed: Globes with a mobile support; sticks to be put on the globe surface to look for shadows; compass; photos of the Earth at different times and seasons and from different locations (as http://www.fourmilab.ch/earthview/). Some countries (Italy, Spain, Argentina,…) have built 'parallel globes' in open spaces for students' use.

Added value of an adaptation: The adaptation in different countries/places will add value to the innovation (e.g. interchange of photos and data between classes experimenting with the parallel globe in different countries) and introduce the "look locally/think globally" problem.

Information available

Many sources of information are available, for instance:
In Italian: http://didascienze.formazione.unimib.it/Lanciano/il_mappamondo_parallelo.htm;
In French: http://math.unipa.it/~grim/cieaem/cieaem57_lanciano_tomassetti.pdf,
In English: Leonarda Fucili, *The shape of the Earth and of the Sky : thinking about a round world,* IV summer school EAAE , Tavira Portugal, july 2000, pdf available
In Spanish it is possible to have a look at a webquest based on the same idea: http://www.eibarpat.net/webquest/lasombradelatorreEiffel/acti4.html

Critical features for sustainability

The innovative practice has been implemented in regular classrooms, as part of regular courses in primary and secondary schools, and in teacher training courses. The level of presentation and discussion can be deepened according to the age of the students.

Critical features for transferability

The innovation is flexible enough to be adapted to different contexts. The critical points for the success of the innovation could be teachers or parents giving low importance to observations and personal involvement in knowledge construction through imagination and models.

Robotics in your school

Keywords:
Secondary school, inquiry learning, robotics, hands on, gender.

Problems addressed

Lack of interest in physics among secondary school students, especially girls.
Lack of innovative and successful practices to motivate teachers to address issues of physics at secondary schools.
In many locations in Mexico there is a lack of options for use of leisure time for youth. Students attend school in after-school hours to attend a robotic club; this has been an alternative use of leisure time.

Quality criteria:

Pedagogically and **methodologically** sound: motivation / interest in science is stimulated.
Fosters **scientific competencies**: includes practical work (hands on activities, lab work, experiments etc.). Offers inquiry based learning activities. Stimulates collaborative work.
Supports **teacher participation** and **professional development**: teachers are involved in designing or adapting the innovation to their own specific situation. Training opportunities are offered within and or outside school.

Innovation appraisal

Evaluation has not been performed, however, the innovation has been received with great enthusiasm in participating schools. In fact, after each application more schools formally request to join the program.
There has been high participation of girls in extracurricular robotics clubs. A girl's team from a participating school has participated in national and international robotics competitions getting first places. Some children have won several prizes in national robotics and mecatronics competitions and have received grants for a higher education. As a result of their participation in this innovation many students (many girls) have expressed their interest in pursue science careers (mecatronics, robotics, engineering, etc.).

Relevant information in short

Topics addressed	Physics, simple machines, pneumatic, robotic.
Age classes	13 to 15 years old.
Extent	Local: Monterrey, 33 schools.
Years of experimentation	4 years.
Duration	12 sessions of one hour (It may extend throughout the school year).
Main innovation promoters	Ministry of education of Nuevo León.
Main innovation partners	Ministry of education of Nuevo León, LEGO Dinamarca.
Website	
Contact person	Adrianna Elizondo, adriana_elizondo@yahoo.com

Curriculum relevance and connection to policy guidelines

This innovation has been integrated into the official curriculum (physics). It follows the national and international recommendations to provide both girls and boys with equal opportunities to participate in science activities in school.

Description of the innovative practice

Theoretical frame: project-based methodology.
In the activities, students develop different solutions to the same problem; they solve the problems independently. To solve the problems they formulate a hypothesis, test their hypothesis with the development of mechanisms or robots, and find solutions to practical problems of handling the world.

Participants start from the concrete and the teachers help them to deduce from it the abstract concepts; the teachers also introduce physics models.

MEXICO Lower secondary

Main aims, features and phases:

- Motivate students to study physics.
- Promote an open inquiry and genuine problem-solving in the classrooms.
- Promote equal participation of both girls and boys in science activities.

Methodology used:

Initially there is a teacher training program for handling robotics and simple machines equipment. In robotics this training is given by Lego experts and for simple machines and pneumatics topic is given by expert teachers. In the class students with experience (from other class groups) work as multipliers or mentors and help other students.

In physics class, teachers address some topics through problems. For example; in simple machines, there is a problem of planning and making a catapult to throw objects at a distance. Students work in teams of six members in three working sessions devoted to design and build a catapult.

During the sessions physics concepts are introduced as students are requesting them. At the end of the three sessions, each team explains the proposed solution and the physics principles involved. Students solve different problems, initially with simple machines and then with pneumatic machines. For the final part of the course, students develop a robot and make a presentation to parents, explaining the purpose of the robot, design, practical and theoretical difficulties and physics principles involved.

Resources needed: Kits are required, depending on the topic to be discussed: pneumatics, renewable energy, simple machines or robotic (LEGO NXT and RCX).

Form of assessment / evaluation used:

Learning is evaluated according to criteria established by each teacher; most of them evaluate through the project development and outputs.

Information available

Description of how to link the kits activities with curriculum issues (20 pages in Spanish).
Training manuals with many options to construct machines or robots are available in the LEGO kits (useful for all languages as they contain a graphic description).
In Mexico novice teachers use the description of activities given by the ministry and expertise use the LEGO manuals and they design their own activities.
LEGO provides training to teachers who purchase equipment.

Critical features for sustainability

The innovation has been implemented in regular classes with great success. Moreover, many schools have created robotics clubs because of this innovation. In the robotics clubs student participate in an extracurricular manner. These students clubs allow students to use more the robotics equipment and generate motivation to study science among young women and men.

Critical features for transferability

The key feature is to purchase robotics equipment and simple machines, which can be expensive. In Mexico some school obtain donations from industry and from LEGO Company.

Degree in Medicine ©

Keywords:
Primary and lower secondary school, health, inquiry, hands on, problem based learning.

Problems addressed:

The Mexican health system does not rely either on sources or culture to solve the new public health problems that are exponentially growing. Today one of the most serious health issue in Mexico is obesity; it is present in more than half the Mexican population, and the worst part is the alarming growth among children.
Self-medication is another common health problem among the Mexican population; it has become in recent decades a very wrong habit, common in everyday life and in most of the adults (average 60%). It has become one of the most serious problems facing the world population and more than 7 million deaths in 2007 may be attributed to obesity. In addition, most children's deaths by accident occur at home, which, in theory, should be the safest area for children.

Quality criteria

Fosters **scientific competencies**: fosters scientific literacy (identify scientific issues, explain phenomena scientifically, use scientific evidence). Include practical work (hands-on activities, lab-work, experiments etc.). Include decision-making activities.
Socially relevant: address national problems in science education; promote actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues.
Supports **teacher participation** and **professional development**: stimulate peer reviews and visits to classes of other teachers inside and outside school(s) to give each other professional feedback.

Innovation appraisal

The innovation is well received, by students, teachers and parents. In order to analyze the short (immediate) and medium term (one to two years) results with participating students, there is a current monitoring going on. Questionnaires have been given to each student, one at the beginning and one at the end of the course; in the first one key concepts, preconceptions of the topics to be discussed at the meetings, attitude toward science and knowledge and career choice have been explored. Participants have been contacted after a year of completion of the course in order to ask again about attitudes toward science and knowledge, and career choice.

Relevant information in short

Topics addressed	Human body systems, senses, nutrition, Biomedicine, accident prevention and first aid.
Age classes	6 to 15 years old in groups (6-9 years, 9-12 years and 12-15 years).
Extent	Metropolitan area of Monterrey, Nuevo León, México.
Years of experimentation	January to April of 2009. New groups will be on summer 2010.
Duration	12 sessions of 3 hour each.
Main innovation promoters	Steel museum horno^3 , Autonomous University of Nuevo León (UANL) and the University Hospital
Main innovation Partners	Steel museum horno^3, University Hospital and the Medicine school from the Autonomous University of Nuevo León.
Website	www.horno3.org
Contact person	Dra. Claudia Fernández Limón, claudiafernandez@horno3.org

Curriculum relevance and connection to policy guidelines

The innovation is part of the curriculum concerning knowledge of the human body and their functioning, as well as accident prevention and health care.

It responds to concerns of health authorities with regard to childhood obesity rates whose main causes are wrong diet and sedentary culture to which children are exposed.
The country's health authorities that have launched programs to prevent accidents and to avoid self-medication, have argued that is essential to work directly with children to develop awareness of these issues of relevance in the population.

Description of the innovative practice

Theoretical frame: The themes are addressed in a trans-disciplinary manner, seeking the connection between sciences. Human body knowledge is approached through their systems and their relations.

Main aims features and phases: The aim of course of medicine for children is to promote the interest of children and youth in the care of their own body and promote health, to prevent common diseases. The specific objectives are:

- Knowledge of how each system part of the human body work
- Deduction of the consequences of wrong food intake
- Understanding of common diseases

In each session different system parts of the human body are analyzed: the function, composition and structure, the form each system operates in relation with others. At the end of each session students establish the relationships between the system they studied in the session and other systems. One key aspect in every session is the relations between the system on study and the whole body to keep our body healthy (diet, exercise and prevention) and what to do in case of disease (first aid).

One session addresses the skeletal system. In a chicken bone, they do transverse or longitudinal cuts and using a magnifying glass they observe the blood cells.Tthe group interprets the relation between blood and bones. Another chicken bone is soaked in vinegar, and this is observed during the following weeks. Participants keep a record of their observations and discuss their results. To discuss the care of bones, there is a talk about the calcium intake and healthy foods. To end actions are performed to treat fractures.

Subsequently the muscular system is studied. Participants are encouraged to make various types of physical exercises, to identify muscles in motion. They touch the different muscles of their body and learn some names. They recognize the striated and smooth muscles in a piece of beef and study ta pig’sheart.

With appropriate hygiene measures, such as gloves, goggles and apron, they proceed to pig heart dissections, for which they are presented the function of the heart and the appropriate security measures are analyzed. When the dissection of heart is done, participants observe ventricles, atria, arteries and veins. Each participant opens a heart, touches it and feels the different textures, comparing the hardness of the heart muscle with other muscles of the body.

The cardiovascular system is analyzed through medical models; they notice the difference between veins and arteries. With a PVC tube, representing the heart arteries and plasticine representing cholesterol, the degree of obstruction with inadequate food intake is analyzed. A thick mixture was passed through a transparent hose to directly observe the flow of blood, and then an intervention is done with a device representing the catheterization.

Blindfolded participants smell and test various foods, or hot or cold objects are offered to them to analyze their responses to those stimuli. The operation of the nervous system is explored with a game of how information is passed, each participant represents one neuron, their arms axons, and their fingers dendrites. A neuron is represented using different materials (ball, plasticine, etc.).

For the study of the respiratory system a dissection of pig lungs is made. First, participants observe their operation through a hose through the inflated trachea then membranes, bronchi and bronchioles are identified. The care of the respiratory system is discussed.

For the digestive system, after the explanation, a dissection of the pork stomach is made. Relation with the circulatory and respiratory system was establishing using the question: What does my finger need to grow?

In the last session of the course participants do demonstrations of learning. Each student does a presentation of the most significant part of the course for them, and prepares some activities; it must include an explanation, prevention, food and first aid. It is important to note that the topic of food is not explained as a specific subject in one session. This topic is addressed across all sessions.

Metodology used: The work is done in collaborative teams that solve real problems. Analogies and models are used, and dissections are performed**.**

Resource requirements:
Staff:

For 30 children: It works with three instructors. It is essential that in each session, within the personal, medical student attending an advanced or licensed physician.

Materials:

Reuse materials like cardboard, cans, wood, sheets, etc.
Dissection kits.
Pig organs for dissection of heart, lung and stomach, chicken bones.
Power Point presentations.
Medical models: Human body, real size skeleton, torso with organs, etc.

Form of assessment / evaluation used: Learning diary of each of the members (observation and record on a checklist of progress in developing the competencies of each member).
The last session is delivered to parents a precis of these observations in a worksheet that summarizes the development of their child.

Information Available

A folder with all the information of the course, from administrative controls, logistics, program, program of each of the sessions, materials, PowerPoint presentations (for each of the sessions and the parents meeting), surveys, questionnaires etc. All this information is in electronic format. It also features a photographic archive of meetings and some videos.
It could be a 20-page compendium; however original documents form a folder of more than 150 pages.
Language: Spanish

Critical features for sustainability

The Innovation is not made in regular classes but can be implemented in a classroom.

Critical features for transferability

It is intended that the group of instructors have a person from the medical field.
In the proposal each body system are studied in an individual session, but is very important to establish relations between systems and the whole function of the body. For transferability some sessions can be included to establish such relations; this can be done when health issues are introduced.
In this innovation multi-age groups are proposed, in school this teaching style depends on the internal organization of the professors.

Sustainable development©

Keywords:
Primary and lower secondary school, sustainable development, argumentation, problem-based learning.

Problems addressed

Mexico faces lack of student interest in science, lack of focus on practical work in science classes and low performance in science.
The issue of natural capital is not taught in a comprehensive manner, and teachers are unaware of its importance, almost all the population tending to have lifestyles more and more away from the planet's sustainability.

Quality criteria

Fosters **scientific competencies**: stimulates argumentation and critical thinking; include decision-making activities; include practical work (hands on activities, lab work, experiments etc.).
Socially relevant: address national problems in science education; promote changes or improvements in educational contexts.
Supports teacher participation and **professional development**: stimulates peer reviews and visits to classes of other teachers inside and outside school(s) to give each other professional feedback. The innovation has a clear teacher manual.

Innovation appraisal

The innovation is well received by students, teachers and parents.
Questionnaires include key concepts of the topics of sustainable development, attitude toward science, knowledge and career choice. One year after course completion, students are contacted in order to re-measure their attitudes toward science, knowledge and career choice.

Relevant information in short

Topics addressed	Natural resources and ecosystems. Cities, demography and human population, transportation and communication. Food and pollution. Alternative Energy and Global Warming.
Age Classes	6 to 15 years old in groups. (6-9, 9-12 and 12-15 years). Students independently apply for the course and groups are organized according to attendees.
Extent	Metropolitan area of Monterrey, Nuevo León, México.
Years of experimentation	From 2008 to 2010.
Duration	12 three hour sessions. It takes place in extra-school hours.
Main innovation promoters	Museum of steel horno3, Technological Institute of Superior Studies of Monterrey.
Main innovation Partners	Museum of steel horno3, Technological Institute of Superior Studies of Monterrey at the Interdisciplinary learning centre.
Website	www.horno3.org
Contact Person	PhD. Claudia Fernandez Limon, claudiafernandez@horno3.org

Curriculum relevance and connection to policy guidelines

It is not part of the official curriculum but complies with the international suggestions to increase scientific competence in the new generations and to apply scientific knowledge to new situations in school and outside school. This objective is also shared by the industries interested on achieving international competitive levels through qualified teamwork. And also follows UNESCO recommendations "Decade for Education for Sustainable Development", DESD, started in 2005.

Description of the innovative practice

The goal is to raise awareness on major environmental issues affecting the region, the sources that cause these problems, the social, economic and ecological aspects, and to make feasible proposals appropriate to the students' age in order to solve these problems; individual actions, group or family in specific contexts.

Theoretical frame

Inquiry approach, learning by doing, hands-on, discovery-based learning based on experience and on solving social, economic and ecological problems in order to improve the quality of life.

Main aims, features and phases:

In the first session with the group of participants, it is important to agree upon the rules for keeping a "Healthy living";": each child mentions a guideline, drawn up with positive phrasing and it is approved by the rest of the group. At the end the group agrees on a common one.

During the course an experiment related to degradation was carried out. In several pots degradable and non degradable products are "planted", such as baby diapers, a plastic bag, a plastic glass, an apple, a banana skin, some peanuts, or pistachios, etc. These containers are labeled and irrigated and, at the end of the course, products are removed and the results are analyzed.

In the sessions the teacher introduces the theme of water cycle. S/he emphasizes that water is the same since the formation of the Earth and that we drink the same water as that of dinosaurs. That is because water is part of a cycle. In the session participants made experiments and solve exercises of evaporation and condensation of water, at the end student argue their conclusions.

Another activity is the analysis of ecosystems. Animals are produced with plasticine and diverse ecosystems are represented. Then intentionally some parts of these ecosystems are removed by the teacher and the group task is to find its balance again. In order to do this activity they form small groups and draw and argue their conclusions.
Subsequently a visit to a park or nature centre is organized; some species and their interdependence are identified, the students suggest how to maintain a sustainable community and make a commitment.

Another activity is done in an upper area of the city such as a building; participants identify pollution evidence. On the same occasion they count the vehicles on the avenues and calculate the number of vehicles; then there is a dialogue among students with the aim of providing and arguing ideas for solutions to the problems of pollution and road systems.
Participants draw several marks of different dimensions on the floor, such as 1 m^2, 2 m^2, 10 m^2, etc. The students are placed among the trademarks and discuss on the need for personal space. They also argue in the need for space for vegetation and animals. Then they analyze how to live in harmony.

Times for food production are analyzed such as the time maize takes from planting to be consumed, etc. This activity is done on a simulated television in cartoon form and with a calendar that goes by month.

In all the sessions 4R is proposed: reuse, refuse, recycling and recover. Finally, the participants develop viable proposals to be met at home or school.

In the last session of the course each participant shows his portfolio of evidence of his learning, and does a presentation of the proposals and actions to take to the parents.

Methodology used:

Each activity will be a learning unit. It is carried out as collaborative teams to solve real problems. It starts from real problems and students propose solutions to them. The students have to argue every decision.

Resources needed:

Staff:

For 30 children: Three instructors (two people in the area of Environmental Science or Biology and one person in the area of Education- the regular teacher-).

Materials:

Reuse: cardboard, cans, wood, leaves, etc.

New: pots, seeds, painting, colors, scissors, etc.

Power Point Presentations:

To present some ideas related to water cycle, ecosystem and pollution.

Form of assessment/evaluation used:

There is a diary of the learning of each pupil by observation and recording on a checklist of progress in the development of their skills.

The last session is delivered to parents a precis of these observations in a worksheet that summarizes the development of their child.

Information available

A folder with all the information of the course is available: administrative controls, logistics, program of each of the sessions, materials, PowerPoint presentations (for each of the sessions and the parents meeting), surveys, questionnaires, etc. All this information is in electronic format. It also features a photographic archive of meetings and some videos.

It could be a 20-page compendium; however original documents form a folder of more than 200 pages.

Language: Spanish

Critical features for sustainability

The Innovation is not made in regular classes but can be implemented in a classroom, the kind of resources needed to implement the activities are accessible to teachers.

Critical features for transferability

This innovation was implemented in a Museum. The activities can be adapted to be implemented in a class room. Could be difficult to generate mixed aged groups, it depends on the organization of the school centers.

To carry out the activities it is necessary to invite a person of the biological or environmental fields, to support the regular teacher.

Sustainable Architecture©

Keywords:
Primary and lower secondary school, sustainable architecture, inquiry, problem-based learning, creativity.

Problems Addressed

Lack of student interest in science.
Lack of awareness about environmental problems, need for including environmental care and sustainable use of resources in the curriculum.
Lack of focus in inquiry and practical work in science classes.
Low students' performance in science.

Quality criteria

Fosters **scientific competencies:** stimulates argumentation and critical thinking; includes decision-making activities; stimulates collaborative work.
Socially relevant: raises the awareness of social, ethical and cultural influence and implications of science and technology. Addresses national problems in science education. Promotes actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues.
Supports teacher participation and **professional development**: stimulates peer reviews and visits to classes of other teachers inside and outside school(s) to give each other professional feedback. The innovation has a clear teacher manual.

Innovation Appraisal

The innovation is well received, by students, teachers and parents. Short and medium term (one to two years) monitoring is being implemented in order to analyze students' progress. A questionnaire is given to each student at the beginning of the course and one at the end. Questionnaires include key concepts and preconceptions of the topics discussed at meetings, attitude toward science, knowledge and career choice. One year after course completion, students are contacted in order to re-measure their attitudes toward science, knowledge and career choice.

Relevant information in brief

Topics addressed	Sustainable Architecture, landscape, bioclimatic architecture, green building.
Age classes	6 to 15 years old in groups(6-9 years, 9-12 years and 12-15 years).
Extent	Metropolitan area of Monterrey.
Years of experimentation	This innovation bas been implemented for two years (from august 2008 and 2009, it will be implemented again in summer 2010).
Duration	12 three hour sessions.
Main innovation promoters	Horno^3 Steel Museum and the "Regiomontana" University (architecture faculty).
Main innovation Partners	Horno^3 Steel Museum and the "Regiomontana" University (architecture faculty).
Website	www.horno3.org
Contact Person	Dra. Claudia Fernández Limón, claudiafernandez@horno3.org

Curriculum relevance and connection to policy guidelines

The course of Children in Sustainable Architecture follows international recommendations on environment awareness education connected to quality of life, housing, proper use of natural resources and urban planning. This objective is also shared by Construction industries interested on achieving international competitive levels through qualified teamwork. This course has not been integrated to the official curriculum but it follows recommendations about core competencies.

Description of the innovative practice:

Theoretical frame

Inquiry approach, learning by doing or hands-on, discovery-based learning, based on experience and in solving social, economic and ecological problems in order to improve the quality of life. The themes are addressed through collaborative strategies and a trans-disciplinary working method.

Main Aims, features and phases:

Aims: To understand and apply basic concepts of sustainable architecture by means of theoretical and practical workshops, developing creative skills and teamwork, to create awareness in students of sustainable development, city planning consistent with climatic zones and improving quality construction in harmony with environmental conditions.

The skills to develop are:

1. Distinguish and apply concepts of architecture, sustainability and creativity.
2. Develop projects through various plastic techniques that allow the application of the concepts mentioned above.
3. Developing teamwork skills.
4. Recognizing the social, economic and ecological dimensions in architectural issues, in order to generate age-appropriate proposals to solve these problems and individual, group or family actions in specific contexts.

Features:

During the first session, participants establish rules needed to maintain "healthy living". Each child mentions a guideline, drawn up in positive phrase. After discussion and agree a common guideline for the entire group is adopted. Then, an exploring creativity moment begins, with the development of an "alebrije" (Mexican mythological creature) with reused material; the central premise is to combine several ideas through shapes and colors, using the symbolic language.

In the following sessions participants look for a client (the teacher or students for other course) who will give them specifications to construct a house. During the course participants design the house according to the specifications. Architecture and buildings topics are introduced through practices using straws, wooden sticks and plasticine. Students make the structure of a house with wooden sticks and plasticine material analyzing their performance and different shapes and types. They must consider the distribution of the piping, cold and heat water, drainage that is made with straws of different colors. Once the structure is done, students give form to the house. Re-use material, cardboard can be used.

At the beginning of the innovation some "money" is given to each student. The bank is the teacher. The urbanization topic is introduced by the analysis of what a city needs. On the basis of a scale model, students draw parcels of land. Each student "buys" with "money" earned through research or through work involved. Students can associate and organize for the purchase of "land and materials". The parcel of land belongs to a specific bioclimatic zone; has specific wind and geographic orientation. Students must make the best decisions for the city to be as efficient as possible. The students have to plan together the types and distribution of buildings of the city.

The teacher introduces the topics of alternative energy systems by designing and developing sustainable construction including roofs and green walls, planting native vegetation and collecting rainwater. The psychology of color is analyzed and landscaping details are studied in order to obtain a better and harmonious view.

Finally, students have two products, one individual (a house) and one shared (a city). The city have hospital, school, industries, houses, etc. Everything designed under their specifications. Parents are invited for the map of the city exhibition. Students explain their work.

Methodology Used:

It is to work in collaborative teams to solve real problems. Each session starts from the participant knowledge, analogies and models are used, and practical activities are performed.

Resources needed

Staff: Two (or at least one) teacher from architecture field and one from education field (for a group of 30 students).
Materials: Re-use material: cardboard, cans, wood, leaves, etc.
New: colours, scissors, etc.
Power Point presentations: showing the basic concepts of sustainable architecture. These presentations are done graphically, so that the whole group can understand.

Forms of assessment / evaluation used:
There is a diary of the learning of each pupil by observation and recording on a checklist of progress in the development of their skills.
The last session is delivered to parents a precis of these observations in a worksheet that summarizes the development of their child.

Information available

Portfolio containing all the information of the course, including administrative controls, logistics, parents' notifications, programs of each of the sessions, materials, PowerPoint presentations (for each session and parents' meetings), surveys, questionnaires, etc. All this information is available in digital format. It also includes photographic and video files of the working sessions.
It could be a 20-page compendium; however original documents integrate a folder of approximate 200 pages. Language: Spanish.

Critical Features for sustainability

The Innovation has not made in regular classes but all the activities can be performed in class. The teachers need the collaboration of some one from architecture field.

Critical Features for transferability

The key mechanism of transfer is the collaboration between the regular teacher and someone of the architecture field. One important aspect is the trans-disciplinary focus; the teachers have to develop competences to collaboration work and to integrate different contents in one activity.
In this innovation the groups are multi-age, in schools at least two groups of different level must be integrated, so the teachers in school must collaborate and work together. In the adaptation is possible to work with students of the same age.

Design a plan for the most CO_2 friendly journey around the world and WIN!

Keywords:

Secondary school, stoichiometry, sustainable development, carbon (and other) cycles

Problems addressed

The innovation is presenting learning about the stoichiometry (chemical calculations) in the context of a journey around the world, addressing CO_2 emissions and sustainable development. The context is a travel agency ECO-travels which is requesting entries for a plan to travel around the world producing the least CO_2. By doing so it follows in the footsteps of Phileas Fogg in Jules Verne's Around the World in 80 days.

Quality criteria

Fosters **scientific competencies***:* stimulates argumentation and critical thinking, includes decision-making activities, and ICT-skills.
Socially relevant*:* in an era of climate crisis and call for sustainable development this innovation promotes actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues.
Considers **developments in science education** and **science education research:** the innovation is backed up by evidence in educational research and educational practice.

Innovation appraisal

The innovation is part of a much larger innovation in which the complete programme of chemistry at upper secondary education is being reviewed. The new programme, including the module described in this innovation, is being appraised in a longitudinal evaluation over a period of three years. In this evaluation teachers' and students' perceptions and experiences with the innovations are very favourable.

Relevant information in brief

Topics addressed	A design requested by a travel agency called ECO-travels as a context to learn about sustainable development, CO2 emissions and carbon cycle.
Age classes	Secondary school. Age 14-16 years
Extent	It is implemented nationally, but the content is very much international, with a journey around the world as the context. About 7 schools have implemented this in a large number of classes over a period of 3 years.
Years of experimentation	3 years
Duration	14 lessons
Main innovation promoters	Committee for the Reform of the Chemistry programme in upper secondary education
Main innovation partners	The Ministry of Education, Culture and Science has tasked the Committee to develop a new Chemistry programme for upper secondary schools. The committee works in partnerships with teachers, universities and professional bodies in chemistry, such as the Society of the Netherlands Chemical Industries (VNCI as the Dutch acronym).
Website	www.nieuwescheikunde.nl (in Dutch).
Contact person	Emiel de Kleijn, secretary of the Committee: (e.dekleijn@slo.nl)

Curriculum relevance and connection to policy guidelines

The innovation has been tried out over the last 3 years in the pilot phase. On the basis of the evaluation results of the pilot the innovation will be scaled up to be introduced at the national level. It is part of formal education in upper secondary schools.

Description of the innovative practice

The innovative practice tries to make chemistry more attractive, interesting and relevant for students, also and especially for girls. It also aims to involve students in a participatory way in the learning process. This means that students are required to work as a group of scientists to solve topical problems in society. It is an example of a context-based approach in science education. The innovation sets out to address issues of lack of relevance of science education for students, and the modernisation of the content of the science curriculum. The innovation is part of a much larger drive to modernise the science curricula in upper secondary schools in the Netherlands. The innovation has been tried in a 3-year pilot phase which has just ended. Expectations are that the Ministry will upscale the pilot to include all upper secondary schools in the country.

Theoretical frameworks: The innovative practice takes its inspiration from the work of Robin Millar and Jonathan Osborne in the late nineties of last century (Millar, R., & Osborne, J. F. (Eds.). (1998). Beyond 2000: Science Education for the Future) in which they argue for a evidence and context-based science education. The resulting Context-Based Science Education in UK and Chimie im Kontekt (ChiK) in Germany have been models for the development of Nieuwe Scheikunde (New Chemistry) in the Netherlands. The innovative practice described here is part of it. It is based on a inquiry based pedagogy.

Main aims, features and phases:
Students learn about the carbon cycle. Students take part in discussion and decide on the most important criteria for sustainability, from a list of 10 pre-determined criteria. These include, among others, sustainable development needs to strive for a well balanced distribution of wealth, no relocation of the problem to other parts in the world, now or in the future. Sustainable development needs to prevent the deterioration of the environment and so on. A choice of most important criteria are selected by the group (the selection can be different from group to group) and used to develop the most efficient trip around the world, i.e. with the lowest possible CO_2 emission. Students need to make a choice of which route they take in their around the world journey, and by what means. A step by step approach in the lessons will make sure that students are able to calculate the CO_2 produced at all stages of the trip. Additional experiments at each continent also prepare students better for the chemical calculations they need to perform at the end of the lesson series. To this end, at each continent the students carry out experiments on relevant problems. As an example for the continent Africa, students determine the vitamin C content in a tablet of vitamin C, based on the (perhaps incorrect) assumption that people in Africa have a deficiency in vitamin C, or the percentage of hydrogen peroxides in mouth water in Asia, and so on. Students choose two of the five possible experiments.

Methodology used: students work in small groups, largely on their own, with lots of lab work using fairly standard equipment and chemicals. Much of the information students need to make adequate decisions is found on the internet.

Resources needed: the innovative practice is typically carried out in a standard classroom situation with a teacher and assistance of a lab assistant. Resources required include standard chemical practical equipment and chemicals, a student text with instructions for student work, and access to the internet to find relevant information.

Form of assessment / evaluation used: students are required to draw up a plan for the journey around the world in such a way that it produces only low levels of CO_2. In addition to this, students are asked to make summaries of various tasks students have done.

Information available

Both student text and text for teachers, currently in Dutch only, are available. The student text, including a resource section is about 50 pages of which some pages contain graphics only.

Critical features for sustainability

The innovation has been designed and evaluated with the help of teachers. It has been used in classrooms in many schools over the three years. The innovative practice has been implemented in regular classrooms with regular teachers in school taking part in the pilot, and as part of the regular chemistry programme for upper secondary schools. The innovation is within reach of most schools and teachers not requiring any complicated equipment.

Critical features for transferability

The innovative practice is flexible enough to be used in different countries, without too much adaptation. It can be viewed as a stand-alone activity without too much demand on resources. The practice is in fact reasonably straightforward. The main feature of the practice is the context of the travel agency which requests the public (and the students) to submit designs for a low-level CO2 journey around the world.

Developing Analogical Thinking: Atom model

Keywords:
Lower secondary school, modelling models, learning from models and about models, analogical thinking

Problems addressed

There are two main reasons for the possible low level of knowledge and competencies of pupils and students in science: lack of experimentation and insufficiently developed abstract thinking. Therefore the question is: how to develop learning from models to learning through making models in a chemistry curriculum? How to stimulate pupils designing and making atom models (creativity, analogical thinking…)? How to introduce critical thinking? How to improve understanding of abstract concepts and terms like 'atom'? How to evaluate pupils' handmade models?

Quality criteria

Scientifically sound: correct science knowledge and understanding; critical look at the Nature of Science
Pedagogically and **methodologically sound**: adaptable methods/ inclusion of all pupils
Fosters **scientific competencies:** stimulates argumentation and critical thinking

Innovation appraisal

The responses of pupils from a questionnaire and the response of a teacher were very good.

Relevant information in brief

Topics addressed	Modelling (making) the structure of atom from different materials
Age classes	Lower secondary school (compulsory education) 8th + 9th class (13 – 14 y)
Extent	Local, Five classes/groups of students involved
Years of experimentation	Two years
Duration	2 – 4 school hours (45 min) (not one after another)
Main innovation promoters	The National Education Institute
Main innovation partners	Lower secondary school OŠ Rado Robič Limbuš, The National Education Institute
Website	http://www.zrss.si/
Contact person	andreja.bacnik@zrss.si; tomaz.ogrin@ijs.si

Curriculum relevance and connection to policy guidelines

This innovative practice is consistent with curricula and national guidelines on bringing flexible lessons (subject teaching) into school practice. It is based on goals and contents of chemistry curriculum for primary schools. It could be carried out at compulsory lessons or in a combination (or independently) with other activities, for example, a science day.

Description of the innovative practice

The innovative practice introduces pupils to modelling of abstract terms and concepts into material models. The idea is applied to atom modelling under the title "Let's show an atom". Pupils model (make) atoms from the images about atomic structure they gain from data (dimensions, particles and their distribution and proportions, shape, etc.). After modelling (making), comparative analysis (assessment) is carried out of different models made. Pupils discuss which model best represent facts about the structure of an atom. Models should show a similarity (analogy) between representation and the known structure of an atom.
Pupils organize the information they got about atomic structure to present a self-consistent picture that can be compared with those of others. Their activity could also be called 'representation' instead of 'model' of an atom. Representations differ in how they illustrate parts of an atom.

Theoretical frameworks:

Constructive approach; PBL- Problem Based Learning; comparative analyses; analogical thinking.

Main aims, features and phases:

- Upgrading learning from models to learning through making models; stimulating pupils to design and make atom models; developing creativity and analogical thinking; bringing analogical conclusions; in each case, starting from pupils themselves.
- Carrying out comparative evaluation (assessment) of models made from the point of view of presenting the particles, their position, measures, etc. in an atom; presenting strengths and weaknesses of individual models with respect to the characteristics of each one; brainstorming about limitations and imperfections of models in general.
- Repeating and deepening knowledge related to 8th class chemistry curriculum goals and connected to the atomic structure and the periodic system of elements.

Phase 1: Recalling terms and individual designing (drawing) of models of the atom (with the possibility of supplementing the basic idea)
Phase 2: Making atom models from different materials to illustrate the known parts on an atom (electrons, nucleus, size, etc.)
Phase 3: Comparative presentation of the models and assessment using suitable criteria, e.g. dimensional analysis (proportions, size), present all particles or some, shape of an atom.
Phase 4: Evaluation with the questionnaire mentioned

Methodology used:

The innovation practice under the title "Let's show an atom" uses project work/ inquiry based activity. Pupils had to think in new ways. They produce their own design. They recall knowledge and search for additional information (deepening of knowledge), realise, present and argue their ideas. Doing this they were creative, thoughtful and gained new understanding and knowledge respectively.
Individual indoor work: designing a model. Interdisciplinary connections included.

Resources needed:

A blank sheet of paper for drawing a model – a sheet of paper for ideas for atom model
Various materials and accessories for making atom models, explaining shape, proportion and kind of particles.
Questionnaire for the evaluation

Form of assessment / evaluation used:

Formative evaluation and a questionnaire: after the activity pupils fulfilled a short questionnaire with 4 questions – designed from a standpoint of content and methodology. Their products and presentations were marked using suitable criteria.

Information available

- Expert foundation e.g. lit.: Hardwick,A.J. (1995), Using molecular models to teach chemistry, Part 1, Modelling molecules, SSR, Sept 1995, 77 (278).
- Phase description of the realization and characteristics of the innovative practice
- Criteria for giving marks to models
- Questionnaire for evaluating and analysis of the questionnaire
- Photos of fulfilled sheets of ideas and models

At the moment only a Slovene version of information (4 pages) is available.

Critical features for sustainability

The innovative practice was tested on an average population (8th class) in a regular school practice. The school where the practice was tested is a school with a flexible curriculum.

Critical features for transferability

A minimum for transferability is a phase description.

Gender Aspects in Science Experiments: Electrical conductivity and solubility

Keywords:
Lower secondary school, gender aspects in science, women and techniques

Problems addressed

Teachers report girls still have less technical skills and interest in technical disciplines (e.g. measuring, electricity, electronics). The problem has its roots in primary schools. How to achieve improvement of the situation in the frame of curricula of science subjects? At the same time the usual problem of proper understanding of the interdependence of properties of solutions and the structure of matter is addressed.

Quality criteria/indicators addressed

Scientifically sound: correct use of scientific content/knowledge according to the context.
Pedagogically and **methodologically sound**: takes gender issues into account.

Innovation appraisal

Evaluation of the innovation has been done by using specially prepared questionnaire for pupils. The innovation has been received by the pupils with great interest; girls were very satisfied to gain new technical skills. Evaluation indicated much better technical skills of girls on the issue.

Relevant information in brief

Topics addressed	Measurements of properties of solutions; structure of matter;
Age classes	Lower secondary schools (9th class 14 y/ 8th class 13 y)
Extent	Local: all 9th and 8th classes in the school/groups of pupils involved
Years of experimentation	2 years at school
Duration	11 school hours in context of structure of matter and real problems
Main innovation promoters	School teachers; The National Education Institute;
Main innovation partners	Lower Secondary school OŠ Martina Slomška
Website	-
Contact person	Karmen.slana@guest.arnes.si

Curriculum relevance and connection to policy guidelines

The innovative practice is consistent with curricula and national guidelines on introducing flexible subject teaching into primary and lower secondary schools. It is based on goals and contents of chemistry and physics curricula for primary and lower secondary schools. It could be carried out at compulsory lessons.

The innovation is explicitly connected with PISA 2006 guidelines/ suggestions: interest of women for science is emphasized. The practice follows European recommendation 3 (Rocard, 2007): "Specific attention should be given to raising the participation of girls in key school science subjects and to increasing their self-confidence in science."

Description of the innovative practice

Innovative practice consists of series of qualitative investigations/measurements on the interdisciplinary area of 'solutions'. Specifically, electrical conductance (electrolytes, non-electrolytes, poly-electrolytes, pH, water) and solubility (mixing liquids, solids and gases: e.g. CO_2) issues are investigated. The activity enables with relative simplicity to differentiate among atoms, ions, and molecules that have important and very different roles in properties of solutions.
The second characteristic of the activity is to bring closer electricity and electronics into practical experimentation in chemistry by a collaboration with physics (e.g. to measure resistance of liquids and solutions) and to give more opportunity for girls to gain technical skills.

First, concepts about electricity quantities are reviewed (voltage, current: direct, alternating; resistivity, conductivity, polarity, galvanic cells, electrolysis) together with structure of matter (electrons, ions, molecules, atoms, states of aggregation, electrolytes/non-electrolytes, polar/non-polar solvents) and

measuring devices by inquiry-based way (experimenting with simple electrical loops, where basic quantities are measured and questions raised), already organized in groups (boys and girls separated).
Next, tests of conductivity of several solutions/solvents (together with distilled water) is carried out and results compared. Several liquid/liquid, solid/liquid and gas/liquid solubility are measured, compared and explained.
The role of polarity of molecules is discussed.
Groups prepare posters to present measurements and explanations.

Theoretical frameworks:
The innovative practice follows IBST-Inquiry Based Science Teaching; also didactic differentiation is involved regarding gender aspect.

Main aims, features and phases:
Main aims: to increase technical education of girls in science subjects; to increase competencies of pupils in basic knowledge; to increase experimentation in science subjects.

Main features: real life problems (e.g. toxicity of some ions; the role of concentration; the process of their accumulation; need for some ions in living organisms; pollution problems; water hardness; tap water treatment; drinking water from sea water; pH of blood/acidosis, alkalosis) addressed, with the use of basics; simple experimentation techniques; minimum of accessories.

Main phases include: 1. Prior knowledge questionnaire fulfilled; 2. Groups formed (girls, boys separated); 3. Experimentation phase, use of worksheets, allowing creativity; 4. Evaluation, using another questionnaire.

Methodology used:
Group work: girls, boys separated. The reason for using this method was that if groups were mixed (also tried out), then as a rule boys are taking the initiative and girls are mostly passive (the number of set-ups are limited to one per group). Indoor and lab work; ICT (to enhance ideas about the processes with the help of models) not compulsory.

Resources needed:
Chemistry and physics lab accessories; measuring set-up; written materials; ICT equipment (whiteboard) – not compulsory

Form of assessment / evaluation used:
Questionnaires/ prior knowledge tests; prior to this method a mixed group method was tested; separated groups are more effective for girls; also a method where one or two boys instructed girls were tested, but again self-activity of girls proved better;

Information available
Worksheets are available in Slovene.
The minimum of materials for transferability: 1. Worksheets in Slovene; 8 pages for translation (with sketches including); 2. Eventually experimental set-up for measuring, as a kit.

Critical features for sustainability
The innovative practice has been implemented in regular classroom, with average teachers and as part of regular courses.

Critical features for transferability
The critical points for the success of the innovation could be: 1. low prior technical knowledge of pupils gained in 7th class; 2. the level of teacher's professional development on methodological issues and on science contents.
The innovation is flexible enough to be adapted in different contexts (environment; biology; etc.)
The added value of an adaptation could be: 1. creative improvement of the practice – technically and pedagogically; 2. carried out in different context (sea water, meteorological context, soil, body…).

Didactic Differentiation Project: Food Digestion

Keywords:
Lower secondary school, inquiry based science learning, didactic differentiation, investigation skills, integrated science

Problems addressed

Deficiency (lack) of differentiation of pupils at lessons to optimally develop research skills, based on their capabilities and interests.

Quality criteria/indicators addressed

Pedagogically and **methodologically sound**: allows for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests.
Fosters **scientific competencies**: offers inquiry based learning activities.

Innovation appraisal

Teachers and pupils marked this activity very high. Teachers found out that interdisciplinary and experimental method of teaching in dealing with nutritive substances and digestion leads to better understanding and results in evaluation of knowledge both in biology and chemistry.

Relevant information in brief

Topics addressed	Food digestion;
Age classes	Lower secondary school 9th class (14 y)
Extent	Local; Two classes/groups of students involved
Years of experimentation	Two years
Duration	One school day (or 5 school hours successively
Main innovation promoters	The National Education Institute (introducing flexible curriculum in primary schools)
Main innovation partners	Lower secondary school Lucijan Bratkovič Bratuša (Renče), The National Education Institute
Website	-
Contact person	Mariza.skvarc@zrss.si

Curriculum relevance and connection to policy guidelines

This innovative practice is in accordance with the aims and contents of chemistry and biology curricula. It is carried out in regular courses, but not during classical 45 minutes school hours (sh) and separated (as 2 sh chemistry and 2 sh biology per week) as are standard lessons. It needs to be carried out as one school day or 5 school hours together. The reason is a need for continuous proceedings and organizations of lessons.

Description of the innovative practice

Innovative practice introduces a didactic differentiation in integrated science lessons (modules) composed of experimental work and presentation, on food ingredients and digestion for the 9th class pupils. Didactic differentiation is one of possible ways in teaching to allow for a diversity of pupils needs and interests. It is recommended that the selection of pupils to form groups should not be the same each time this practice is used, but should vary somewhat.

Theoretical frameworks:

IBST-Inquiry Based Science Teaching; Didactic differentiation (e.g. http://journals.indexcopernicus.com/abstracted.php?icid=888497); Interdisciplinary collaboration for integrated lesson.

Main aims, features and phases:

Teaching goals from chemistry and biology curricula (9th class) were joined in an interdisciplinary way(Slovenia among countries with separated science subjects in last triad of 9y compulsory schooling – TIMMS overview). Pupils learned about ingredients of various kinds of food; how food is ingested; how the digestive system works; how our body uses various ingredients of food.

Usually such contents are taught separately within each subject, chemistry and biology. Linking contents which are in real life inseparable enables pupils to recognize and easily understand the process as a whole.

Pupils experimentally established nutritive substances in various foodstuff and also substances which result in the body after digestion of food. So the presence of digestible carbohydrates (starch and sugar) and proteins are assayed by specific chemical reactions. The role of enzymes is investigated.

The didactic differentiation is introduced by grouping pupils in a class regarding to their prior science competencies based on teacher's knowledge. Basically two groups are formed, but in classes where the situation is more spread more groups could be formed. The group with lower competencies experimented, based on instructions; the other got the open-ended and problem-based task, stressing planning of experiments and developing research method. For better organization of experimental work subgroups are formed.

At the end of the activity pupils combined all new knowledge and presented it in a poster form, each group separately. In case subgroups were formed, each subgroup presents its findings. Using posters they explain how they understand and link together new terms and processes as a whole.

Methodology used:
Experimenting and presenting gained knowledge in groups;

Resources needed:
Worksheets for two experimental exercises; for each exercise two different worksheets for the two groups of pupils are prepared.
Laboratory accessories
Chemicals: Fehling's solution (e.g. http://en.wikipedia.org/wiki/Fehling%27s_solution), Biuret reagent (e.g. http://en.wikipedia.org/wiki/Biuret_test), Iodine/KI reagent
Samples of various foods; Capsules with pancreas enzymes.

Form of assessment / evaluation used: A questionnaire for pupils

Information available

Two different worksheets for pupils are distributed: 1. one with detailed instructions and a description; 2. the other as problem-based variety (open, low degree of teacher's monitoring). Eight pages all together in Slovene. Both kinds of worksheet are given to each pupil, but they are asked to use the one which belongs to the group.

Critical features for sustainability

The innovative practice was tested with an average population in a 9th grade (14 y) class with 23 pupils. The practice was tested in a school which makes use of novelties in a Slovene school space – flexibility of curriculum. This means that a predetermined number of hours for lessons (curriculum) could be arranged arbitrarily over a school year, for most of the subjects.
When forming groups, and in deciding upon which variety of experimental exercise will be tried out by the group pupils and a teacher collaborated. This collaboration allows pupils to express their preferences.

Critical features for transferability

The Didactic method introduced by this innovative practice could be transferred to all other contents and experimental exercises.
IBSE – Inquiry-based science education (e.g. http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf) considering differences among pupils and using didactic differentiation requires some level of qualification of teachers. The method to be applied successfully also requires some level of conviction (usually gained through practice) that the knowledge gained by pupils through this method has higher level of quality and durability (retention). Many teachers share the view that that the method requires much more time and that pupils gained less

knowledge. Prerequisite to successful realization of this problem-based experimental practice is some experimental investigation skills pupils gained in prior experimental practice.

The method practised requires flexibility in organizing lessons and some shift up of the number of hours per week per definite subject. Such flexibility is possible in Slovenia.
Added value of the activity is its capability to teach successfully a real class with differences among pupils in interests and talents.

Invasive species: the danger from outside

Keywords:
Lower secondary school, reading comprehension, ecology, invasive species

Problems addressed

This activity focuses on the difficulties secondary school students have in reading and understanding texts with scientific contents shown by. The problem addressed is the scarcity of instruments and skills to achieve a meaningful and critical reading of popular science texts.

Quality criteria

Pedagogically and **methodologically sound**: the design, learning materials, learning activities and teaching methodology take current theories about science learning into account
Fosters **scientific competencies:** stimulates collaborative work (with discussion, argument, decision making by learners); uses Ict-skills; fosters scientific literacy (identify scientific issues, explain phenomena scientifically, uses scientific evidence; core competences and skills identified as learning outcomes within the activities -e.g. PISA competences-).
Socially relevant: address national problems in science education; promotes global citizenship (includes environmental education and ESD/Global citizenship within science teaching).

Innovation appraisal

Positive welcome by teachers committed to improve students' reading. Students engage actively in these activities and greatly appreciate the degree of autonomy they achieve. Students perform better in PISA items.

Relevant information in brief

Topics addressed	Invasive species and their effect on ecosystem
Age classes	12-13 years old (8th grade)
Extent	Local (Barcelona) & regional (Catalonia) High schools associated to a science education research department (Universitat Autònoma de Barcelona-UAB)
Years of experimentation	Five years
Duration	2-3 hours
Main innovation promoters	Language and science teaching research group (Grup de recerca Llenguatge i Ensenyament de les Ciències-LIEC, Universitat Autònoma de Barcelona-UAB)
Main innovation partners	UAB, Ministry of Education-ME
Website	www.leer.es (project web) http://crecim.uab.es/xarxaremic/ (research group web, click LIEC on left menu)
Contact person	Anna Marbà Tallada (Anna.Marba@uab.cat)

Curriculum relevance and connection to policy guidelines

The scientific topics are framed in the national curriculum of secondary education in which Natural Sciences (Biology & Geology) is a compulsory subject. Reading comprehension is also explicitly mentioned in policy documents as a transversal competence goal for secondary education. It is also framed by PISA findings and recommendations about reading comprehension competence, for large proportions of students cannot understand what they read, particularly when reading science.

Description of the innovative practice

Theoretical frameworks: Socio-constructivist framework, STS perspective, participative methodologies, research and education collaboration.

Main aims, features and phases:
Aims for the students: The development of strategies to read and understand popular science texts. To apply the knowledge about ecosystems learned in science classroom to new situations from real life. To use scientific concepts to assess science-related news in press. To construct argumentative texts and to draw evidence-based conclusions about scientific problems. To achieve and implement reading skills in order to develop critical perspectives. To develop regulation strategies for learning.
Aims for the teachers: To guide the language and cognitive skills development. To regulate the reading process. To promote critical thinking.
Features: The task is designed for the whole class and addresses the diversity of students, therefore enough time should be given so all students can read the texts and carry on the activities. It is recommended to tell students about the available time and to encourage them to keep it.
All the tasks are organized following this working structure: individual work, small group discussion and whole class discussion. The objective is to facilitate the regulation of learning for all pupils: in the small group phase, regulation is achieved between peers, while in the whole class, the teacher takes an active role leading the groups towards the adequate answers. It is also important that, while working in small groups, the teacher would visit the teams to help those showing more difficulties.
Phases:
PHASE 1) The teacher distributes the handouts with texts and questions to each student. After reading the title (press headline), and before reading the texts, students are asked to answer these questions individually (20 minutes):

Q1a: Why do you think we're going to read this text?

Q1b: What do you know about invasive species? Write the name of the ones that you know.

Questions for small group discussion:

Q2. What did you agree about the text that we are going to read?

The teacher discusses with the class the objectives of the activity. The purpose is to share the objectives with the students and to activate the knowledge required to understand the texts.
PHASE 2) Students read the first text and answer these questions (30 minutes):

Q3a: Underline the words or ideas that you do not understand and that you think you need to know in order to understand the text.

Group work: Students discuss the unknown words with their peers and try to find out their meaning:

Q3b: Share your selected word and ideas with your colleagues and try to explain them.

After an introductory explanation by the teacher, students discuss about the meanings and ecological implications of the concepts of *alien/exotic species* and *invasive species*, in order to understand the scientific meaning of the text:

Q4: Thinking about what you know about how ecosystems and food webs work: What do you think it means that 'invasive species are exotic species with the ability to spread'?

The purpose is to work with words that they do not know. Its goal is to teach students to differentiate between words that are necessary to understand the meaning of the text and others that are accessory.
PHASE 3) The students answer the questions 5 and 6, mobilizing their knowledge to build justified claims. Students need to think in terms of ecology, arguing in a more holistic way, considering for instance the case of crops. Invasive species are only considered as such when they colonize natural ecosystems or, in the case of crops, when they are not intentionally planted. In contrast, those species that have been introduced to get better crops, and also have displaced native ones (as the case of traditional versus transgenic corn) are not considered as invaders from a social/economic point of view, while from an ecological view, they are invaders (20 minutes).

Q5: Considering what you know about ecosystems, give an explanation for the three reasons mentioned in the text.

Q6a: Why do you think the author says that not all invasive species cause problems?

Q6b: Apart from the ecological, what other reasons are taken into account to decide if the introduction of a species causes problems?

PHASE 4) Students read the second text, which describes some invasive species in the Iberian Peninsula. They are asked to write a report about one of the invasive species in the text. They have to discuss (first in small group and then in the whole class) what information should be considered as relevant for the task, justifying the decision. For example, it is important to know the country of origin of the species and the way of spreading, in order to explain their presence in certain areas.

Q7a: Discuss with your group what information you should know in order to understand the effects that this invasive species caused in the local food web.

Q7b: Write the information you have agreed that you will need to carry the task.

Students prepare and carry out an oral presentation about the information they have found, in order to promote communication skills. One session may be used to discuss the information to be included and to agree about how to present it.

PHASE 5) Writing a group report and presenting it to the classroom:

Q8: Write a text justifying a) the effects of the introduction of the species in the ecosystems, b) possible ways to combat the spread of invasive species and c) measures to prevent similar situations in the future. Searching for information and writing the report can be homework or the teacher may decide to use a couple of sessions to do it in the classroom.

Methodology used: individual and cooperative group work (including small group and whole class work) in the classroom. Use of ICT to search (internet) and to present (PowerPoint) information.

Resources needed: Newspaper articles and activity sheet for students. Computers, Internet access and video projector.

Form of assessment/evaluation used: The activity encourages the students to regulate their own learning during the tasks. The teacher makes a continuous evaluation of the students' progress. The final report and the written materials produced by the pupils can be used as an input for the final mark.

Information available

Reading texts, templates and comments for this proposal are available to translate and download. Information about other reading comprehension activities and research can be consulted through internet (see web links).

English:

-Izquierdo, M.; Marzábal, A.; Márquez; Gouvea, G. (2007) Experimental stories in science textbooks. Paper presented at VIIth ESERA Conferences. Malmö.

-Marbà, A. & Márquez, C. (2006) Learning to read biology (and reading to learn biology). ERIDOB Conference (European Researchers in Didactic of Biology). ERIDOB, London, September 2006.

-Prat, A; Márquez, C; Marbà, A (2007) Reading critically press advertisements in the science class. Symposium: Reading critically science in the media: perspectives and experiences of classroom practices.

Spanish:

-Marbà, A; Márquez, C.; Prat, A (2006) La lectura en el proceso de aprendizaje de los modelos científicos, en M. Quintanilla; A. Aduriz-Bravo (eds.) Conocimiento y práctica de los profesores de ciencias naturales: algunas distinciones y aproximaciones desde la didáctica. Chile: Pontificia Universidad Católica de Chile.

-Márquez, C. & Roca, M. (2006). Plantear preguntas: un punto de partida para aprender ciencias. Educación y Pedagogía, 45, 63-71.

Critical features for sustainability

This proposal have been implemented in some secondary schools as a regular part of the curriculum, but teachers have been specially trained by the LIEC (Language and science teaching research group at UAB) in using this methodology approach in classroom.

Critical features for transferability

This proposal can be adapted to any context (the teacher can easily provide other examples in the local/regional area) and needs no special requirements or hardware. It is important to promote a classroom environment that encourages the students to work cooperatively and to present their questions, doubts or learning difficulties. The training and disposition of the teacher is critical for the success of the innovation.

Cooking with the Sun

Keywords:
Lower Secondary school, natural resources management, renewable energies, education for the environment.

Problems addressed
Low interest and motivation at school, particularly among students from depressed areas. This may result in strong rejection of science disciplines, due to the greater effort required.

Quality criteria
Pedagogically and **methodologically sound:** Motivation / interest in science is stimulated.
Fosters scientific competencies: Stimulates argumentation and critical thinking; stimulates collaborative work (with discussion, argument, decision making by learners); uses ICT-skills.
Socially relevant: Promotes actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues (ethical, social and cultural issues raised); promotes global citizenship (includes environmental education and ESD/Global citizenship within science teaching); uses resources and teaching contexts from outside the school.

Innovation appraisal
This innovation has been implemented in secondary school in addition to other activities to bring science and technology closer to students. Students told the teacher that this experience was very interesting and they still remember it as one they have enjoyed most.

Relevant information in brief

Topics addressed	Energy and natural resources management. Designing and building different models of solar cookers.
Age classes	14 year old (9th grade)
Extent	Local. Whole class involved (7 students) working as a small group.
Years of experimentation	Started in 2008.
Duration	8-10 class sessions, plus 2/3 to test the cookers.
Main innovation promoters	Teachers from "IES Isabel la Católica", Guadahortuna (Granada).
Main innovation partners	
Website	
Contact person	Begoña Carretero (begocarretero@hotmail.com)

Curriculum relevance and connection to policy guidelines
The proposal is part of a regular teaching unit of Science & Technology discipline framed in a "Curriculum Diversification Program". CDPs are designed as an "attention to diversity" measure in order to achieve the overall objectives of this stage of compulsory secondary education, through an adapted methodology and contents.

Description of the innovative practice
Theoretical frameworks:
STS perspective; cooperative learning and participative methodologies; scientific literacy; use of ICT; science for real life; education for the environment.
Main aims, features and phases:
Aims for the students:
To bring science closer to students, contributing to scientific literacy and helping them to care about the environment and to become responsible citizens. To develop ICT skills for searching information and organizing data. To develop manipulative skills (taking measurements, use of proportions, using different tools, etc.). To work in a collaborative and participative group using everyday materials. To

achieve a critical perspective of global energy issues and their relations with human activities, and to develop the ability to analyze socio-environmental conflicts. To discuss different alternatives and to make decisions individually and collectively. To be aware of difficulties in everyday life for many people in our planet.

Aims for the teachers: To promote a change of attitude that helps students to develop their ability to make decisions and to use their knowledge to find solutions to environmental problems. To promote in students a sustainable lifestyle and respect for the environment, helping them to develop an attitude of solidarity among their peers and to the environment. To construct links between science disciplines and everyday life, making science more attractive and accessible to the students.

Features:

Students are asked to investigate solar energy and construct different solar cookers with everyday materials. This is a interdisciplinary proposal framed by CTS perspective that allows them to integrate knowledge from various disciplines such as:

-Mathematics: the calculation of proportions, the management of units of measurement and working with variables and graphs.

-Natural sciences: alternative and renewable energies; environmental management; health and environmental risks of the use of common energy.

-Social sciences: economic problems, unequal distribution of resources, sustainable development.

-Technology: Design and construction of different models of solar cookers.

-Physics and Chemistry: concepts of temperature, energy transmission, heat transfer, reflection of light, etc.

-ICT: working with internet and other computer applications.

-Physical education: healthy lifestyle, enjoying the environment, outdoor activities.

-Foreign languages: management of information in different languages (mainly in English) through internet.

-Education for citizenship: solidarity behaviour, care for the environment.

Phases:

After the teacher introduces the proposal, students must carry out some activities related to the use of alternative energy.

1) Searching for information in internet about solar energy and its applications.
2) Making a practical activity related to the greenhouse effect. This practice, called "Heat from the Sun," was obtained from the Greenpeace website. Students must use various measuring instruments, collect data and represent the temperature variations by graphics.
3) Browsing the web to get different solar cooker models, basic designs and list of materials for their construction.
4) Choosing the model/models to construct and purchasing the materials.
5) Constructing the cookers and checking their functioning by making temperature measurements with different substances (water, alcohol and paraffin).
6) Representing the data collected in the previous section.
7) Searching for solar cooking recipes using the internet.
8) Selecting and preparing some recipes.
9) Making and presenting a PowerPoint to the class with photos and information about the development of the experience.
10) In addition, students can present their results in a science fair.
11) Carrying out a questionnaire (Educators for Sustainability, see references) in order to assess the students' degree of commitment to build a more sustainable future. This questionnaire has been conducted twice, before and after the experience.

Methodology used:

ICT; outdoor/indoor; project work; collaborative group work; lab work.

Resources needed:

Common materials from everyday life: cardboard boxes, Styrofoam, aluminium foil, glue, umbrellas, sunscreen for car and common kitchen elements. Common school lab materials. Internet access and ICT hardware & software. The designs and information about solar cooker models are available through the internet.

Form of assessment / evaluation used:
Continuous assessment. This proposal is part of a regular teaching unit and the teacher takes into account the degree of implication of the students and the final results for the final mark.

Information available

Spanish:

Carretero Gómez, M. B. (2010). El sol, la cocina solar y la solidaridad: una receta muy sabrosa. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias, 7*(2), pp. 544-557.
Available online at: http://www.apac-eureka.org/revista
Educadores para la Sostenibilidad, (2008). Es el momento de nuevos compromisos de acción ¡podemos hacerlo y vamos a hacerlo!. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias, 5* (3), 367-372.
Available online at: http://www.apac-eureka.org/revista

Critical features for sustainability

The proposal has been implemented in regular classroom as a part of a teaching unit in the Science and Technology discipline. Duration (8-10 class sessions, plus 2-3 outdoors) and proposed activities can be adjusted in order to fit every classroom programming.

Critical features for transferability

The innovation is flexible enough to be adapted to other contexts, even in less sunny countries, and could be implemented as a part of other science disciplines and teaching units. The critical points are the duration and particularly the disposition of the teacher to spend a minimum of two weeks to develop the activity.

Physics and toys

Keywords:
Secondary school, toys, physics, curiosity for science, IBST

Problems addressed

Low interest in science and technology; dissatisfaction with traditional ways of introducing the concepts; scientific issues far away from student's real life and naive views of science; cultural diversity.

Quality criteria

Scientifically sound: provides insight in the way scientific knowledge is constructed (science and alternative theories of explanation).
Pedagogically & methodologically sound: allows for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests; motivation / interest in science is stimulated
Fosters **scientific competencies:** fosters scientific literacy (identify scientific issues, explain phenomena scientifically, use scientific evidence).

Innovation appraisal

The innovation has been implemented for three years in some secondary schools from Castilla y León and achieved a high interest from teachers and students, as reflected by the evaluation questionnaires submitted to the participants.

Relevant information in brief

Topics addressed	Understanding physical concepts and laws using toys
Age classes	From 13 to 18 years old (9th to 2nd year of Baccalaureate)
Extent	Local. 8 courses involved. Students work in small groups.
Years of experimentation	3
Duration	1 school year. Class hours: Depending on the number and the complexity of the activities. 1-3 experiences (toys) for each classroom session is recommended.
Main innovation promoters	Department of Physics and Chemistry, IES (high school) "Padre Isla", León.
Main innovation partners	Education Council of Junta de Castilla y León. CFIE (Teacher Training Centre) from León
Website	http://iespadreisla.centros.educa.jcyl.es/sitio/ (High school web)
Contact person	Purificación Rodríguez Aparicio, CFIE León (ciencias@cfieleon.com)

Curriculum relevance and connection to policy guidelines

The innovation is part of the curriculum of "Physics and Chemistry" discipline, compulsory for 9th and 10th grade and electible at upper secondary (Baccalaureate). It is implemented as a regular activity of the Ph&Ch teaching programme. It is also framed by the PISA recommendations about promoting the development of scientific competencies by using students' knowledge to explain real life phenomena.

Description of the innovative practice

Theoretical frameworks: Constructivist approach and collaborative learning; IBST; contextualised practice of science; argumentation and use of evidences; research and education collaboration.
Main aims, features and phases:
Main aims for the students:
-To awaken scientific curiosity.
-To use the language and methods of science to explain common phenomena.
-To build some simple devices to explain some physical phenomenon.
-To communicate ideas and conclusions to their peers.

Main aims for the teachers:
-To bring Physics and its main principles closer to students by using toys and other materials that are attractive to them.
-To foster student participation and to encourage their creativity.
-To ensure the understanding of Physic concepts by the students.
Features: Bringing the toys into Physics classroom, the teacher tries to support the construction of physical and other scientific knowledge taught in class by arousing in students an initial interest. Mechanics, heat and energy, electricity and magnetism, optics…, have one or more toys to experiment with and to discover their "hidden" scientific laws of operation.
Phases:
1) Exposition: The teacher presents the toys to the students in order to illustrate some main physic laws that they have been studying in classroom. Small groups (4-5) are settled.
2) Manipulation and investigation: Students' groups work with toys discussing their functioning and trying to find out some scientific explanations for their behaviour, justifying their claims.
3) Classroom debate: Students present their results and findings to the classroom, and with help and guidance of the teacher, they reach a consensus about the scientific explanation that underlies each toy. Students can be asked to write a brief report for each element.
4) Dissemination: Each toy with its scientific explanation can be presented to a school science fair.

Methodology used: The teacher presents the proposal within the regular Ph&Ch classroom programme. Students will work in small groups and discuss with the whole class their conclusions under the teacher's guidance.

Resources needed:
Mechanics: Hourglass, batteries car, carousel, Newton pendulum.
Heat and energy: Lava lamp, radiometer, Galileo thermometer.
Electricity and magnetism: Visualization of magnetic field lines (iron fillings, magnet, paper), "Supermang", Levitron.
Optics: Newton disk.
Other common lab materials.
Form of assessment/evaluation used: Continuous evaluation from the beginning to the end of the proposal.
Assessment tools:
- The degree of implication of the students.
- The achievement of the initial objectives.

Information available

Each toy file will be available at the end of the project at CFIE León webpage: http://cfieleon.centros.educa.jcyl.es/sitio/
Some examples online (Spanish):
http://www.jpimentel.com/ciencias_experimentales/pagwebciencias/pagweb/Los_talleres_de_ciencias/Taller_de_fisica_y_juguetes.htm (from High School Juana de Vega, Ávila).

References (Spanish):
-López García, V. (2004). La física de los juguetes. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias, 1*(1), pp. 17-30.
Can be downloaded from:
http://www.tareaescolar.net/tareaescolar/fisica/LA%20FCDSICA%20DE%20LOS%20JUGUETES.pdf
-Varela Nieto, M. P. & Martínez Montalbán, J. L. (2005). "Jugando" a divulgar la física con juguetes. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias, 2*(2), pp. 234-240.
Can be downloaded from:
http://www.apac-eureka.org/revista/Volumen2/Numero_2_2/Varela_Mart%EDnez_2005.pdf

Critical features for sustainability

The innovation has been implemented over three years. In 2010, it became an Educational Innovation Project developed and funded by the local government (Junta Castilla y León) and made part of the Teacher Training Programe at CFIE (Teacher Training Centre), León.

Critical features for transferability

This innovation is flexible enough to be adapted to other contexts: toys and materials required are cheap and could be found across different countries.

Critical points: teacher professional development and training on this particular methodological approach.

Dynasty of the Kuglinge[1]– pupils grasp the spirit of evolution

Keywords: primary school, evolution game, intra-specific variation, selection, adaptation

Problems addressed

There is an increasing scepticism against the general idea of evolution as a scientific theory in society. It is more and more difficult to teach the theory of evolution without contrasting it with the biblical representation of the origin of the world. In addition, teachers especially at primary and lower secondary level often lack the scientific background, experience and good examples to teach evolution at these levels. Thus, this important topic is often neglected. The evolution game 'Dynasty of the Kuglinge' provides a tool for learner activities at school that make it easy to understand the principles of e.g. variation, mutation, selection, and adaptation. It focuses on observable phenomena instead of using scientific vocabulary and leaves teachers and pupils enough leeway for their own variations of the game according to their needs and interests.

Quality criteria

Scientifically sound: correct use of scientific content/knowledge according to the context
Pedagogically and **methodologically sound:** allows for diversity in learning activities and teaching methods in order to meet a variety of pupils' needs and interests.
Socially relevant: promotes public understanding of science.

Innovation appraisal

The game has successfully been tested twice as part of a course in evolution for gifted pupils of the town of Zurich (Begabtenförderung der Stadt Zürich). Pupils were heavily engaged and participated vividly in discussions. In the following weeks and months, pupils repeatedly referred spontaneously to processes that had been simulated with the game.

Relevant information in brief

Topics addressed	Evolution: variation, selection, adaptation, mutation
Age classes	11-13 years old (could well be adapted for 13-16 yrs old)
Extent	local, full class involved
Years of experimentation	1 year
Duration	1.5-3 h (2-4 lessons), depending on how much the game is extended
Main innovation promoters	Life Science Learning Center, University of Zurich & Swiss Federal Institute of Technology Zurich
Main innovation partners	Individual teacher and teacher trainer (Claudia Kunfermann)
Website	--
Contact person	Dr. Peter Jann & Claudia Kunfermann, Life Science Learning Center, peter.jann@molbio.uzh.ch

Curriculum relevance and connection to policy guidelines

Evolution is explicitly listed in the compulsory curriculum at primary school level and lower secondary level only in certain regions of Switzerland. In the other regions, many topics related to this fundamental concept are listed. Whether or not evolution will be integrated in the new curricula that are currently developed will show in the years to come.

Description of the innovative practice

Theoretical frameworks:

Active learning. Learning by playing.

Main aims, features and phases:
The aim of the game is to set a flexible stage for observation, question raising and discussion of evolutionary processes by the pupils. The moulding of play dough transfers these abstract processes to experiencing concrete processes, in which the pupils are actively involved and to which they can relate easily. Therefore, the simulation of the processes simplifies certain aspects, e.g. the pattern of inheritance. These simplifications should be addressed in the discussion, according to the teacher's objectives and the pupils' age.
The approach of focussing on observable phenomena instead of using scientific vocabulary is less exposed to fundamentalist criticism by the opponents of the evolutionary theory and its teaching at school. The game is an adaption from and an extension of commercially available evolution games (e.g. from Schlüter Biologie, www.schlueter_biologie.de). The manual shaping of the Kuglinge was added to link intraspecific variation to all the aspects looked at.

The following examples address variation, adaption, and mutation.

'Dynasty of the Kuglinge' (intraspecific variation)
a) Introduction and preparation (groups of 6-10 pupils)
- Each pupil from a group gets one colour of play dough and forms little balls from it, the 'plain Kuglinge'.
- For one of their plain Kugling, pupils form one trait that is specific for her/his Kugling, e.g. a flat side, a hole or a horn. These first Kuglinge build the parental generation (P).

b) Reproduction of the Kuglinge (groups of 6-10 pupils)
- Pupils pair up and have their Kuglinge reproduce: 2 offspring are born. Plain Kuglinge are manipulated such that the parental traits mix: from each parent, the most conspicuous trait is inherited. (This rule helps the pupils decide which traits to pass on to the next generation, it does not reflect a biological concept). These Kuglinge build the first offspring generation (F1).
- The parental generation is arranged on a grid (see resources needed below). Each pupil chooses a distinct number for her/his Kuglinge and places the Kugling that reproduced on the field of the respective generation.
- The reproduction procedure is repeated for the generations F1 to F10. Each time, pupils build new pairs. The Kuglinge that reproduced are placed on the grid.
- After completion of the reproduction, a picture is taken of the grid with all the Kuglinge. This might help with the reconstruction later.

c) Reconstruction of the Kuglinge's family tree (groups of 6-10 pupils)
- The Kuglinge are removed from the grid and mixed up.
- Pupils try to reconstruct the family tree of their own Kuglinge by placing them on the grid in the assumed order (individual work).
- For each lineage of Kuglinge, the respective parents are pointed out on the grid to the group, e.g. Kugling F3-10 has the parents F2-10 and F2-6. In case the parents cannot be found, pupils help each other with finding the mistake and reconstructing the family tree correctly.

d) Discussion (in groups or in class)
- Pupils discuss their questions related to the game.
- The change of the Kuglinge over time and the intraspecific variation from the parental generation to the last offspring generation is a major focus, e.g. the frequencies of different traits in the final population. Hypotheses can be put forward, discussed, and tested in a next cycle of the game.

'Survival of the Fittest' (selection, adaptation)
a) Introduction and preparation (in class)
- Pupils are asked for their interpretations of the expression 'Survival of the Fittest' [2]
- Each pupil forms a given number of small balls (plain Kuglinge) from one colour of play dough. If available, the Kuglinge from 'Dynasty of the Kuglinge' above can be used.

- All Kuglinge are put onto a coloured pad (e.g. large sheet of paper). Each group has a different colour, representing different habitats (e.g. forest, sea, mountain, desert).

b) Predation (groups of 3-5 pupils)

- Distribution of the roles: 1 game leader, 1 data collector, 2-3 predators (in small groups, the game leader might also be the data collector)
- The Kuglinge represent the prey, the pupils the predators. Pupils turn their back to the pad. On a signal by the game leader, the predators turn to the table and quickly grasp one prey (Kugling). This is repeated until half of the Kuglinge have been removed from the pad.

c) Reproduction of the Kuglinge (groups of 3-5 pupils)

- Each Kugling that remained on the pad is duplicated (colour, maybe traits). This way, the number of the Kuglinge will be the same as before predation.
- The steps b) and c) are repeated several times.

d) Discussion (in class)

- In many cases, conspicuously coloured Kuglinge – with respect to the pad – are picked more frequently than the 'adapted' ones. In the different groups, Kuglinge of different colours will predominate. This way the camouflage of prey to their environment can be modelled. The fact that being inconspicuous is the most beneficial strategy should be contrasted to the lay interpretation of the expression 'Survival of the Fittest'.
- Pupils discuss their questions related to the game.

Mutation can be introduced in the phase c) after several cycles of predation and reproduction. A pupil is asked to produce two Kuglinge of a colour not present on the pad instead of their original colour or two Kuglinge of a different shape could be introduced. Usually, the Kuglinge carrying the mutation are picked and removed from the pad soon. The subsequent discussion can address questions such as "Are mutations always disadvantageous?" or "Why are some animals brightly coloured but not preyed upon, e.g. poison dart frogs?"

Methodology used:
Pupils work alone, in changing pairs or in groups. Discussions take place in groups and in class.

Resources needed:

- Play dough in different colours (one colour for each pupil of a group) or white self hardening play dough that is painted later.
- Sheet with a grid to place the Kuglinge. Size: Number of generations incl. the parental generation x Number of pupils in a group
- Digital camera
- Differently coloured pads or sheets of paper

Form of assessment / evaluation used:
none when tried out (extracurricular course).

Information available

Game instructions (in German, 1 p for each concept), a PowerPoint presentation with the instructions in pictures (in German).

Critical features for sustainability

None.

Critical features for transferability

The game is flexible and allows for a broad variety of new rules according to the given context.
Teachers must have a good understanding of the concepts of evolution in order to chair the discussion and to relate the phenomena and the remarks of the pupils correctly to the conceptual framework of evolution.

Furthermore, teachers must be open and flexible to extend the game according to the ideas and group dynamics of the pupils.

[1] 'Kuglinge' derives from the German word for sphere, 'Kugel'. You are free to change the dynasty's name such that it relates to their shape, a sphere. In English, one could think of 'spherelings' or 'spherows', for example.

[2] In German, this expression is often translated as 'Survival of the Strongest'. Pupils tend to think that mainly strength determines an individual's survival.

Problem based learning – eye and optics

Keywords:
Lower and upper secondary school, interdisciplinary, problem based learning, optics, gender

Problems addressed

a. Low interest of pupils/students in science classes, particularly in physics. Approaching physical phenomena in the context of their application in health issues increases young peoples' interest, especially girls'.
b. Students lack problem solving skills
c. When school science is taught as separated subjects (biology, chemistry, physics) this does not reflect the interdisciplinary character which research questions and applications in S&T often have.

Quality criteria

Pedagogically and **methodologically sound:** allows for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests; takes gender and (multi)cultural issues into account; motivation/interest in science is stimulated.
Scientific competencies: stimulates argumentation and critical thinking; includes decision-making activities; stimulates collaborative work.
Socially relevant: address national problems in science education; promotes actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues; uses resources and teaching contexts from outside the school.

Innovation appraisal

More than 160 student teachers have tested this teaching unit. Their feedback is positive: to study a problem strongly related to one's personal daily life experience is motivating. 7-10 of them implemented this method in regular classes after their certification, but there is no feedback available yet.
Individual study and the problem analysis in groups can be very time-consuming. However, the teacher trainers feel that the questions from and the solutions presented by the student teachers show an in-depth look into the subject by the approach of PBL.

Relevant information in brief

Topics addressed	'optics' (biology and physics), problem based learning
Age classes	12-16 years old, easily adaptable to 17-19 years old (depths of content knowledge, student autonomy)
Extent	Regional (Central Switzerland), full classes involved
Years of experimentation	4 years
Duration	a minimum of 4,5 hours (6 lessons,45 min each)
Main innovation promoters	University of Teacher Education of Central Switzerland Lucerne (Pädagogische Hochschule Zentralschweiz PHZ Luzern)
Main innovation partners	Individual science teacher trainers (Dorothee Brovelli, Markus Wilhelm)
Website	http://www.phydid.de/index.php/phydid/article/view/70/Artikel%2070 (in German)
Contact person	Dorothee Brovelli, Pädagogische Hochschule Zentralschweiz Luzern dorothee.brovelli@phz.ch

Curriculum relevance and connection to policy guidelines

Part of the compulsory curriculum, can be extended to an expansion and deepening thereof. Interdisciplinary teaching is requested by curricula at lower secondary level, esp. in the areas where school science is taught as "Integrated sciences". Likewise, student-centred problem-based learning is encouraged in curricula at several levels.

Description of the innovative practice

Theoretical frameworks:

Constructivist perspective, PBL- Problem Based Learning (7steps method, Weber, 2004). For PBL in its original context in medical education, see Barrows & Tamblyn, 1980.

The scientific educational frame: the connection of personal and daily life experience with scientific contexts.

Main aims, features and phases:

Objectives: physical and biological understanding of visual processes in the eye (optical refraction as basis for picture generation, anatomy and function of the eye, ametropia and its treatment, basics of geometrical optics)

During all phases to follow, "the teacher is a guide on the side, not a sage on the stage". The teacher hints as to what knowledge would help students with their problem solving. If necessary, the teacher sets up additional experiments or gives a brief theoretical input. This depends on the level and previous knowledge of the students.

Phase 1: eye surgery: problem, first problem analysis (2 lessons, in groups of 8 students)

1. Students read the problem / clarify items: A good friend of yours, Moni, is short-sighted and thinks about an eye surgery. Another good friend of yours, Arno, had a 'LASIK eye surgery' (LASIK = Laser Assisted In Situ Keratomileusis) done and tries to persuade Moni to do the same. She is undecided because of potential risks and as a doctor advised her against it. What could and should Moni do?
2. Students identify and define the problems based on their previous knowledge
3. Students analyse the problem (brainstorming, hypotheses): What options does Moni have to come to a conclusion?
4. Students organize explanations: how to solve this problem?
5. Students formulate and specify questions and specify what kind of information they need to find

Phase 2: acquiring knowledge, laboratory experiments (2 lessons, individual study or in small groups, at home and in the lab, maybe short sequence in class)

1. Students gather information: To evaluate this case, students need to acquire a differentiated knowledge about 'geometrical optics' (picture generation, lens), anatomy and function of the eye, ametropia. Basic information about medical treatment can be found on websites of hospitals or centres for laser surgery. These individual studies are supplemented by laboratory experiments and, if necessary, theory inputs at school. The teacher decides based on his/her teaching expertise, observations of the groups in Phase 1, and the experimental equipment available at school, which experiments and theory inputs are needed by or helpful for the students in solving the problem.

Phase 3: Detailed problem analysis (2 lessons, in groups of 8 students)

2. Students exchange information such as what kinds of treatment are possible ('LASIK eye surgery' or lens implant), side effects, their – and maybe Moni's – personal attitude towards eye surgery (discomfort, fear, optimism), financial aspects, etc. Take a decision: which treatment is best for Moni and why? (In reality she keeps to reading glasses and contact lenses.)
3. Ideally a reflection on and evaluation of the learning and decision-taking process

Methodology used:

Students study and experiment individually or in small groups, problems are analysed and discussed in larger groups

Resources needed:

- experimenting/demonstrating material for the topic 'geometrical optics', e.g. picture generation, lenses, anatomy and function of the eye, forms of ametropia (depending on the prior knowledge of students and the way they address the problem; teachers will find appropriate experiments in physics and biology text books)
- prescription for glasses (probably someone in class be able and willing to provide one – informed decision of the student about sharing sensible data with his/her classmates is needed)

- information about 'LASIK eye surgery' and lens implants

Form of assessment/evaluation used: Open to the teacher's choice: formative or summative assessment based on the students' journals documenting their learning process and/or the written argumentation for Moni's final decision.

Information available

Specifically this problem:
Brovelli D. & Wilhelm M. (2009) Problemorientiertes Lernen für den integrierten Naturwissenschaftsunterricht – Vorschläge für Unterricht zur Optik und Akustik. Physik und Didaktik in Schule und Hochschule. 2/8, 2009, 65-72. (German)
Wilhelm M. & Brovelli D. (2009) Problembasiertes Lernen (PBL) in der Lehrpersonenbildung: Der Drei-Phasen-Ansatz der Naturwissenschaften. Beiträge zur Lehrerbildung 27(2), 2009, 195-203. (German)
PBL in general:
Barrows H. & Tamblyn R. (1980) Problem-based learning: an approach to medical education. Medical Education. New York: Springer Publishing Company. (English)
Weber A. (2004) Problem-Based Learning: Ein Handbuch für die Ausbildung auf der Sekundarstufe II und auf der Tertiärstufe. Berne: hep. (German)
For this teaching unit: problem (for the students) and learning objectives (for the teacher) (in total, 2 pages in German).

Critical features for sustainability

Students not familiar with PBL need to be guided through the individual steps such as problem analysis and decision finding by the teacher. Advanced students with respect to PBL will need the teacher's advice only selectively.

Too heterogeneous groups of students are a mixed blessing because of advanced and dominant students dominating the learning process in the group phases. Individual study and problem analysis in groups can be very time-consuming. However, the students' motivation and quality of the learning and problem solving process are justifying this.

Student teachers for integrated science at lower secondary level are taught this unit (albeit more detailed with respect to content knowledge), such that they will be familiar with this methodology and use it themselves in their classroom. This unit is part of a two-term class with 3 problems each.

Critical features for transferability

Teachers need to acquire competency in both, the biological and physical, aspects of optics and ametropia. In addition, they need to be willing to adopt PBL, a teaching method, which requires teaching in context to everyday life and group dynamics, and a different role of the teacher, mainly as coach.

X-rays – a combination of physics and human biology / medicine

Keywords
Lower secondary school, interdisciplinary, radiation, health education, gender

Problems addressed
a) Low interest of pupils/students in science classes, particularly in physics. Approaching physical phenomena in the context of their application in health issues increases young peoples' interest, especially girls'.
b) When school science is taught as separated subjects (biology, chemistry, physics) this does not reflect the interdisciplinary character which research questions and applications in S&T often have.
c) In certain areas of Switzerland, school science is taught as "integrated sciences" at lower secondary level. Appropriate teaching and learning material is scarce.

Quality criteria
Pedagogically and **methodologically sound:** Allows for diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests; takes gender and (multi)cultural issues into account; motivation/interest in science is stimulated.
Socially relevant: Address national problems in science education; uses resources and teaching contexts from outside the school.
Scientific competencies: Includes practical work (hands-on activities, lab-work, experiments etc.); stimulates collaborative work; use ICT-skills

Innovation appraisal
One teacher has successfully tested this teaching unit. Based on the students' feedback in questionnaires and interviews, the teaching unit has been revised. The students felt the teaching unit was very inspiring.

Relevant information in brief

Topics addressed	X-ray beams and the electromagnetic spectrum, x-ray photographs, film negative and positive
Age classes	13-15 years old
Extent	local, full classes involved
Years of experimentation	2,5 years
Duration	4-5 lessons à 45 minutes
Main innovation promoters	ETH competence centre for teaching and learning (Swiss Federal Institute of Technology)
Main innovation partners	Individual teacher lower secondary (Toni Müller) and a teacher trainer (Albert Zeyer)
Website	http://www.educ.ethz.ch/unt/um/ta/roe (in German)
Contact person	Dr. Albert Zeyer, University of Zurich, albert.zeyer@igb.uzh.ch

Curriculum relevance and connection to policy guidelines
Part of the compulsory curriculum, can be extended to an expansion and deepening thereof.

Description of the innovative practice
Theoretical frameworks: Constructivist perspective, IBSE-Inquiry Based Science Education,
The scientific educational frame: connection personal experiences and daily life experience with content

Main aims, features and phases:
Students get acquainted with the spectrum of electromagnetic waves, in particular visible light and x-rays. Through experiments with casting shadows, the students grasp the principle of x-ray

photographs. After this teaching unit, students are able to come up with basic anatomical interpretations of x-ray photographs.

Preparation: Students collect their personal x-ray photographs if applicable (available e.g. from their family doctor or dentist). A group of students can share an x-ray photograph. In this case, the respective students have to take an informed decision on sharing this sensible data with their class mates. As a back-up, the teacher can provide anonymous x-ray photographs, taken e.g. from the internet. However, this lessens the direct relevance for the students of the content learned, which has been found to be a key factor to student motivation for this teaching unit.

Lessons:

1. Introduction

- Students talk about their experiences with x-raying and x-ray photographs
- Students formulate their own question about light, x-rays, and their medical application, e.g. how a doctor could diagnose a fracture before x-raying was developed.
- Hands-on: Wave lengths between 400-750 nm are visible to humans. If light is refracted by a prism, you can see these different wave lengths as colours (violet to red). X-rays have a wave length between 10^{-8}-10^{-12}m, humans are not able to see this "light".

2. Visible and invisible light

- UV-light, radio waves, x-rays (see above), including risks of radiation and x-rays
- Students compile a profile of William C. Röntgen and his discovery of x-rays (web quest) (see comment transferability below)

3. Building a model of an x-ray apparatus

- Inoffensive analogy to x-raying: Bones in front of a light source cast shadows. Students build a model of an x-ray apparatus
- Students produce themselves x-ray photographs by drawing the shadows, which skeleton parts throw on a white sheet of paper (film positive in contrast to the film negative of an x-ray photograph)

4. Shadow images / x-ray patterns

- Why is not useful to x-ray internal organs? Students investigate this question with means of organ shapes cut out from transparent folders
- Students answer the questions they formulated in the first lesson

Methodology used:

Students work alone and in groups, hands-on exploring (light spectrum, x-ray apparatus model), use of ICT (web quest).

Resources needed:

- x-ray photographs (e.g. students bring their personal x-rays to school)
- overhead projector, slide projector or beamer
- experimenting/demonstrating material for the topic 'optics', e.g. a light source producing beams of coherent light, prism
- skeleton, thorax model
- optional: a camera (analogical or digital) to produce film negatives

Form of assessment / evaluation used: none

Information available

All teaching and learning materials online (in German: description of the lessons (8 pages) and 3 work sheets for the students (without solutions)). A collection of links to useful online resources.

Critical features for sustainability

Depending on the teacher's competence, she or he has to read up on x-raying and the interpretation of x-ray photographs.

Critical features for transferability

In the context of the discovery of x-rays, a reflection of the role of chance and serendipity in scientific research is strongly encouraged (Nature of Science, knowledge about science).

The mobiLLab

Keywords:
Lower secondary school, mobile high-tech experiments, interdisciplinary, active learning

Problems addressed

a) Teachers at lower secondary level rarely teach scientific and technical issues in an explorative, hands-on and sustainable way. Especially since the scientific disciplines have been integrated into one subject and the number of lessons has been reduced, students lack a solid basic science education.
b) Low interest of youth in science and technology (S&T)
The mobiLLab provides learning and teaching materials for autonomous student activities and supports teachers (pre- and in-service training). For student inquiries, mobiLLab offers the use of authentic equipment from industry, which schools cannot acquire for economic or personal reasons. This high-tech apparatus spark the interest of youth in S&T and professions in this field.

Quality criteria

Pedagogically sound: the design, learning materials, learning activities and teaching methodology are clearly described and consistent with the pedagogical basis; allows for diversity in learning materials and teaching methods in order to meet a variety of pupils' needs and interests; motivation/interest in science is stimulated.
Fosters **scientific competencies:** includes practical work (hands-on activities, lab-work, experiments etc.); Argumentation and critical thinking; stimulates collaborative work
Supports **teacher participation and professional development:** Training opportunities are offered within and/or outside school.

Innovation appraisal

32 classes have successfully used the mobiLLab (regional, Canton of St. Gallen). Many teachers have the mobiLLab come to their school. The teachers' written feedback is very positive. Students' verbal feedback is mostly positive like 'very exciting' or 'interesting'. Written feedback from students will follow this year (pre-, post I- and post II-tests).

Relevant information in brief	
Topics addressed	Technologically advanced measurements in physics and chemistry with help of everyday and industrial apparatus
Age classes	13-15 years old
Extent	Regional (North eastern Switzerland), full classes involved
Years of experimentation	1 year
Duration	experimental part half a day, pre- and post-preparation with class 2-5 lessons
Main innovation promoters	University of Teacher Education (Pädagogische Hochschule St. Gallen PHSG)
Main innovation partners	Teacher trainers, industrial partners, Foundation Metrohm (Herisau)
Website	http://www.mobillab.ch/ (in German)
Contact person	Prof. Dr. Kurt Frischknecht, PHSG, kurt.frischknecht@phsg.ch

Curriculum relevance and connection to policy guidelines

Part of the compulsory curriculum, can be extended to an expansion and deepening thereof.

Description of the innovative practice

The mobiLLab is a bus loaded with transportable experimental equipment driving out to schools, where students are working with it to investigate their own questions. Relevant methods and procedures from industry and research are used in the experiments, providing insight into various professions in S&T.

Presently, the mobiLLab offers a selection of modules using high-tech instruments, such as : ‘infrared camera’, ‘MIR-spectrometer’, ‘UV/Vis-spectrometer’, ‘UVA-/UVB-measurement’, ‘X-ray fluorescence’, ‘spectrometer’, ‘microwave synthesis’, ‘microwave oven’, ‘exhaust gas measurements’, ‘CO2-O2 gas sensor’, ‘high-speed camera’, and ‘ion and gas chromatography’ (4 more to come).

Theoretical frameworks:
The scientific educational frame: active learning by doing and exploring, developing scientific questions

Main aims, features and phases:
Preparation (mininum 2 lessons):
Teacher: He or she gets acquainted with the handling of the equipment (in-service training, pdf-handbook with teacher, student and tutor documents for each topic/apparatus) and decides which measurement possibilities to offer to the students.

In class (at least 2 lessons): Student pairs choose 2-4 instruments and get acquainted with the equipment using the power point presentations and video instructions provided in school or at home. For each topic, they formulate practical and testable questions they want to investigate, taking the technical possibilities and limits into account. A possible question formulated by students for the topic ‘X-ray fluorescence’ might be: *Does my tongue piercing contain any toxic metal?* (While this question could be investigated also by other means, the connection of questions from students’ daily life to the use of high-tech instruments sparks their interest.)

The mobiLLab (half a day):
The mobiLLab comes to school for one day (two classes do the experiments, one class in the morning, the other in the afternoon, date fixed in advance by the teacher) with experimental equipment organized in boxes (see pictures). The equipment is set up by the students together with the mobiLLab crew in one or several rooms. Guided by pdf-instruction sheets with incorporated instructional videos, students autonomously conduct one or two standard experiments to learn how to handle specific apparatus. Then they investigate their own questions, e.g. perform measurements on material and samples they brought from home or outdoors. The mobiLLab crew - consisting of a teacher trainer in science, a technical assistant, 3 tutors - and the form teacher support the groups of students during their inquiry if necessary. Capacity: 24 pupils.

Post processing:
After half a day of experimenting the student groups present briefly the experiments they conducted and their findings. Teachers may decide to have students prepare more detailed presentations with posters, powerpoint presentations, etc. in regular class after the visit of the mobiLLab.

Methodology used:
Work in pairs, hands-on

Resources needed:
As a teacher conducting experiments from the mobiLLab:
- in-service introduction and training of 1,5 days (all 12 modules, ca. € 110.- per school)
- rent of the mobiLLab per school: ca. € 70.- (The difference to the cost price of € 290-360.- for the University of Teacher Education is partly covered by the Metrohm foundation.)

As an offering institution, e.g. teacher training college:
- laboratory and/or technical equipment, e.g. apparatuses used in science teacher training, other devices and consumables can be sponsored e.g. by local industry or foundations (the mobiLLab is founded with €180.000)
- a way of transporting the equipment to school
- experimental protocols and suggestions as to what questions students could address
- salaries for staff

Form of assessment / evaluation used:

According to the teacher's choice: formative evaluation of the students' logbooks, grading the student presentations or none

Information available

All the instructional protocols and student activities are available online for teachers (password needed), further teaching materials are provided during the in-service training.
For each topic ca. 50 pages plus power point presentations addressed to students and teachers, in German.

Critical features for sustainability

The innovative practice is implemented in regular classroom, with teachers trained in-service (1,5 days) and/or pre-service (2 semesters: 1 semester 'Special didactics for integrated sciences' and 1 semester 'Experimental class'. It has been found that advanced teacher training is crucial for giving teachers security and self-confidence to handle the experimental equipment and to supervise students using it. Therefore, teacher in-service training is compulsory (introduction to topics, the methodology, the experiments, the proper handling of the equipment).

The fact that the equipment and technical support is coming to the schools makes teachers (a) address these topics and (b) in a way they could not on their own.

Critical features for transferability

Funding is essential to keep the material costs low and to cover some of the personnel costs. Given the large founding the mobiLLab receives, it is unrealistic to transfer this project in full. Rather, one could think of a transfer on a smaller scale, i.e. offering few modules depending on availability of the instruments. [We are waiting for suggestions as to which modules would be suitable in the responsible teacher trainer's view.]

In full range, the mobiLLab is manpower intense: for 12 modules, 6 persons (incl. the teacher) supervise the student groups; maintenance of the devices and materials; administration of the mobiLLab bookings. If offered on a large scale, ideally an internet platform is set up, where teachers sign up for in-service training and reserve the date for the mobiLLab coming to their school. Contact addresses to support teachers in case of questions should be provided.

Air to breathe – asthma and air pollutants

Keywords:
Lower secondary school, education for sustainable development (ESD), interdisciplinary, asthma, health education

Problems addressed

Education for sustainable development (ESD) should be integrated and implemented in class (see policy guidelines below). Many teachers find this difficult in the face of the many possible issues that can be addressed and the complexity inherent to ESD. In addition, curriculum leaves little capacity for new issues to be taken up.)

Quality criteria

Socially relevant: raises the awareness of social, ethical and cultural influence and implications of science and technology; promotes actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues; address national problems in science education.
Pedagogically and **methodologically sound:** allows for diversity in learning activities and teaching. methods in order to meet a variety of pupils' needs and interests; motivation/interest in science is stimulated Fosters **scientific competencies:** stimulates collaborative work.

Innovation appraisal

One student teacher tested this teaching unit and revised it thereafter. So far, we did not receive more information on the experiences in class.

Relevant information in brief

Topics addressed	Asthma and other respiratory diseases, air pollutants in conjunction with mobility behaviour
Age classes	13-15 years old
Extent	Local, full classes involved
Years of experimentation	1
Duration	6-8 hours (8-10 lessons)
Main innovation promoters	Entire set of teaching units: Swiss Conference of Cantonal Ministers of Education, a consortium of eight Swiss Universities for Teacher Education.This teaching unit: Scuola universitaria professionale della Svizzera italiana/Dipartimento formazione e dell'apprendimento, Locarno
Main innovation partners	Individual student teacher at lower secondary (Linda Vanetta) and two science teacher trainers (Urs Kocher and Patrick Kunz)
Website	None
Contact person	Linda Vanetta, linda_vanetta@yahoo.commailto:urs.kocher@supsi.ch

Curriculum relevance and connection to policy guidelines

With reference to the UN decade for ESD (2005-2014), ESD has recently been or will be integrated in the near future into the compulsory curriculum (different states of curriculum revision in various (language) regions of Switzerland) (Agenda ESD of the Swiss Conference of Cantonal Ministers of Education 2007-2014, in collaboration with six federal ministries).

Description of the innovative practice

A set of exemplary teaching units was developed by teachers, teacher educators, and student teachers in a participatory process on site, focussing and expanding existent teaching units towards sustainable development. This approach and the teaching units developed should empower teachers to implement ESD in their classroom. Here, we present one of these teaching units, in which students write newspaper articles and produce posters on asthma and other respiratory disease as well as means to reduce air pollution.

Theoretical frameworks: education for sustainable development (ESD)
The educational frame: find democratic and inclusive solutions for society and as a group

Main aims, features and phases:
Lessons 1–2: describe symptoms and possible causes of asthma, relationship between air pollutants and asthma, mind map of causes of air pollutants
- Students read a story about a passionate sportsman (football) who is affected by asthma.
- Students fill in a questionnaire 'Do you know what asthma is'? This way the teacher learns about the students' previous knowledge.
- Discussion of the results of the questionnaire in class
- Students create a mind map with facts about air pollution

Lessons 3-5: write and review a newspaper article
For this part, collaboration with the language teacher would be an added value, in order to deepen the knowledge and reflection on the structure of different types of newspaper articles.
- Students write a newspaper article (content wise and linguistically correct) in pairs on asthma or other respiratory diseases. Suggestions: interview with a specialist like a medical doctor or an affected person, process information from a web quest. A part of this writing exercise should be done at home.
- It is advised to have students use the same (electronic) template for their articles. This makes the final compilation of the articles easier. Ideally, all texts are issued as a newspaper in the end. (This, however, is time consuming.)
- Students reflect and critically comment a newspaper article of their class mates

Lessons 6-7: produce a poster on respiratory disease and its causes and practicable solutions how to reduce it
- Students create a poster about this complex issue from which a reader can learn about facts, the factors involved and their interaction, the urgency of the issue, and possible solutions focussing on sustainable development (developed by the students)(for poster evaluation criteria, see work sheet)

Lessons 8-9: present, discuss and evaluate the posters
Different suggestions how to organise this phase:
- each group presents its poster to the class, then all posters are evaluated in class or
- exhibition of the posters, students fill in the evaluation sheet or
- new groups are formed containing one expert of each poster group. This expert presents the poster to the new group.

Methodology used:
Students work alone, in pairs, in groups or full class; outcomes are posters and newspaper articles.

Resources needed:
- story about a passionate football player (on CD)
- questionnaire (on CD)
- work sheet for the newspaper article (on CD)
- flipchart, packing paper, cutter, glue, marker, computer, printer
- example of a poster and evaluation sheet for posters (on CD)

Form of assessment/evaluation used:
None when tried out. The newspaper articles and posters could be graded. The comments and evaluations received by the fellow students and the teacher could be used either for formative or summative assessment.

Information available
All teaching and learning materials are from a book with teaching units on ESD including a CD with PDF- and Word-documents of the work sheets and links to useful online resources (in German): Handeln statt hoffen: Materialien zur Bildung für Nachhaltige Entwicklung für die Sekundarstufe I. Edited by: Kyburz-Graber, R; Nagel, U; Odermatt, F. Klett&Balmer,Zug, 2010
For this teaching unit, the materials are also available in Italian (5-10 pp).

Copyright: Not clear yet: The use of the published material within the frame of a research project is allowed, as long as the reference is clearly indicated. But the subsequent production of teaching materials to be disseminated would need the permission of the copyright holders. Whether or not the public report Deliverable 4.1 'Adapted Innovations' is considered as dissemination will depend on the form of publication and its content.

Critical features for sustainability

- ESD framework: It is important to teach the students how they personally can contribute to improve and influence a given situation, teaching a pessimistic view could be counterproductive and leave the students with a feeling of helplessness.
- This issue is a good basis to discuss social and economic mobility

As introduction of this teaching unit, asthma is taught in conjunction with air pollutants. Here, it has to be pointed out to the students that scientific evidence exists that air pollutants can affect the intensity of asthma. However, it is unclear whether air pollutants *per se* can cause the disorder asthma. It could be stressed that this is the general limit of every health issue that can be related to environmental conditions. From a more general point of view, it could be emphasized that owing to the complexity of the relations involved the one to one cause-effect relation cannot be stated.

Critical features for transferability

- Education for sustainable development (ESD) is a challenging subject for teachers, see also 'problem addressed'.
- The teacher should have expertise in ICT for compilation of the newspaper articles and to help students when using various media for their inquiry.

Acting instead of talking! Students participate in the (sustainable) development of their school

Keywords:
Education for sustainable development (ESD), Lower secondary school, environmental education, principle of participation, school development

Problems addressed

Education for sustainable development (ESD) is to be integrated and implemented in class (see policy guidelines below). Many teachers find this difficult in the face of the many possible issues that can be addressed and the complexity inherent to ESD. In addition, curriculum leaves little capacity for new issues to be taken up.
The problems addressed by the teaching unit are:
a) Participation is one of the bases of ESD and rarely granted to pupils and students
b) Students are seldom acting in a sustainable way, even if sensitized for environmental problems

Quality criteria

Pedagogically and **methodologically sound:** allows for diversity in learning activities and teaching methods in order to meet a variety of pupils' needs and interests
Fosters **scientific competencies:** includes decision-making activities; stimulates collaborative work.
Socially relevant: Raises the awareness of social, ethical and cultural influence and implications of science and technology; promotes actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues; address national problems in science education

Innovation appraisal

Only few teachers of the school took up the initiative (the others declined for reasons of high work load and insecure positions due to reorganisation of the school). These teachers appreciated addressing the subject with their classes. The students were very satisfied with the project, in spite of the difficulties sometimes encountered when approaching other persons and classes.

Relevant information in brief

Topics addressed	Environmental/ESD issues according to the choice of the students or teachers (here reducing the amount of paper used), principle of participation, project class
Age classes	13-15 years old
Extent	Local (one school), 4 full classes involved
Years of experimentation	2
Duration	8 hours (10 lessons), here spread over a semester, could be expanded
Main innovation promoters	Entire set of teaching units: Swiss Conference of Cantonal Ministers of Education, consortium of eight Swiss Universities for Teacher Education This teaching unit: Haute Ecole Pédagogique Lausanne, HEPL
Main innovation partners	Individual teacher student at lower secondary (Séverine Mahrer-Bonvallat), a science teacher trainer (Charles-Etienne Vullioud), and a school (Etablissement Secondaire La Planta, Chavannes-près-Renens VD)
Website	--
Contact person	Séverine Mahrer-Bonvallat, severine.mahrer@vd.educanet2.ch François Gingins, HEPL, francois.gingins@hepl.ch

Curriculum relevance and connection to policy guidelines

With reference to the UN decade for ESD (2005-2014), ESD has recently been or will be integrated in the near future into the compulsory curriculum (different states of curriculum revision in various (language) regions of Switzerland) (Agenda ESD of the Swiss Conference of Cantonal Ministers of Education 2007-2014, in collaboration with six federal ministries).

Description of the innovative practice

A set of exemplary teaching units was developed by teachers, teacher educators, and student teachers in a participatory process on site, focussing and expanding existent teaching units towards sustainable development. This approach and the teaching units developed is intended to empower teachers to implement ESD in their classroom.
Here, we present one of these teaching units, in which students participate in the (sustainable) development of their school by planning and implementing a project about a topic from environmental education/ESD they decided upon.

Theoretical frameworks:
Education for sustainable development (ESD)
The educational frame: student participation, if possible at the level of the school/school development

Main aims, features and phases:
Sensitization for sustainable development
Lessons 1–2: introduction
- Students watch the film 'An inconvenient truth' (Al Gore, 2006) (93') or other comparable media releases and fill in a work sheet
- Discussion of the answers in class

Lesson 3: sensitization
- Students read and discuss in groups different articles about environmental problems (selection by the teacher), write an abstract and a conclusion, and present them to the class
- Discussion in class about sustainable development and possible ways to contribute individually in everyday life, e.g. reduce the use of paper or buy local fruit (a list further examples is available on CD).

Finding a project: brainstorming, selection, and implementation
The groups of students work as self-organized and autonomous as possible. The students are the main protagonists while the teacher acts as a coach and advisor. This way, students learn to be responsible for a process, find practical solutions that take into account the interest of different stakeholders, become aware of the social and economic aspects of sustainable development.

Lesson 4: the principle of participation? Topics according to the choice of the class or the teacher
- Students in groups look for information about topical environmental problems on a global, national, regional or local level. The teacher can set a framework with respect to the content and the level of implementation if indicated.
- In class, students select one or more topics, which they want to pursue; further reading can take place at home

Lesson 5: brainstorming
- For the selected topics, students collect ideas for actions that would contribute to sustainable development and on possibilities of implementation at different levels (individually, class, school, community). (full class)
- As a class, students decide in a democratic way on which idea or ideas they want to follow up. Here, the suggestions should be analysed critically from different points of view. An action that will have a positive effect on a certain aspect might have a negative effect on another important aspect. For the example 'reducing the use of paper of the entire school' the class decided to pursue the following ideas: each classroom gets a waste paper basket only for paper to be recycled, each sheet of paper is used on both sides when photocopying or printing or students get only a new notebook, if the old one is used up to the last page.
- Students build groups and prepare the implementation of a specific action. For the examples above, students contacted the headmaster, the janitor, all teachers from the school, and they produced a PowerPoint presentation summarizing the most important points on how the use of

paper can be reduced (this was later presented to other classes and to the teachers in the staff room). In the teaching materials, a list of questions the students compiled before contacting the janitor illustrates what aspects might have to be considered for proceeding (on CD).

Lessons 6-10 or more: implementation of the project (groups)
Note: the larger the projects, the longer time the implementation takes.

Methodology used:
Students work in groups or in full class, project class

Resources needed:
- the film 'An inconvenient truth' (Al Gore, 2006) (93')
- work sheet about the film (on CD)
- other resources according to what kind of project a class implements – use resources you have and have students find solutions taking these resources into account.

Form of assessment / evaluation used:
The students documented their work and ideas in a journal as a group. The teacher assessed the originality of the ideas, their possibility of realisation, the way of approaching and involving other persons, the students' commitment and motivation. In the end of the project, all documentation can be compiled for the entire class.
Ideally, but not done when tested, the students reflect on their learning process and evaluate the project by monitoring the effects of the measures implemented.

Information available

All teaching and learning materials are from a book with teaching units on ESD including a CD with PDF- and Word-documents of the work sheets and links to useful online resources (in German): Handeln statt hoffen: Materialien zur Bildung für Nachhaltige Entwicklung für die Sekundarstufe I. Edited by: Kyburz-Graber, R; Nagel, U; Odermatt, F. Klett&Balmer, Zug, 2010 (in total 8 pages)
For this teaching unit, the materials are also available in French.
Copyright: Not clear yet: The use of the published material within the frame of a research project is allowed, as long as the reference is clearly indicated. But the subsequent production of teaching materials to be disseminated would need the permission of the copyright holders. Whether or not the public report Deliverable 4.1 'Adapted Innovations' is considered as dissemination will depend on the form of publication and its content.

Critical features for sustainability

- Ideally, students pursue these projects for a longer time. A possibility to set the projects on a long-term basis is to connect different classes (years): before the more advanced class leaves school, it passes on the responsibility for the project to a younger class.
- If a project affects the entire school, the backing and support of the headmaster and the teachers is important.
- It is important that students experience how they can personally contribute to improve and influence a given situation. If a project implementation fails, the teacher should think of alternative solutions and actions with the students, pointing out the importance of perseverance and creativity in carrying out projects successfully.

Critical features for transferability

Education for sustainable development (ESD) is a challenging subject for teachers, see also 'problem addressed'.
This teaching unit might cover a wide range of topics and levels because it is based on the principle of participation: students and teachers decide which project or projects are implemented. The outcome of this teaching unit is deliberately left open. The teacher, and possibly the school, has to be at ease with such an open-ended process. However, this openness gives an adapting country and each school a maximum of flexibility of fitting the teaching unit to its individual situation and framework.

Ideas about science in 21st Century Science Course

Keywords:
Secondary school, new curriculum, ideas about science, discussion, argumentation

Problems addressed
Images of science, dissatisfaction with traditional ways of presenting concepts, grasping the complexity of real life, and the role of scientists; the projects could also include gender diversity.
International background to this includes PISA and TIMMS references.
The English National science syllabus focuses more on subject knowledge and skills and not enough on the nature of science, theories and hypotheses and the ways in which scientists actually work.

Quality Categories
Scientifically sound: Raises awareness of the Nature of Science; provides insight in the way scientific knowledge is constructed
Pedagogically and **methodologically sound**: the pedagogic basis/background is clearly described and learning activities are consistent; the design, learning materials, learning activities and teaching methodology are clearly described and consistent with the pedagogical basis and take current theories about science learning into account
Fosters **scientific competencies:** offers inquiry based learning activities; stimulates argumentation and critical thinking; uses ICT-skills

Innovation appraisal
Evaluations have been carried out by independent researchers, whose comments are generally positive.
The collected teachers' responses often provide interesting insights into the strengths of the materials, e.g. *"I think the course has made me think about having more discussion group based classroom activities. But I do think I need retraining or a bit of help in knowing good techniques – in understanding which techniques work".* Students also commented on how the course helped them make better sense of news in everyday life, "*You actually know what they are talking about – Yes, like watch the news and understand",* Hanley et al (2008) p 111.

Relevant information in brief

Topics addressed	Twenty First Century Science is a set of GCSE science courses developed to give all 15 to 16 year olds a worthwhile and inspiring experience of science
Age classes	15-16 year olds.
Extent	National/Local Number of classes/groups of students involved 78 schools in pilot for three years from September 2003
Years of experimentation	3 years
Duration	One year
Main innovation promoters	University of York
Main innovation partners	Nuffield Foundation, Salters' Institute and Wellcome Trust are the project sponsors.
Website	http://21stcenturyscience.org/
Contact person	Rachel Cullivan uyseg-c21@york.ac.uk Maja Melendez mmelendez@nuffieldfoundation.org

Curriculum relevance and connection to policy guidelines
This is a curriculum innovation with specially designed materials and activities. The objectives are to interrelate science explanations and ideas-about-science in the teaching of the subject. The project influences include PISA 2006.

Description of the innovative practice

The strength of the 21st Century science course is that it meets the needs, through flexible options, of those who will go on to be professional scientists and of those who will not. It requires teaching students **ideas about science**. This involved teachers in increasing the amount of the following styles – whole class discussion, small group discussion, discussing topical scientific issues, debating student initiated issues, independent study, accessing the Internet, student presentations.

Theoretical frameworks:

The theory behind this innovation is linked to social constructivism in that students are expected to communicate with each other in small and large discussion groups, make informed decisions and use persuasive argument to put across their views in comparison to alternative views on controversial issues.

It is underpinned by a modern epistemological approach to the nature of science; how scientists work; the inherent uncertainty in measurements; the limits of the scientific previsions; the difference between correlation and causal relation; the influence of cultural social technological elements on the evolution of science.

Main aims, features and phases:

Pupils are encouraged to link their own ideas to those currently being debated in the news or educational, social or political arenas, hence seeing science as an essential element in society. Problem based learning is part of this process, both in identifying problems they consider to be important and in finding ways to understand and present their own opinions on such matters.

Methodology used:

Generally, this curriculum does not need any specialist school setting, unless hands-on lab based activities are used to support discussions. Students would need table space and paper and pens, but they might also save their ideas using ICT methods. An essential aspect of the work would be group debate and structured discussion.

Resources needed: These would depend on the particular modules being taken, see for example, the Barringer crater information sheets, key assessment task information, question sheets marking criteria. There are also some video materials available, showing teachers and pupils talking about the scheme.

See http://21stcenturyscience.org/resources/assessing-ias-4-the-scientific-community,1575,NA.html

Form of assessment / evaluation used:

Students can be assessed in a variety of ways depending on the context and country: in England, for example, these are run by an Exam Board OCR.

Information available

Useful information on a video http://21stcenturyscience.org/support/voices-from-the-classroom,1561,NA.html But you could easily get an impression of the course and how it is innovative without buying the whole thing, from some of the materials available free on the website. Training materials are also available on the following module (http://21stcenturyscience.org/the-courses/core-science-science-for-scientific-literacy,907,NA.html) for example: "Why air quality?" The quality of air is becoming a major world concern. In this module students explore environmental and health consequences of certain air pollutants and options for improving air quality in the future. The emphasis is on health issues arising from burning fuels, rather than global issues such as climate change, which is covered in module P2 "Radiation and life"

Critical features for sustainability

This has been carried out in normal schools and also evaluated in practice

Critical features for transferability

One finding from the evaluation is that teachers do need some training in how to use materials like these, since they are less likely to be able to transfer their pedagogy from the more usual science lesson in lab or classroom, to this much more talk-based and epistemologically concerned teaching style.

Hanley, P. Osborne, J. and Ratcliffe, M. Teaching Twenty First Century Science, *School Science Review* September 2008, (90) 330 p 107.

Science Across the World

Keywords:
Secondary school, intercultural exchanges, languages in science, real-life context, communication, problem-solving

Problems addressed

The main problem is about comparing different ways of defining science concepts and of using science concepts in different countries. The exchange model, where schools exchange information and ideas, is often centred on the use of scientific concepts in real life situations. Age needs to be considered as it may be difficult for younger pupils to communicate in other languages.

Quality criteria

Pedagogically and **methodologically sound:** the pedagogic basis/background is clearly described and learning activities are consistent ; the design, learning materials, learning activities and teaching methodology are clearly described and consistent with the pedagogical basis; take multi-cultural issues into account.
Fosters **scientific competencies:** fosters scientific literacy (identify scientific issues, explain phenomena scientifically, use scientific evidence); stimulates multicultural collaborative work; use ICT skills
Socially relevant: raises the awareness of social, ethical and cultural influence and implications of science and technology; use resources and teaching contexts from outside the school; promotes global citizenship.

Innovation appraisal

DeWitt, J and Osborne, J. (2008) report that teachers like to use SAW for:

- contacts with other schools in different countries
- student interest and motivation
- development of Key Skills in Communication, ICT, Working with others, Problem Solving
- development of Thinking Skills in Reasoning, Enquiry, Creative thinking and Evaluation
- language learning value
- usefulness of the topic/issue
- source of different pedagogic skills

Students also gain by extending science into cross curricular activities, including citizenship and sustainable development education

Relevant information in brief

Topics addressed	Many Unit/topics are available, for example: Chemistry in our Lives. Domestic Waste , Drinking Water, Eating and Drinking Around the World , Keeping Healthy, Talking about Genetics Around the World , Acid rain, What do you eat?, Climate change, Biodiversity, Renewable Energy
Age classes	8 – 17 year olds, the majority of the topics is for 12-15 year old
Extent	The innovation has reached 8,340 teachers in 149 countries, where students are collaborating on school science topics.
Years of experimentation	Data are available since 2004
Duration	The projects vary in size and length, the average is 6-8 hours for each unit
Main innovation promoters	Association for Science Education www.ase.org.uk
Main innovation partners	Glaxo/Smith/Kline
Website	http://www.scienceacross.org/
Contact person	DeWitt@peoplescienceandpolicy.com On the SAW website the list of contact persons for every country (and language) is available

Curriculum relevance and connection to policy guidelines

The project links to Global Citizenship as well as science in practical terms. It also includes the practice of students communicating directly with others in different countries and with different cultural experience and backgrounds.

Description of the innovative practice

Teachers have to subscribe to the web site where they can download the units for free or use the web pages to communicate with schools working on the same units in the same year.

Theoretical framework: Communication about how science is conceived and applied in different countries is the focus of this scheme. Children and teachers contact each other directly to share ideas and data from their own communities and to learn about similar issues and ideas in other places. Hence a social constructivist framework is the basis of this innovation.

Main aims, features and phases: To encourage students and teachers to develop contacts and links with other schools in different parts of the world.

Students are interested and motivated by global science issues and communicating with other young people from different countries and cultures.
Students look at the wider aspects of science around issues of diet and health, genetics, the environment and energy use.
Students develop Key Skills in Communication, ICT, working with others and Problem Solving.
Students develop Thinking Skills in Reasoning, Enquiry, Creative thinking and Evaluation.
Teachers can develop different pedagogic skills and extend science into cross curricular activities, including citizenship and sustainable development education.
Methodology used: Schools are encouraged to find international partners and to take part in a great variety of activities. There is a common structure to the units, including activities and collection of information (often gathering data related to students' own lives and locations to compare with the lives of students elsewhere), sending the modules to more schools, discussion of the results comparing different cultural views. Schools are encouraged to find international partners and to take part in a great variety of activities – for examples see the sample activities on the website, such as **"What did you eat?"**. This topic focuses on the nutritional aspects of food and looks at links between diet and health. Students are able to reflect on the nutritional and social values of different diets.
In this topic the learning activities include:

- a personal survey of what is eaten during a typical day,
- current and traditional eating habits,
- concerns about diet and suggestions for improving it.

This topic will fit into the general biology curriculum as well as chemistry, home economics and languages. In most countries it is suitable for students aged 12 to 14 years.

Another topic concerned issues on **global warming**, where students discussed their ideas, such as
"With the sea level it depends on how low you are, because if you are up a mountain you won't get affected that much."
"It affects some countries more than others, because such as the Uk, if the Gulf Stream was affected we could become a lot colder, but some countries probably wouldn't change that much, a bit warmer or a bit colder."

Resources needed: The website presents the units already translated in many languages. The resources needed depend on the topics but in general are very easy to find and cheap. The collaboration with one or more language teachers (depending on the countries chosen for the exchange) is important.

Form of assessment / evaluation used:
Many different forms of assessment can be used, depending on topic, age range, country, etc.

Information available

The units are available in different languages, the number of languages available depend on the topic. In general all the main European languages are available. Some topics have been translated also in African and Asian languages.

Critical features for sustainability

The projects have been running for many years, so are relatively sustainable. A critical feature of the scheme is the collaboration between science teachers and foreign language teachers, while another critical feature is finding international partners, although there are usually other local agencies which can help with this process, in the UK, for example, the British Council.

Critical features for transferability

Schools could get an idea of the overall project through the use of some of the sample activities. Some materials are available in a range of languages (see above). The whole scheme is available free through the website.

Reference

SSR DeWitt, J and Osborne, J. (2008) *School Science Review*, December 2008, 90 (331) p.109 - 116 Association for Science Education: Hatfield

Drama and Science

Keywords:
Primary/lower secondary school mainly, modelling, communication, participative methodologies

Problems addressed

There is a general dissatisfaction with traditional ways of presenting concepts, the science syllabus being too much about the subject knowledge and not enough about the progress made by children as they develop their understanding of the complexity of the world. Drama is a good way of helping children to understand more abstract concepts in science such as the directions of forces, the reactions of elements and compounds, kinetic theory of matter, etc and the role of scientists, included gender diversity.
Drama gives children an alternative way of expressing and developing their ideas as they cooperate in groups to solve particular problems.

Quality Criteria:

Scientifically sound: correct use of scientific content/ knowledge according to the context, raise awareness of the Nature of Science.
Pedagogically and **methodologically sound:** allow for a diversity in learning materials and teaching. methods in order to meet a variety of pupils needs and interests; Include all pupils, including those with special educational and physical needs; motivation / interest in science is stimulated.
Fosters **scientific competencies:** stimulates argumentation and critical thinking; includes decision-making activities; stimulates collaborative work .

Innovation appraisal

Evaluations have been carried out by independent researchers who report that students' conceptual understanding of more abstract ideas have been increased through drama. (Litteldyke M. 2004)

Relevant information in brief

Topics addressed	Drama is used in a range of scientific contexts, including chemical reactions, kinetic theory, life cycles, plant pollination, the processes of digestion, etc.
Age classes	All ages, mainly 6-15th
Extent	International/National/Local Number of classes/groups of students involved in this case was of a class of secondary school girls
Years of experimentation	2 years
Duration	As long as you have time for – could be very short sketches or much longer productions and presentations.
Main innovation promoters	Varied – see the literature for some examples of educational authorities/research institutes which promote drama in science.
Main innovation partners	Researcher, actors
Website	
Contact person	Michael Littledyke, mlittledyke@glos.ac.uk

Curriculum relevance and connection to policy guidelines

The current science national curriculum does offer some suggestions for cross curricular links, often with ICT and maths. A section of the national curriculum on Inclusion mentions the need to develop understanding through "the use of all available senses by … encouraging pupils to take part in everyday activities such as play, drama, class visits and exploring the environment" – The National Curriculum for England, 1999, p 64, London: DfEE.

Description of the innovative practice

Drama can be used with students of all ages to support their understanding of abstract ideas. Collaboration between science and drama/class teachers would be useful in bringing in specific drama techniques and ensuring that the science principles dealt with are as accurate as possible, given the current state of knowledge of the students.

Theoretical frameworks: There are many techniques available through drama that can be developed in scientific contexts – face painting of different actors to suggest the metal, like gold or iron, they represent, making masks to show an animal or plant interacting in an environment, etc. These techniques have their own theoretical frameworks in the literature, but within science education would fall into social constructivism theories.
Some of the activities could be described as Problem-based learning. "Participative methodologies" is another descriptor for this teaching and learning process.

Main aims, features and phases:
The use of drama is aimed at developing the conceptual understanding of students who may have different learning preferences or styles. Drama techniques need to be introduced and then students encouraged applying them to specific science problems and presenting them to audiences.
Various drama techniques can be used in a range of scientific contexts, including chemical reactions, kinetic theory, life cycles, plant pollination, the processes of digestion, etc.
For instance, children could be encouraged to think of digestion as a continuous process, the parts of which can be explained through drama. The "salivary glands actors" would need to pump liquid into the mouth cavity – how children would enjoy demonstrating this by squirting water into the "food particles actors"! The "stomach wall actors" would then need to pulse once every 20 seconds to mix up the food inside and help digestion to continue.
Another example is about describing the reactions of metals using face paint for gold and white with blue bubbles for oxygen and then base the conversations and actions of the elements at a cocktail party.
Role play, as a drama technique, can include the following: -

- Real life simulations can also be the starting points for further drama and science activities: -
- Role of the expert – children take on roles as presenters or audience, explaining scientific concepts to younger children, or to aliens with no knowledge of life on Earth,
- TV or radio documentary – presenting ideas and concepts as clearly and interestingly as possible, with video or audio recording and the construction of a programme
- Magazine or newspaper – children take roles of editorial staff and journalists, to present a written account based on earlier interviews,
- Petitions – children in pairs take turns to try to persuade someone to sign a petition about an issue,
- A law court – issues are presented by "barristers" and decisions made by a "judge" and "jury", with the involvement of members of a local community angered by illegal waste disposal, or pollution or threats to endangered species.

Methodology used:
A lot of group work involved in this. Activities would include background research by students into the correct science and supported by science teachers, discussions about design of the drama, the costumes and props needed, the best ways to present the work to a variety of audiences, of different ages and scientific experience. ICT would be used to gain further scientific information and as a presentation tool.

Resources needed:
Not very many and would depend on local interests, styles, theatrical format, use of animation, or real actors, puppets and other symbols. These could include costumes and masks which children could make, also stage makeup. Cameras and video equipment for presentation and assessment.

Form of assessment / evaluation used:
Students can be assessed through filming their work, through audience feedback and through the normal science tests of scientific conceptual understanding.

Information available

Littledyke M. Drama and Science, *Primary Science Review,* no 84 Sept/Oct 2004. 3 pages to translate

Critical features for sustainability

It is essential for science and drama teachers to cooperate within a school, to deliver an integrated part of the curriculum which would enable a better understanding of scientific processes and concepts.

Critical features for transferability

The teachers' scientific knowledge and willingness to experiment and to allow pupils to make their own decisions.

Biodiversity Action Plans

Keywords:
Secondary schools, outdoor Education, biodiversity management, action plans and action

Problems addressed

- Losses in biodiversity in the local environment
- School grounds are highly fragmented, heterogeneous landscapes, offering a range of opportunities for wildlife.
- National Environment and Rural Communities (NERC) Act (2006) directs all public bodies that carry out functions of a public character (including schools) to have regard to biodiversity in their grounds. By 2020 all school grounds should be: -"regarded as living, learning places where pupils see what a sustainable lifestyle means through their involvement in the continual improvement of the school estate."
- Grasping the complexity of real life – addresses real life context and place.

Quality criteria

Scientifically sound: provide insight in the way scientific knowledge is constructed.
Fosters **scientific competencies** includes practical work (hands-on activities, lab-work, experiments etc.); stimulate argumentation and critical thinking; stimulate collaborative work .
Socially relevant: raises the awareness of social, ethical and cultural influence and implications of science and technology; uses resources and teaching contexts from outside the school; promotes public understanding of science.

Innovation appraisal

A case study by the University of Worcester (Mansell, M. 2010), using their Biodiversity Action Plan (BAP), demonstrates potential for local and national actions in partnership with other bodies which have published their own BAPs. The UK BAP (2008) and local action plans, e.g.
Brighton and Hove (2005) (www.citywildlife.org.uk/pdf/BAP_Final.pdf) are a source of information and data which can be used by schools, although no evaluation has yet been done on schools using BAPs.
Mansell, M. 2010 Biodiversity in school grounds: auditing, monitoring and managing an action plan. *School Science Review,* March 2010, 91(336) p. 89 – 98 Association for Science, Hatfield:UK

Relevant information in brief

Topics addressed	Biodiversity in school grounds
Age classes	11 to 19.
Extent	Local, but with links to national initiatives
Years of experimentation	Case study of 1 year,
Duration	Ideally the action plan is continuous, once it has started.
Main innovation promoters	University of Worcester,
Main innovation partners	National and local BAP publishers
Website	www.worc.ac.uk/about/1161.html Sustainable Schools website www.suschool.org.uk
Contact person	John Meadows, meadowjj@lsbu.ac.uk

Curriculum relevance and connection to policy guidelines

- The action planning cycle fits well within the English science national curriculum in both key stages 3 and 4 (ages 8 to 16)
- BAPS offer the chance for students to carry out practical science and data collection in a relevant and authentic context.

Description of the innovative practice The practice of carrying out audits, planning and managing change in local environments are easily transferable to other localities, since many countries are bound by international agendas concerning environmental action. Students could work in groups to collect and analyse data including site plans, tree surveys, planting plans and records, habitat and species surveys, local biological records, protected species information, the policies of local authorities on biodiversity, local maps and plans, on-site knowledge, such as interview with people who remember changes to the grounds. The students then produce a baseline audit of the local habitat, using their own monitoring of habitats, species, etc. Their subsequent planning could include enhancing the quality of existing habitats, and creating new habitats, eg. bird boxes linked to cameras for observation, decaying wood, etc.

Theoretical frameworks:
The project requires practical hands-on work in a real context, with problem-based learning opportunities, within a social constructivist theoretical approach.

Main aims, features and phases:
The use of BAPs in school grounds provides opportunities for students to raise their own concerns as well as dealing with existing situations in a cross-curricula way, linking geography, local history, aesthetics and science in actions to monitor and improve the local environment of the school grounds.
Students would need to work within the community, seeking partnerships with other bodies which have BAPS and who have an interest in changes in the local environments and its habitats.
There are three main phases in each cycle – auditing, planning and action, with each phase linked closely to monitoring. The details of the work would depend on the age and scientific knowledge of the students involved.

Methodology used:
ICT would be useful in data logging and data handling; outdoor and indoor work; project work and collaborative group work would be the best ways of managing this activity for a class.

Resources needed:
School grounds with some biodiversity or a nearby bio-diverse park or green area.
Materials for surveying and recording data about the local environment and ICT equipment for handling and collecting data, access to local information.

Form of assessment / evaluation used:
Not available, but a variety of forms of assessment could be included including peer assessment. Assessment could also include evaluation of the students' participation and interest in all the activities.

Information available

Article in School Science Review, Mansell, M. 2010 Biodiversity in school grounds: auditing, monitoring and managing an action plan. *School Science Review,* March 2010, 91(336) p. 89 – 98 Association for Science, Hatfield:UK. There are no published materials linked directly to this innovation as it has not yet been trialled in schools.
Other websites www.worc.ac.uk/about/1161.html
Bird project www.birdinfo.co.za/landbirds/14_oxford_swift_project.htm
Sustainable Schools www.suschool.org.uk

Critical features for sustainability

The project has not yet been evaluated by schools.

Critical features for transferability

Teachers' professional development on science contexts; outdoor facilities within the school grounds.

Physics and sports

Keywords:
Upper secondary school, interdisciplinary, use-oriented, sports-experiments in physics

Problems addressed

Low interest in science and technology of youngsters
Missing knowledge-transfer between theory - praxis - everyday-life
Counteract the negative image of physic lessons

Quality criteria

Fosters **scientific competencies:** foster scientific literacy (identify scientific issues, explain phenomena scientifically, use scientific evidence); include practical work (hands-on activities, lab-work, experiments etc.)
Support **teacher participation** and **professional development:** innovation has a clear teacher manual.

Innovation appraisal

Qualitative evaluation via methods-triangulation: 1) analyse of individual portfolios, 2) individual interviews with project-supervisor and pupils, 3) group-discussions. The two aims 1) to enthuse the students and 2) to foster the interest of pupils in physic-education were achieved. The teacher regards this project as succeeded. The evaluation of the project showed predominant acceptance of this teaching structure of physic lessons by the pupils, which in turn justifies the additional time and effort compared to "normal" lessons (evaluation is available).
The follow-up projects also were evaluated, proving the success of the project, especially in terms of raising interest in physics.
Furthermore quantitative evaluation of velocity distribution in the 60-metre sprints and long and high jump (video camera recording that followed analysis on the PC, logging of force distribution by means of measuring interfaces on the PC) is available.

Relevant information in brief

Topics addressed	Using sport themes to approach physic topics
Age classes	16 years old pupils
Extent	local one class, 17 pupils
Years of experimentation	2004/05 – 2007/08 (including follow-up projects)
Duration	About 3 months in all, each theme in a block course
Main innovation promoters	IMST3 promoted by Austrian Federal Ministry for Education, Arts and Culture
Main innovation partners	Sport-institute of the University Graz
Website	http://imst.uni-klu.ac.at/ http://imst3plus.uni-klu.ac.at/imst-wiki/index.php/Hauptseite http://imst.uni-klu.ac.at/materialien/2004/279_endbericht_duenbostl.pdf
Contact person	Mr. Theodor Duenbostl, Theodor.Duenbostl@univie.ac.at

Curriculum relevance and connection to policy guidelines

This practice is part of the compulsory (theme, theory) and optional (method, competence-transfer) curriculum with an explicit reference to the Austrian curriculum-paper.
The results of the international survey PISA 2006 show little interest of Austrians' students in physics, average achievements in the category 'physical systems' and a relatively weakness in 'using scientific competences'. (http://www.oecd.org/dataoecd/15/13/39725224.pdf; Schreiner C.; Schwantner U: PISA 2006.) Physic and sports is part of a big national initiative called IMST programme (Innovationen machen Schulen Top!) of the Austrian Federal Ministry for Education, Arts and Culture to improve the education in different subjects, especially science and technology. IMST works in four programmes (thematic / regional network, gender network, culture of examination and stocks for education- and school-development) and evaluates education, school development and the education system.

Description of the innovative practice

The innovation propose an interdisciplinary approach to physic experiments using sport-themes: (velocity-run at the 60m run, long jump, high jump) for the physic-topics speed, velocity and force/power.

Theoretical frameworks: Project based Education; use-oriented, interdisciplinary and constructivist perspective

Main aims, features and phases:
Aims: combination of theory - praxis - every-day life; to create its knowledge after a theoretical input and to put this knowledge into practice in the experiments; counteract the negative image of physic lessons.

Target of the project was to convey physics to the pupils of the 10^{th} level of education in a way in which they were actively involved with the effect that they took much pleasure in the physic lessons. Physic lessons were combined with sports lessons to show that this subject does not only provide abstract formulas but also explanations for everyday situations. The focus of the project was on the study of movement (velocity-run, long- and high jump). Thereby times were measured, velocities determined and forces logged by means of measuring interfaces. In addition videos were shot by the pupils themselves and evaluated using appropriate software.

Phases:
1) information about the project
2) measurements / evaluation:
   a) velocity distribution in the 60-metre sprints
   b) long and high jump (video camera recording that followed analysis on the PC, loging of force distribution by means of measuring interfaces on the PC)
3) theoretical input by teachers and a theory lecture by a professor (sports department of the University of Graz) on the topic of jump methods and afterwards train those methods with the pupils in the gym.
2/3 alternating.

Methodology used: project work (given exercises by the teacher, pupils try to solve them with supervision of teacher); indoor (analyse) and outdoor (sports measurements)

Resources needed:

Personnel:	one physic-teacher and one gymnastic-teacher Professor from a sport-institute for a theoretical input (once)
Materials:	different instruments for measurements: chronoscope, light barriers, power set (for outdoor), equipment for high/long-jump, camera, power-measurement plate, gymnastic area (indoor our outdoor for 60-metre sprint and long / high jump) various instruments for analysing sports activities (computer, programmes, videoshell, video program), ULAB-data logger (measuring-interface) with software Coach 6

Form of assessment / evaluation used: students' assessment is made by observing their participation and by oral repetition. Furthermore the teacher evaluates the engagement of the students using oral tests, short informal tests and a final report written by the students.

Information available

Detailed description is available (situation background, scientific theoretical background, measurement-instructions / method-instructions, written documentation of measurement / method visualized with photos, evaluation instructions, documentation of evaluation and its results, work-sheets, pedagogical evaluation of project)
Project description available in German. About 30 pages to translate.

Interesting follow-up: book "Sports and Physics" ("Sport und Physik") with a collection of 50 worksheets, that propose activities within various types of sports and exercises of physics (qualitative and quantitative)

to be connected. The book includes hints and explanations to the sports exercises as well as solutions of the physics exercises.
Themes are: basic principles of bio-mechanics, athletics, ball games, watersports, mountaineering, cycling, combination of sports.

Critical features for sustainability

Innovative practice has been implemented in one regular classroom with a committed teacher. As a follow up, it has been implemented in several classes (see below) with great success. The evaluation of the follow ups showed that for more than 50% of the students the project was positively increasing the interest in physics. The context can vary (formal / informal sector, bigger / smaller groups, gender-focus, various school types etc.) which helps to implement the project as a sustainable part of curriculum in a school.

Critical features for transferability

The project is perfectly adaptable because it provides a range of possibilities of exercises and trials to connect physics and sports. "Physics and Sports" has already been successfully transferred to other 14 classes in 9 schools of different school types.
The project-supervisor needs to be willed to do interdisciplinary teaching. Preparation of one teaching unit is up to three hours for experienced persons, minimum about one hour depending on the experience of the teacher.
The critical point might, at first view, be the costs of the measuring instruments. According to the author of the project, measuring instruments are easier to handle now, and there are some quite economically priced ones, e.g. acceleration sensors which send the measured data directly to the measurement station. The measurement instruments also might be rented, as it was handled in the follow ups.
The author of the project published, with colleagues, a book "Sports and Physics" as a collection of exercises to select for teachers which helps to transfer the project.
Not all three parts of the study-movement (velocity-run, long- and high-jump) must be implemented. One single study-movement can be chosen and implemented as well due to time and resources needed.

Secrets of culinary art in science experiments

Keywords:
Secondary school, chemistry and physics integration, cooking science, everyday life experiments

Problems addressed

Students do not see any interrelation between physics and chemistry.
Knowledge-transfer between theory - praxis - everyday-life is missing.
Lack of everyday-life-oriented topics in science classes.
Low interest and low motivation of students, also because of lack of integration of students´ ideas.

Quality criteria

Foster **scientific competencies:** Foster scientific literacy (identify scientific issues, explain phenomena scientifically, use scientific evidence); include practical work (hands-on activities, lab-work, experiments etc.)
Pedagogically and **methodologically sound:** Motivation / interest in science is stimulated.

Innovation appraisal

Two different forms of evaluation were carried out: "One Minute Papers" after each double-lesson and a summative evaluation by an external evaluator (central question interview): some of the students were aware of the interrelation of physics and chemistry, all of them realized the relevance of physics and chemistry in everyday-life. The experiments helped to increase the motivation in and acceptance of chemistry and physics. It was verified that the whole concept supported self-directed learning. Students found that their ideas were respected and implemented. This course was recommended by most of the students.

Relevant information in brief

Topics addressed	Use-oriented physics and chemistry experiments with food, interdisciplinary, everyday-life-oriented
Age classes	11th grade, 17 years
Extent	Local one class, 12 pupils (mixed)
Years of experimentation	School year, 2005/2006; follow-up and modified follow-ups in the years afterwards
Duration	6 months (four times three weeks with breaks), two hours per week, in total 36 hours
Main innovation promoters	IMST3-Innovationen machen Schulen Top! - promoted by Austrian Federal Ministry for Education, Arts and Culture
Main innovation partners	
Website	http://imst.uni-klu.ac.at/ http://imst3plus.uni-klu.ac.at/imst-wiki/index.php/Hauptseite http://imst.uni-klu.ac.at/materialien/2006/1063_353_Langfassung_Binder.pdf
Contact person	BG/BRG Gmünd Mag. Harald Lenz, harald.lenz@gmx.at, Mag. Ronald Binder, ronald.binder@kphvie.at; Gymnasiumstr. 5, 3950 Gmünd

Curriculum relevance and connection to policy guidelines

The practice "Secrets of culinary art in science experiments" is part of the national compulsory science curriculum. In secondary school upper level, students have to choose deepening courses in two subjects. This school offered a special interdisciplinary course (chemistry and physics) with focus on lab-work. Alternating, students are educated in chemistry for one week and in physics for the other. In each subject the same themes are treated.
The practice is part of a big national initiative called IMST programme (Innovationen machen Schulen Top!) of the Austrian Federal Ministry for Education, Arts and Culture to improve education in different subjects, especially science and technology. IMST works in four programmes (thematic/regional network, gender

network, culture of examination and stocks for education- and school-development) and evaluates education, school development and the education system.

Description of the innovative practice

Theoretical frameworks: Participative methodology, problem-oriented learning, active learning, Integrated Science Education, Experiential Education

Main aims, features and phases:

The project is subdivided into 4 phases with duration of three weeks, in each phase one topic is physically and chemically treated (phase one: theoretical and practical background, phase two: experiments on beverage, phase three: egg, phase four: selected food). The project aims at making the relation between physics and chemistry and the relation between daily-life phenomena and science evident to the pupils.

Aims:

1) Although students are basically interested in the science classes, as this i integrated course is optional, one aim was to increase the motivation in physics and chemistry, by awaking curiosity in physical and chemical backgrounds in the kitchen.
2) Pupils are autonomous and self-directed: some experiments are compulsory (they should motivate), but students are also invited to put their own suggestions and ideas into practice and to evaluate them.

Phases:

1) Theoretical and practical background: pupils repeat how to build up, carry out and to analyze the results of an experiment. This ensures that pupils know the methods and how to handle chemicals and equipment. (Chemical background: distillation, titration, extraction, chromatography; physical background: ways of heat transfer, specific heat capacity, boiling curve, degree of efficiency)
2) Beverage: analysis of different wines (chemistry: sugar concentration, pH-value, ethanol-concentration, acid concentration, remaining extract; physics: analyse the tone frequency of different filled wine glasses and empty wine bottles; additional feature: construction of an antique wine-carafe).
   Coffee: analysis of espresso-machine: measure cooling-down curve by changing parameters (water amount, material, cup size etc.)
3) Egg: Question: Why does the yolk of a cooked egg sometimes become green? Student had to acquire the theoretical background information on composition, relevance and appearance of proteins by themselves (by open learning). Change of yolk and egg white in combination with heat – cooking of the perfect breakfast-egg by measurement of the core temperature; chemical composition and evidence of proteins, experiments to differentiate uncooked or cooked eggs). In order to find the answers, they had to do experiments out of a list to be chosen by themselves.
4) Selected food: baking of a pizza by making their own yeast dough. Question: Why does a yeast-dough sometimes not rise? Biotechnological analysis of yeast-dough;
   Making chocolate;
   Analysis of colorimeter in pudding, jelly and paprika;
   frankfurter question: Why do sausages taste better in a sausage chippy? Explanation by diffusion;
   cooking a beef broth with and without salt; explanation of difference with osmosis.

Methodology used: indoor; project work; everyday-life-oriented and use-oriented learning; group work; Lab work, in parts inquiry based learning – questions raised by pupils.

Resources needed:

Personnel:	one physics teacher and one chemistry teacher
Materials:	basic equipment for experiments, no separate kitchen necessary Experiment instructions

Form of assessment / evaluation used:
Student's assessment were made on three levels: participation in the classes (contribution to solving problems, etc.); quality of the practical implementation (experiments, etc.) and quality of students´ protocols documenting the experiments.

Information available

Description is available (situation background, theoretical background, project operation, pedagogical evaluation of project);
Description available in German ~15 pages to translate

Critical features for sustainability

This innovative practice was implemented in one regular classroom with teachers of physics and chemistry. Parts of the project are carried out in this form or in a modified form (situational dependent) in regular classes. At least in this school the project has sustainable character, always keeping the focus on the interdisciplinary (physics and chemistry) realisation of the project.

Critical features for transferability

The experiments are simple to handle for chemistry and physics teachers, no special theoretical skills (but pedagogical for group work) are needed. The project is simple to adapt (the number of experiments can be reduced down to one or increased). Schools with an equipped lab don't need further materials, others do. Equipment depends on the experiments planned and realized, so that amount of necessary financial resources is flexible. Group-size of students should not be too big. According to the teacher, slight problems might be caused by big losses of teaching units as the project is interdisciplinary and therefore synchronised progress is needed.

Female students´ ideas of chemistry: initiation of a conceptual change

Keywords:
Secondary school, conceptual change/conceptual growth, chemistry, girls´ interest

Problems addressed

- Lack of girls´ interest in science & technology and low self estimation of girls in their performance and achievements in S&T (as the international survey PISA 2006 showed).
- Students´ presumptions and ideas of science impede scientific thinking and understanding, the connection between science and every day life is not perceived by the students; lack of scientific literacy
- Science-school-topics are often not in the sphere of interest of the students
- In science teaching, often the focus is on teaching input and not on learning output

Quality criteria

Pedagogically and **methodologically sound:** the design, learning materials, learning activities and teaching methodology take current theories about science learning into account; motivation / interest in science is stimulated.
Fosters **scientific competences :** fosters scientific literacy (identifies scientific issues, explains phenomena scientifically, uses scientific evidence), offers inquiry based learning activities.

Innovation appraisal

The conception of the innovative project is oriented on action research. During the project, research and evaluation were connected. This led to reformulations of the issue and to the development of new strategies. Different hypotheses were formulated and evaluated via qualitative empirical social research. They are available (see websites and literature).
The preliminary elicitation (using the creative method "interest-flower") of students´ spheres of interest showed that ambitious and broadly interested students are more interested in science than others. The analysis of students' ideas of chemistry showed that their notions are very similar and based on society stereotypes ("things which smoke, stink and crack are connected with chemistry"). This project led to a broader idea and conception of chemistry and some students placed chemistry in a better position in a subject-ranking, up to an increase of 75%-100% of girls interested in choosing chemistry for secondary school leaving examination.

Relevant information in brief

Topics addressed	conceptual change in chemistry
Age classes	17 years old girls, 11th grade
Extent	Local, two classes, 52 students
Years of experimentation	One school year (2005/2006)
Duration	One school year (10 months); 45 units with each class
Main innovation promoters	IMST3- Innovationen machen Schulen Top! - promoted by Austrian Federal Ministry for Education, Arts and Culture
Main innovation partners	Technical University of Graz
Website	http://imst.uni-klu.ac.at/ http://imst3plus.uni-klu.ac.at/imst-wiki/index.php/Hauptseite http://imst.uni-klu.ac.at/materialien/2006/1293_269_Langfassung_Pietsch.pdf
Contact person	Dr. Alice Pietsch Alice.Pietsch@phst.at, Gymnasium and ORG der Ursulinen, 8010 Graz

Curriculum relevance and connection to policy guidelines

This innovation is part of the compulsory curriculum; chemical contents are taught with innovative methods.

The innovative practice "Students' ideas of chemistry: initiation of a conceptual change" is part of a big national initiative called IMST programme (Innovationen machen Schulen Top!) of the Austrian Federal Ministry for Education, Arts and Culture to improve the education in different subjects, especially science and technology. IMST works in four programmes (thematic / regional network, gender network, culture of examination and stocks for education- and school-development) and evaluates education, school development and the education system.

Description of the innovative practice

Students' ideas of different chemistry-themes were evaluated and an education concept was developed based on the results of this evaluation. This project was organized in a mono-educated private girls-school. The implementation took one school year (10 months), because achieving a conceptual change is a long process.

Theoretical frameworks:

Inquiry based learning, conceptual change/conceptual growth, scientific literacy, constructivism

Main aims, features and phases:

The students participated on three levels in the implementation of the concept of the lessons: they worked out a topic based on their interests (which were acquired beforehand). Simultaneously, these individually chosen topics were integrated in the regular curriculum based lessons. The highlight of the project was a presentation of the students´ work, given by themselves to other students (of various school levels) - students change the role from pupils to teachers. In addition, accompanying measures (Information campaign, etc.) were offered to support the acceptance and access to S&T studies.

Aims:

- To make girls follow a new approach to chemistry
- To achieve a conceptual change towards scientific conceptions in chemistry
- To know girls ideas of chemistry as a science subject
- To achieve a higher popularity of all science subjects, especially of chemistry

Phases

Characterisation of the initial situation: Characterisation of students' spheres of interest via a preliminary elicitation using creative method ("Interests-flower"). (1 lesson)

Analysis of students´ ideas by treating different themes autonomously

Definition of core topics: Students have to choose one of the topics in which they are interested.

Implementation steps

Students search for materials (background information as well as experiments)

Students perform experiments to solve the topic chosen by themselves

Teaching of theoretical needed background

Preparation of presentations by the students

Presentation of elaborated themes and topics during a "chemical amusement day": students presented / taught their knowledge to others (school-mates, to pupils from primary school and to kindergarten). Further 18 school-directors visited the exhibition.

Deepening the interest via experiments about the topics: acids, bases and chemical bonds.

Additional offers

Presentation: "Girls at Technical Universities"

Big chemical innovations (baby-nappy, birth control pill) were presented by students

Info-campaign about girls turn on to science

Visit of a fire brigade

Methodology used:

To reach conceptual growth a methodology was developed by the teacher on a solid base of educational research and practice, group work, autonomous learning, presentations, problem-oriented and inquiry based learning.

Resources needed:
For the core of the practice just special resources for the research (computers, literature, optional: lab) and material for the presentations are needed.
Optional: specialists for talks, cooperation for excursions

Form of assessment / evaluation used:
The evaluation of students´ assessment focussed on the change of the image of the science subject chemistry. The final evaluation was realised by performing a taped group discussion at the end of the development process. Questions asked: Have the science classes changed your image of chemistry? Would you position chemistry in a different place in the range of subjects now? Within the discussion detailed questions by the teacher lead to intensely differentiated answers.

Information available

Detailed description of theoretical background (conceptual change and students' ideas) is available, each phase of the innovative practice is didactically well-founded. Worksheets and questionnaire for the evaluation are available. The whole theoretical background, planning, implementation and evaluation of the project are very well and in detail described.
About 40 pages to translate from German
In addition to the report: Holzinger, A.; Pietsch,A.: Begabung wahrnehmen, Interesse wecken. 2 Forschungsberichte, Verlag PHSt Graz 2008 (engl: „Perception of Giftedness, Sparking of interest") is available and utile.

Critical features for sustainability

Innovative practice has been implemented in two regular classrooms with a committed teacher. The innovative practice was within the regular curriculum. As students do research on their own, the teacher has to offer the information needed, no special resources are needed. The project can be implemented regularly. The implementation takes a whole school year.

Critical features for transferability

This innovative practice is easily adaptable. The accompanying measures do not necessarily have to be exactly the same and can be implemented as additional offers. The process of a conceptual change/conceptual growth takes at least one school year, therefore reductions in terms of time should be avoided. According to the author of the project no problems in planning, implementing and evaluating the project arose. One organisational aspect should be considered: Due to the intense individualisation in the elaboration of the themes and topics of chemistry by the students, the organisation of the classes was quite complex. Nearly each student was working on one self elected theme and needed the support of the teacher. Therefore the support of a second teacher would have been useful in order to avoid that the students had to wait too long for receiving the personal mentoring by the teacher

Analysing the life cycle of industrialised products

Keywords:
Secondary school, environmental education, products life cycle, contextualisation, chemistry education

Problems addressed

One of the main difficulties associated with the implementation of context-based approaches to Chemistry teaching is to balance contextual features and conceptual aspects. This innovation seeks to promote a teaching/learning activity that is not only scientifically sound but also committed to the need for preparing students for responsible decision making in society.

Quality criteria

Scientifically sound: Correct use of scientific knowledge according to the context; provides insight in the way scientific knowledge is constructed**.**
Socially relevant: raises the awareness of social, ethical and cultural influence and implications of science and technology; promotes actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues.
Foster**s scientific competencies:** offers inquiry based learning activities.

Innovation appraisal

The innovation has been selected by the Brazilian Ministry of Education (MEC) as an innovative practice. It has been the object of a two-part TV documentary which was broadcasted nationwide and made available through an internet public domain educational database kept by MEC.

Relevant information in brief

Topics addressed	Energy, Synthetic Polymers, materials (metals, paper, glass etc.) and their chemical properties, constitution and models, chemical reactions
Age classes	14-16 years old
Extent	Secondary School in Minas Gerais, Brazil
Years of experimentation	10 years (started in 2000)
Duration	3 months (in parallel to the development of syllabus)
Main innovation promoters	COLTEC – Universidade Federal de Minas Gerais
Main innovation partners	-
Website	www.bibvirt.futuro.usp.br/ (to access documentary in Portuguese click videos – tv escola – ensino médio – com ciência - a história das embalagens)
Contact person	Dr Andrea Horta Machado (ahortamachado@gmail.com)

Curriculum relevance and connection to policy guidelines

The innovation addresses demands present in the Brazilian Curriculum Guidelines (PCN and DCNEM) for promoting context-based approaches and citizenship education, fostering both critical and informed reflection about real and experiential situations, and for bringing theory and practice together in the curriculum through the pedagogical re-contextualisation of chemical knowledge.

Description of the innovative practice

This innovation articulates aspects of Chemistry knowledge and environmental education through the development of classroom based projects designed by students in order to analyse the life cycle of industrialized products.

Theoretical frameworks: Education for citizenship and decision making. STS approaches. Inquiry based learning.

Main aims, features and phases:
The objective of the project is to perform a qualitative analysis of the life cycle of industrialised products and their packaging. The analysis allows the discussion of the constitution of (i) the materials involved in the products and their packaging, of their process production, of the chemical transformations involved, of the properties and structure of the materials, (ii) their environmental impacts and (iii) their consumption.

Methodology used:
In the project students carry out small-scale investigations and engage in debates about a theme which is not only relevant but grounded in contexts of their daily life experience. It is divided into three main stages, each one lasting for about one month.

First stage: Conceptualisation of the notion of life cycle through the viewing and debate of videos which discuss chemical and social aspects of industrial production (e.g. Annie Leonard's documentary 'The story of stuff' and educational videos produced by the Brazilian Chemical Society featuring evolution, application and recycling of paper and glass) and visit to the supermarket in order to observe and select different types of packaging for study (e.g. plastic bottles, aluminium foil wrap etc).

Second stage: Elaboration of written reports about (i) the materials packages were made of and their origin; (ii) the transformation processes involved from raw material extraction till the final form of the packaging; (iii) properties of the materials and the relationships between these properties and their use; (iv) the energy involved in the production of the packaging (mainly heat and/or electricity); (v) processes of transportation within and between the different stages of production of the packaging; (vi) exchanges with the environment (e.g. energy intake and emissions of residuals to the air/water).

Third stage: Construction of a scheme for the life cycle of the packaging selected considering all aspects discussed in the second stage and including (i) comments about the social, economical and environmental aspects involved in the production, use and disposal of packaging based upon surveys of statistics concerning the numbers of the industrial production and the environmental, economical and social impacts of the life cycle of a given packaging.

Resources needed:
Personnel: one teacher.
Material: educational videos; models for the construction of molecules.
Other: Internet access; educational resources library.

Form of assessment / evaluation used:
Students' participation in the debates and engagement in the proposed activities. Competent display of chemical knowledge and quality of argumentation by students in oral debates and written reports. Students' self-assessment of their learning and of the potential of the Project to raise their awareness about responsible consumption was also encouraged.

Information available
Papers in teacher educational journals and conference proceedings; videos in a public domain educational video library. All in Portuguese only (average length: 10 pages).

Critical features for sustainability
Teacher motivation. Previous knowledge of available information about the topic by the teacher is strongly advisable, as he/she will suggest relevant bibliography and Internet resources to start off students' research. Availability of videos (or other educational resources) and resources for research (library, internet access) must be considered.

Critical features for transferability
The existence of available materials about the topic in the country's native language.

Physics teaching and visual disability

Keywords:
Secondary school, physics teaching, visual disability, inclusive education, hands-on.

Problems addressed

Brazilian Law nº 9394/96 establishes that students with disabilities should be included and integrated in regular schools and regular classes. Since 1998, there has been a large increase in student enrolment numbers in Brazilian public schools. Nevertheless, there is a consistent difficulty to integrate and include these students in regular schools. This innovation addresses the educational specificities of teaching physics to both 'seeing' and visually impaired students with a methodology not centred on vision but on touch and hearing in order to allow the impaired student to make contact with physical phenomena, collect records and measurements, take part in evaluation activities etc.

Quality criteria

Pedagogically and **methodologically sound:** allows for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests; includes all pupils, including those with special educational and physical needs.
Socially relevant: address national problems in science education; promotes changes or improvements in educational contexts.
Supports **teacher participation** and **professional development**: teachers are involved in designing or adapting the innovation to their own specific situation; innovation has a clear teacher manual.

Innovation appraisal

No information has been found about that so far, except for some positive reactions by teachers and students reported by the main promoter.

Relevant information in brief

Topics addressed	Physics concepts such as friction, gravity and acceleration.
Age classes	14-17 years old
Extent	Local Full classes of students (able/impaired) involved.
Years of experimentation	About 5 years (since 2005)
Duration	4-5 classes (10h) minimum (up to 80h may be programmed)
Main innovation promoters	Universities and school teachers
Main innovation partners	UNESP-Bauru (State of São Paulo, southeast region) Local secondary tech-schools
Website	-
Contact person	Eder Pires de Camargo

Curriculum relevance and connection to policy guidelines

The activities address regular concepts and contents of Brazilian physics curriculum for secondary schools. The innovation is explicitly connected with national guidelines and laws, referred to above.

Description of the innovative practice

Theoretical frameworks: The innovation has a Constructivist perspective, based on "learning by doing". Education of the visually impaired (explicitly derived from the works of B. Lowenfeld) is also a reference. It is possible to assume that the innovation implicitly takes into account the alternative conceptions theory.

Main aims, features and phases: the innovation is structured as a physics course for secondary schools. The activities are based on observations of tactile and sound effects of moving objects in situations that involve friction, gravity, acceleration etc. and on learning by doing. Five sets of activities are conducted by the means of specially formulated tasks, group work and debate. The first and the second sets of activities are about friction and acceleration. The third and the fourth are about gravity and acceleration and the last one is a problem-based activity. Each of these sets is structured in three main actions: interaction with the object of study, problem solving and model confrontation.

Methodology used: At first, using specially constructed objects, the teacher presents to the students a physical phenomenon related to friction, gravity and/or acceleration. He/she also proposes a problem related to what was observed (not only by vision but also by touch and/or sound). These are the forms of interaction with the object (a concept) of study. After that, students gather in groups and work on the resolution of the problem. In the end, the whole group starts a debate in which everyone presents the solutions they have found (model confrontation activity). The teacher walks around the class helping out groups. He/she also should coordinate the final debate and present the scientific models that will generate the confrontation with students' conceptions. The teacher may or may not be visually impaired.

Resources needed

In terms of personnel: one teacher and, in the case this teacher is visually impaired, an assistant. Materials: kits that allow student's interaction with physical phenomena (low cost apparatus using everyday materials such as wood, pipes, wires, alarms for sound interfaces, toys, and audio recordings, if the teacher is visually impaired).

Form of assessment/evaluation used: students' assessment is made by the evaluation of their actual participation in all the activities and discussion. Two parameters are used: "viability", if the participation is enough to show the student is included and integrated in the class; and "difficulty", if the participation is not fully observed. Nevertheless, none of these parameters is used to fail the student, but to improve the teaching/ inclusion process.

Information available

A book chapter in Portuguese with detailed information (about 30 pages) and 9 photos. As the activity is detailed, most of the information available should be translated.

Critical features for sustainability

The innovative practice has been implemented in regular classroom with average teachers and has been designed as part of regular courses. The critical point of sustainability may be the regular presence of visually impaired students in schools/physics classes.

Critical features for transferability

The critical points for the success of the innovation may be the preparation of the objects used in the activities. No other outdoor facilities or lab facilities are needed. Teachers should be prepared to deal with visually impaired students in regular classes. The innovation is flexible enough to be adapted in different contexts. Interchange between classes doing the same experiment in different countries could provide information on interaction between the visually impaired student and the ones who are not visually impaired. This innovation may be an opportunity to prepare teachers for inclusive actions in regular schools.

Water in the spotlight

Keywords:
Secondary school, chemistry education, scientific literacy for citizenship, STS approach, inquiry-based learning.

Problems addressed

In the context of fostering scientific literacy for the public understanding of science, the innovation addresses two main problems:

1. How to relate (a) knowledge of scientific concepts to (b) knowledge of the social implications of natural science and technologies in science education practices?
2. How to devise teaching and learning activities that lead to the development of values and attitudes towards a responsible social action?

Quality criteria

Pedagogically and **methodologically sound:** allows for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests; motivation/ interest in science is stimulated.

Fosters **scientific competencies** and scientific literacy: identify scientific issues, explain phenomena scientifically, use scientific evidence; offers inquiry based learning activities; stimulates argumentation and critical thinking.

Socially relevant: promotes actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues; uses resources and teaching contexts from outside the school.

Innovation appraisal

Restricted to the assessment of the teacher responsible for the innovation and of the main promoters, who reported positive reactions by teachers and students involved.

Relevant information in brief

Topics addressed	Quality of life and quality of water. Activities involved physical and chemical analyses of an urban lake. Preparation and presentation of reports containing results of analyses at the city's legislative council.
Age classes	15 -17 years old
Extent	Within school: Full classes of students are involved in the project. Geographically: two state capital cities in the Northeast and in the Southeast of Brazil.
Years of experimentation	Six years (on-going)
Duration	About 3 months, one for planning and two for implementation.
Main innovation promoters	UFMG (Federal University of Minas Gerais), with funding from Brazilian Science and Technology Ministry's Research Council – CNPq).
Main innovation partners	Universities and secondary schools
Website	http://www.foco.fae.ufmg.br/
Contact person	Eduardo Mortimer (mortimer@ufmg.br)

Curriculum relevance and connection to policy guidelines

The innovation addresses National Curriculum Guidelines. The NCG stresses the importance of (a) scientific literacy for citizenship and (b) establishing connections between science technology and society, which also includes:

- The development of attitudes and values
- Debates over Socio-scientific Issues
- Fostering scientific literacy for citizenship
- Promoting communication both inside and outside school
- Learning by inquiry

Description of the innovative practice

Theoretical frameworks:
Socio-constructivist perspectives on learning; Inquiry Based Leaning; STS Education.

Main aims, features and phases:
The project's aim is to produce knowledge about water quality in some streams and lakes in the metropolitan region of Belo Horizonte and Recife, development both for preserving values of individual health - warning of the danger of contact with contaminated water - such as those involved in collective actions in order to support proposals to improve the quality of the water samples. These proposals may generate political actions such as letters and petitions to the authorities, such as rallies or demonstrations such as "Hugging the creek", where participants hold hands around the creek in a symbolic gesture meaning care and protection, etc (extracted from http://www.foco.fae.ufmg.br/). A great deal of attention is given to the preparation of students in order to get the water samples in the Pampulha Lake.

Methodology used:
The planning of the project interventions in schools was developed considering the issues listed below. For each topic there was a proposed lesson plan, with strategies and approaches to classroom.

1. Water quality and quality of life (In this introductory stage, discuss the properties of water and how they relate to environmental content as life on land and in aquatic environments).
2. Physical-chemical parameters to determine water quality: dissolved oxygen
3. Physical-chemical parameters to determine water quality: pH
4. Physical-chemical parameters to determine the quality of water: turbidity
5. Sampling and preparation of the output field for collecting and analyzing water samples.
6. Outwork
7. Analysis of the data
8. Preparation of collective actions aimed at improving water quality analysis and evaluation of the project. However, teachers are free to make choices in teaching methodology and content activities.

Sample sheets include a description of the point where the water is collected in terms of geographic coordinators (measured by GPS), weather conditions in the day of collection, type of construction, presence of sewers, garbage, type of vegetation, etc, nearby the collection point. Students evaluate qualitatively the presence of coliforms. We have the occasional consultancy of a biological teacher in order to do the evaluation of bioindicators. Students' data is compared with the data from the environment authorities. The methodologies used in the students' and in the environmental authority's analyses are also object of discussion by the students. Some of the samples are collected by the students in the same collection points used by the environment authorities. In the university labs, dissolved oxygen and pH is measured through electronic devices for increased reliability whereas in the school labs, chemical procedures are used. Improvised methods are used to measure turbidity, which leads to unreliable measurements. Differences between the analyses made by environmental authorities and by the students relate to the greater variety of parameters used by the former (e.g. different metals, biochemical demand of oxygen, different kinds of coliforms etc.) and to the regularity of data collection which accounts for the variation on the data in function of the season, mainly wet and dry season. Students use these data to draw different kinds of graphics which give us the seasonal variation of several parameters.

Resources needed:
Personnel: 1 school teacher; 1 beginning teacher and 1 researcher;
Materials: Lab kits and Internet access.
Other: transportation, permission of the management, security.

Form of assessment/evaluation used:
Pre-test and post-test are applied in the beginning and in the end of the activities. During the project students do exercises and prepare work for the group presentation.

Information available

The innovation is the object of funded projects. Different aspects of the innovations are documented. There are booklets, conference papers, book chapters, research reports, and publications in refereed journals, mostly in Portuguese. The innovation has been investigated in the context of a PhD thesis which included analyses of: (a) the difficulties teachers have when they work with the innovation in their everyday practice, (b) changes and adaptations made in order to implement it in classrooms, and (c) teacher professional development activities to support teachers to work with the innovation. One book chapter is in English. Materials for teachers exist only in Portuguese. We estimate about 20 pages to be translated.

Critical features for sustainability

There has been reported some difficulties in dealing with the "logistic" requests of this innovation, since applying it involves a lot of time and resources for preparation, such as transportation of students, parents permission, access to private places etc. Teachers might not find favourable conditions for applying it in every new term.

Critical features for transferability

The innovation has been implemented in regular classrooms as well as in contexts of initial teacher training, but depending on teachers' background there may be a need to devise support materials dealing with topics such as: STS education, kits etc. It is important to find ways to fit the innovation within the school curriculum. From time to time objectives will have to be adapted according to the current state of scientific and educational knowledge.

Students' video production in the physics laboratory

Keywords
Secondary school, didactic laboratory, hands-on/minds/on, teaching strategy, video production.

Problems addressed
Dissatisfaction with traditional physics laboratory classes.

Quality criteria
Scientifically sound: correct use of scientific content/ knowledge according to the context; provide insight in the way scientific knowledge is constructed).
Socially relevant: promotes changes or improvements in educational contexts.
Fosters **scientific competencies**: includes practical work, stimulates collaborative work; uses ICT-skills.

Innovation appraisal
The videos produced have been critically assessed by peer groups (3 to 5 students) within each class in order to evaluate both comprehension and communication of physical concepts. The students within each group had strong involvement with all the steps required to make the video, which motivated both conceptual revision (learning) and technical abilities necessary for video production.

Relevant information in brief

Topics addressed	Electricity, Thermodynamics and Light
Age classes	16 -18 years old
Extent	Local 5 full classes / around one hundred students
Years of experimentation	2 years
Duration	About 4 months (once a week)
Main innovation promoters	Education, Science and Technology Federal Institute of Rio de Janeiro (IFRJ) and Federal University of Rio de Janeiro (UFRJ)
Main innovation partners	IFRJ and UFRJ
Website	-
Contact person	Marcus Vinicius Pereira (marcus.pereira@ifrj.edu.br)

Curriculum relevance and connection to policy guidelines
The activities are developed as part of the regular curriculum. They are implemented as a teacher's project for his laboratory classes. They may be classified as an example of *minds on* and *hands on* methodologies.
They relate to Brazilian curriculum guidelines as they promote learning by inquiry and foster the acquisition of the following abilities: science communication, usage of information and communication technologies, development of attitudes such as initiative and teamwork.

Description of the innovative practice
The activity involves the production by students of a short video of a physics experiment as part of regular science lab work.

Theoretical frameworks
The constructivist perspective; enactive learning; participative methodologies; nature of science (NOS) for conceptual development.

Main aims, features and phases
The project's aims are: to make competent use of video technology to perform essential steps in science experimentation (e.g. gathering data); to reflect upon the role of the physics laboratory in teaching and learning; to develop students' understanding of physical phenomena through audiovisual representation; and to foster a feasible strategy to increase students' engagement in

science learning and to construct physical concepts/models through the production of videos of physical experiments designed by students.

Methodology used

Classes about 25 students working in groups (up to 5). Each group will work in the lab in order to produce a video about a given Physics concept. The teacher has to be present in all stages of the project's development in the 4 months duration of the project:

1st month: definition of groups, research on the subject to choose the experimental activity;
2nd month: testing experiments, mapping concepts and elaboration of a storyboard; critical appraisal of the storyboard;
3rd month: development of the screenplay, video production and video editing;
4th month: video screening; evaluation of the videos by peers and teacher; discussion of aspects suggested during the screening sessions (charging objects through friction, heat exchange, calorimeters, latent heat.

Resources needed

One physics teacher and one assistant, who can be a beginning teacher or a colleague.
The project requires computer and digital camcorder to produce and edit the videos. It is also necessary to provide laboratory materials for the experiments designed by the groups.

Form of assessment / evaluation used

Videos are evaluated by the classroom teacher, by the students involved in the production and by students in fellow groups. Parameters for evaluation include scientific correctness, creativity and competent use of video equipment and provide elements for formative evaluation.

Information available

There are papers published in journals and conference proceedings in Portuguese (three) and English (one).

Critical features for sustainability

Teacher motivation seems to be a relevant point for sustainability.

Critical features for transferability

Teachers' proficiency both in science as well as in pedagogical content is crucial. Experience in conducting practical work and in helping students to design experiments is also needed. Knowledge of video capturing and editing are essential. The innovation is flexible enough to be adapted in different contexts, and it would be interesting to exchange videos produced in different countries.

"The principle of Le Châtelier" - a different way: experimenting along the national education standards

Keywords:
Secondary school, Inquiry Based Learning, independent team work, creative experiments, carbon cycle.

Problems addressed

- Lack of hands-on, inquiry-based science in classrooms in secondary education
- Connection to the daily life of children and young people is often missing in the classroom, references used are outdated
- limited possibilities of a transfer of pre-existing knowledge of pupils/students (especially for Chemistry)

Quality criteria

Scientifically sound: raises awareness of the Nature of Science.
Fosters **scientific competencies**: includes practical work (hands-on activities, lab-work, experiments), offers inquiry based learning activities.
Socially relevant: addresses national problems in science education, promotes actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues

Innovation appraisal

- the number of visitors of the website shows strong interest in the practice
- evaluation of teachers and schools: positive experiences, high interest and motivation of learners

Relevant information in brief

Topics addressed	"The principle of Le Chatelier" - creative experimenting / "Egg-Racing" (see below)
Age classes	age 14-17
Extent	National, number of schools and field trials unknown, survey necessary
Years of experimentation	since 2007
Duration	2h (age 14-15); 3h (age 16-17), can be extended according to depth and related teaching units
Main innovation promoters	different schools all over Germany, science teachers
Main innovation partners	
Website	http://ne.lonet2.de/gregor.vonborstel/Seiten/1_1_Unterrichtmaterial/1_1_1_Egg_race/egg_r.htm; http://www.naturwissenschaften-entdecken.de/le-chatelier.php
Contact person	Gregor von Borstel

Curriculum relevance and connection to policy guidelines

The topics are relevant to the high school Physics and Chemistry curriculum. Also the national education standards of the ministries of education (currently being developed), a base for quality development of schools, are taken into account. All phases of the practice are connected to different areas of competencies.

Description of the innovative practice

Based on the advertising of beverages containing oxygen like "Active O2" students examine how much oxygen can dissolve in water. In the upper secondary level (age 16-17) the principle of Le Chatelier can be introduced based on the solubility of carbon dioxide in water which then is transferred to the oxygen-containing beverage. All experiments are cost effective, secure and easy to perform with some basic medical equipment. The connection to the daily life of the students allows an introduction into the solubility of gases as well as calculations of the gas law or the law of mass action. One of the motivations is the fashion drink "Active O2",as it allows for a critical discussion of statements and propositions of advertising in general.

Theoretical frameworks:

"Egg-Race": The procedure of an "Egg-Race" (creative experimenting, pupils/students develop most experiments independently and find their own ways for a solution, autonomous work for problem solving, inquiry based learning) supports hands-on, inquiry based learning activities. A general task is given (in this practice the solubility of carbon dioxide in water) and some framework conditions are defined (e.g. safety, materials). Then pupils/students try to solve the problem by experimenting within teams. Solutions that are not successful have to be modified by the working groups until a suitable procedure has been developed. Finally all solutions are presented to all groups. Although during the process groups may develop approaches for solutions that will definitely not lead to a successful outcome, time should be given to the groups to detect and correct their procedures independently.

Main aims, features and phases:

Since 2001 "O2 Active" has been on the market, an "oxygen water beverage" that is enriched with 15 times the amount of oxygen compared with a normal mineral water. According to the manufacturer the oxygen is brought into the water with a change in the physical parameters pressure and temperature and under strong turbulence. The oxygen is then physically dissolved in the water and after opening the bottle it takes a surprisingly long time before the oxygen disappears. In the sports and outdoor scene "O2 Active" is currently perceived as a "power substance for fuelling", very well positioned and known to many pupils/students. Based on the advertisement for the drink, the questions are raised as to why it is so popular and what is actually behind the statement that it contained 15 times more oxygen than ordinary mineral water. The drink will then be examined more in detail; experiments follow dealing with the solubility of carbon dioxide with the influence of temperature, pressure, pH-value and solutes. Pupils/students are also trained in the handling of unfamiliar equipment (here basic medical equipment like syringes and tubes) and creative experimenting for further application on related or different topics.

As a means of generalization and evaluation/documentation of results, links are possible to the Carbon cycle in nature and technology as well as the influence of oceans on the natural cycle of Carbon dioxide and the greenhouse effect.

Learners should acquire a number of competencies according to the national education standards, pupils / students should:

- "Knowledge": know about and the ability to influence the solubility of gases depending on various parameters
- "Knowledge Discovery": develop and implement tests/experiments independently, optimize tests if appropriate
- "Communication": experiment in teams, document and present results and conclusion according to correct technical terminology
- "Evaluation": recognize that seemingly scientific statements in advertising are often suggestive and should be evaluated; discuss and question their own behaviour as consumers.

Methodology used:

- **Hands-on**: creative experimenting, "Egg-Racing" (see description above)
- **Inquiry-based learning**: experiments are part of a learning cycle using existing knowledge, the possibility of wrong solutions and ways of modification of solutions
- **Working in groups**: groups develop, discuss and perform the experiments together, prepare and give the presentation

Resources needed:

- Basic laboratory materials, computer/presentation equipment, video playback (descriptions of the use of medical equipment for untrained teachers/pupils)

Information available

- Information material/documentation (German, 4 pages)
- teaching materials (German, 4 pages)
- teaching plans for groups age 14-15 and for age 16-17 (German, 2 pages)
- videos about laboratory work, advertisements (Active-O2), no translation necessary

optional:
- information about creative experimenting/"Egg-Race" (multi-page Web-site, German)

Critical features for sustainability

- practice has been tried as a part of regular courses
- no substantial costs necessary, all materials can be easily acquired (basic medical equipment like syringes and tubes)

Critical features for transferability

- practice is easy to implement by average teachers and average schools

Remotely Controlled Laboratory – Example: Discovery of the atomic nucleus with the Rutherford scattering experiment

Keywords:
Remote lab work, physics experiments, ICT, groupwork

Problems addressed

Average schools are not able to carry out special experiments which need extensive test arrangements. Schools only have the possibility to move classes into professional research labs – a cost-intensive and in most cases an unfeasible way. Though there is a number of important experiments in science education, schools tend to skip these experiments for the reasons mentioned. This leads to number of problems in science education (unsufficient hands-on activities, followed by less interest of pupils in science etc.).
Remotely Controlled Laboratories (RCLs) allow schools to do experiments that would need too many resources for in-school usage or which are too dangerous concerning the substances needed (e.g. radioactive materials). Learners are able to carry out the experiments (here the Rutherford scattering experiment is described but a lot of experiments are available on the website) in school or at home, measurement data are collected and examined in group work and then compared to the predictions of the Dalton, Thomson and Rutherford atomic models.

Quality criteria

Scientifically sound: correct use of scientific content/ knowledge according to the context, raises awareness of the Nature of Science.
Fosters **scientific competencies**: stimulates argumentation and critical thinking, stimulates collaborative work.
Socially relevant: uses resources and teaching contexts from outside the school.

Innovation appraisal

Teachers and students using the RCL have given a very positive feedback in evaluation sheets, interviews and workshops. But the innovation is still not known to a majority of teachers/schools in Germany. Workshops and teacher training seminars are held to spread this knowledge.

Relevant information in brief

Topics addressed	Remotely Controlled Laboratory (RCL), experiments carried out via computer with internet access (the Rutherford scattering experiment as an example)
Age classes	Secondary level, 15-18 years
Extent	National/Local; Number of classes/groups of students: flexible
Years of experimentation	RCLs have started in 2001, first user schools in 2004, increasing number of participants and experiments available until 2010
Duration	10-15 lessons, according to aims and group of learners (for the single experiment described, other experiments may need less time)
Main innovation promoters	Research institutes, University of Karlsruhe, schools
Main innovation partners	Research institutes, Project "Explore Science", Eberhard von Kuenheim Foundation, Intel GmbH Education Group
Website	http://rcl.physik.uni-kl.de/ (in German, English, French and Italian)
Contact person	Sebastian Groeber

Curriculum relevance and connection to policy guidelines

Relevant to the high school Physics curriculum, part of the compulsory curriculum.

Description of the innovative practice

Remotely Controlled Laboratories (RCLs) mainly replace in-school experiments or are in most cases the only way for a teacher/class to carry out several experiments. The capability of doing experiments with extensive test arrangements leads to a higher focus on experimental science education within participating schools.

Theoretical frameworks:
The Remotely Controlled Laboratory (RCL) offers learners the opportunity to plan their own measurements, within short or limited time frames and much shorter time than the in-school experiment, if applicable. RCLs on the one hand offer experiments that encourage playing, curiosity and interest for amateurs or younger pupils who want to realise their own RCL-project in school, on the other hand they are also able to give access to experiments that are used in secondary or even higher education. The RCL-website offers a range of experiments for all science subjects.

The Rutherford scattering experiment also links theoretical research and present industrial application as the standard analysis of material is based on Rutherford Backscattering Spectroscopy. Material for the Rutherford scattering experiment (in German) offers added value as amongst others it deals with a historical and critical perspective on experiments and the repetition of these experiments now.

A number of other experiments are available on the RCL-website, among them speed of light, world pendulum, wind tunnel, radioactivity and others. All of these experiments do need a sophisticated lab structure in order to be carried out properly.

Main aims, features and phases:
The Rutherford scattering experiment is set up as a traditional real-life experiment; pupils/students collect data by hand and do the evaluation. Using a variety of free or existing software (like Excel), data collection can also be automated. In addition, the website offers the results of long-term/long-lasting experiments, if pupils/students have to work with such data.

Features for the experiments:

- intuitive and easy operation
- interactivity (variation of parameters),
- observation of experiments via web cams,
- transfer of data to the user,
- authenticity like demonstration in the lesson,
- provision of background information (physics, setup, technics)

Within the Rutherford scattering experiment the pupils/students are able to

- apply knowledge from mechanics, electrostatics and radioactivity to the explanation of the dispersion of alpha particles
- use the RCL to examine Rutherford scattering experimentally
- compare predictions with measuring results
- present working results properly

Methodology used: remotely controlled lab-work, project work, group work, ICT
Methodological learning potential:

- classification of the Rutherford scattering experiment and the Rutherford atomic model as a significant historical step in the development of our image of atoms
- understanding of the interaction between model and experiment

Resources needed: one or more computer(s) with internet access at school (or at home), internet browser with Java installed, spread sheet software (e.g. Microsoft Excel or other freeware), simulation software (e.g. Powersim or Coach 6 Studio MV, both freeware).

Form of assessment/evaluation used: To evaluate the usage and acceptance of the RCL the activities of users are tracked with the help of log files. Additionally the experiments themselves offer internal evaluation methods and tests.

Information available

- In German: Lesson structure (3 pages), extensive task collection (40 p), modeling files to be used with Powersim or Coach 6 Studio MV, measuring examples;

- original article by Rutherford in the Philosophical Magazine 1911
- In English, French and Italian (for all RCL experiments): extensive description about the setup, theory, tasks for teachers and learners, analysis and discussion, learning materials

Critical features for sustainability

Low adaptation costs, computer with internet access exist in many schools, free or existing software can be used. Experiments have been used by high numbers of regular classes and average teachers.

Critical features for transferability

Research institutions that offer RCL services are needed, preferably on national level (in terms of language), but the location and distance of RCLs is of no importance. Schools have to register at the RCL, therefore sufficient capacities are needed. A clear documentation of the method is available.

"The simulated rubber cloth" - Curvature of space in a virtual model

Keywords:
secondary school, virtual experiments, general relativity, curvature of space-time

Problems addressed

- Lack of sufficient time for the explanation of abstract models in Physics like curvature of space, step-by-step approach necessary
- Pupils/students are often "observers" of experiments, not "performers" because experimentation equipment is not available in sufficient numbers
- Difficulties in obtaining or creating models for experimentation, virtual models allow for easier preparation and evaluation as well as collection and visibility of data

Quality criteria/indicators addressed

Fosters **scientific competencies**: includes practical work (hands-on activities, virtual experiments derived from models used in traditional science learning), offers inquiry based learning activities, uses and fosters ICT-skills, demonstration of advantages of ICT compared to physical models.

Innovation appraisal

- the number of web-site visitors and downloads show strong interest in the project
- positive teacher comments and surveys

Relevant information in brief

Topics addressed	"The simulated rubber cloth" - Curvature of space, gravitation, general relativity theory: use of a virtual model (computer program), Physics, Astronomy, project-courses
Age classes	age 15-18
Extent	National, groups according to available computer working places, up to 30 pupils/students
Years of experimentation	Since 2006
Duration	2h, flexible according to depth
Main innovation promoters	School teachers
Main innovation partners	Science experts, school teachers
Website	http://www.naturwissenschaften-entdecken.de/raumkruemmung.php, http://www.mabo-physik.de/
Contact person	Matthias Borchardt

Curriculum relevance and connection to policy guidelines

Relevant to the high school Physics curriculum, part of the compulsory curriculum.

Description of the innovative practice

Theoretical frameworks:

The effects of curvature of space (general relativity) can be clearly demonstrated by using a rubber membrane with a heavy ball in the middle, denting the surface of the membrane. A little ball that rolls over this surface is affected by the depression as if it would be attracted by the heavy ball. These rubber cloth models are, however, difficult to construct. The presented computer program simulates such a deformable surface and allows for the demonstration of the path of a small ball rolling over the surface.

The computer program used, "Raumkrümmung.exe" (curvature of space) allows the virtual exploration of the effects of the curvature of a surface on the path of a rolling ball under different parameter settings (depth of the depression, start position and velocity of the ball). In this way the students can be introduced gradually to the concept of space curvature and they find out that the known paths within gravitational fields can be understood by the concept of a curved space (or, as in the virtual model, a curved surface).

Main aims, features and phases:

The method allows for a hands-on, playful way of experiencing various situations by the pupils/students. Various levels of parameters and settings offer the possibility to lead learners step-by-step into the model of curvature of space or surface, gradually increasing the depth and level of the experiments performed. Experimentation outside schools, e.g. at home, is also possible.

Learners should acquire a number of competencies by using the virtual model, their own computer working place and the presentation.
Pupils/students should:

- experience that the abstract idea of a three-dimensional, curved space can be illustrated by using a rubber cloth / membrane model (reduction of the curved space to a curved surface)
- realize the educational possibilities of such a model with the help of a computer simulation in a hands-on way
- use concrete data to simulate different trajectories of bodies in the vicinity of large masses
- recognize that deviations from the classical gravitational potential lead to rosette-shaped orbits

Methodology used:

- **Hands-on**: simulation/experimenting with the simulation allows for a playful way of exploring and learning, very much actively using - and playing with - computer tools
- **Inquiry-based learning**: activities are part of a learning cycle, which starts with examining the knowledge that the pupils already have and is then followed by the simulation of a chosen situation, the interpretation of the results and finally the presentation of the data
- **Collaborative work**: according to computer places pupils work in groups of two to four
- **ICT experiment**

Resources needed:

Computer working places for either single or collaborative work, presentation tools like projector, free software

Information available

- Information about and description of experiments, settings and parameters (German, 5 pages)
- Teacher information, tasks
- Additional information for interdisciplinary use

Critical features for sustainability

- Experiments have been used by large numbers of regular classes and average teachers
- "normal" infrastructure needed, provided by most schools, no substantial funds needed

Critical features for transferability

- easy access and usability of the provided information, materials and software
- low adaptation costs, free software, easy to be used
- sufficient computer working places needed

Mobile education project –"Science on Tour" to schools in the state of Brandenburg/Germany

Keywords:
Upper secondary school, mobile education project, learning laboratory

Problems addressed

- Lack of qualified persons in a rural region due to migration processes into urban regions
- Low interest of pupils in scientific and technical professions
- Improvement of the transfer of a group of topics in science subjects from universities into schools
- Insufficient access of rural population / rural pupils and students to scientific institutions and events in urban areas

Quality criteria/indicators addressed

Pedagogically and **methodologically** sound: allows for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests; includes all pupils, including those with special educational and physical needs; motivation / interest in science is stimulated.
Fosters **scientific competencies**: includes practical work (hands-on activities, lab-work, experiments etc.), stimulates collaborative work.
Socially relevant: uses resources and teaching contexts from outside the school.

Innovation appraisal

- Positive public recognition (press and evaluation study "Schuelerlabor und Co"[1])
- Current demand shows strong interest in the project
- Feedback of teachers and pupils
- Presentation on homepages of schools

Relevant information in brief

Topics addressed	Mobile education project – Science on Tour (in the region Lausitz), experiments come to the schools
Age classes	Currently age 15-19; future aim: 7-19
Extent	Participants: 2.500, schools visited: 61, missions/courses: 115 (by 2010)
Years of experimentation	Pilot phase: half a year, new topics also require individual pilot phases
Duration	Experiments need 1,5 – 3h, maximum of two school visits per day
Main innovation promoters	University of Applied Sciences Lausitz (Hochschule Lausitz, FH), professors and teachers
Main innovation partners	Hochschule Lausitz (FH), Ministry for science, research and culture of Brandenburg, Job Agency, European Scocial Fund
Website	www.scienceontourlausitz.de
Contact person	Sebastian Hänsel e-mail: Sebastian.Haensel@HS-Lausitz.de Katrin Erdmann e-mail: Katrin.Erdmann@HS-Lausitz.de

Curriculum relevance and connection to policy guidelines

- all offers are oriented side along the curriculum and adapted to the level of knowledge of pupils
- the offers add practical and experimental components to the normal school subjects

Description of the innovative practice

The core of the project is a mobile lab, where materials and information useful for hands on experiences in different science areas are transported. The mobile vehicle will be equipped according to the needs of the school (which experiment(s), how many participants) and stays at the school for the time of the experiment and preparation/evaluation. Schools have the possibility to plan these experiments together with the university. Although the vehicle is mainly for transport, two lab working places in the vehicle are available and allow independent working conditions (if for example the school does not offer suitable rooms or experiments are presented outside schools). Because schools are able to do low-level experiments on their own, only high level experiments are presented (e.g. production of paracetamol, aspirin or special cosmetics like sunblockers, extraction of caffeine, production of a dye-sensitized solar cell, DNA analysis, thin layer chromatography, graphic programming of a Lego-robot, movement-coordination (fine motor skills, practice-catalogue given to pupils for experimentation and imitation on themselves). The vehicle mostly transports expensive equipment that is not present at schools and it has very special features (e.g. allows the problematic transport of dangerous chemicals due to a special air conditioning system and safety installations).

Theoretical frameworks:
All offers follow a problem-based, interactive and hands-on approach.

Main aims, features and phases:
- **general development and start of the project**: analysis together with teachers and pupils in a region (showed for example the need of schools only for high-level experiments), selection of involved professors and cooperating schools, coverage of funds, selection of staff, acquisition and rebuilding of a vehicle (with experiments on board), knowledge about internal possibilities at school, identification of suitable offers, kick-off event at schools, development of further experiments by professors and students at the university
- **development of the offers / of each new experiment:**
  1) exploratory discussions between teachers/pupils and academics of the university Lausitz
  2) feasibility check; formulation and setting of aims; description of the concept and target-specific planning; choice of materials and equipment
  3) first test of the offer at the university Lausitz, first performance of the offer together with pupils from cooperating schools
  4) second and third test for fine tuning (also with pupils of cooperating schools)
  5) inclusion of the offer into the regular program of Science on Tour Lausitz

Methodology used:
- moderation, guidance
- independent working (of pupils)
- working in small groups (very important), individual experimenting
- evaluation
- courses for pupils mostly take place in technical school rooms, in special cases also outdoor or lab—work (according to the topic)

Resources needed:
- scientific staff from a university
- administration (planning of appointments with schools, preparation, post-processing, currently done by the university)
- students of the relevant subjects
- worksheets, presentations during the experiments, lecture notes for teacher preparation
- sometimes teaching materials are used that are supplied by industry

Form of assessment / evaluation used:
- regular meetings with representatives of the cooperating schools
- feedback rounds with pupils and teachers after the experiments, anonymous questionnaires, post-discussions with pupils, special questionnaires during the 3 test phases of a new experiment.

Information available
- short description (1 page, German)
- concept (10 pages, German, at least 5 pages have to be translated)
- description for each experiment (5 to 10 pages per experiment, German, have to be translated if the special experiment will be used)

Critical features for sustainability
- Science on Tour is an informal offer, can be ordered and used within the framework of the normal school lessons

- direct use and the application of the offers depends on the equipment of the schools/institutions
- the project creates incentives to deal with science and technology because all experiments show a substantial real-life aspect (seems to be especially important for all pupils participating in the evaluation)

Critical features for transferability

- sufficient vehicle for transport of the experiments needed (for the given example a new transporter was used, re-modeled (around 8000,- Euro) and equipped with instruments necessary for the various experiments (around 20.000,- Euro)
- free offer with access for everybody, schools and groups outside schools don't have to pay for the offer
- scientific staff and students needed for authentic learning
- incorporation into a scientific institution
- rooms/labs needed for preparation (e.g. buying and handling of dangerous substances), follow-up and storage (central storage needed where equipment for all experiments is stored / vehicle will be equipped according to the needs of the respective school)
- adaptation with state-specific curricula and knowledge level of the participants

[1] **Schülerlabor & Co.** Außerschulische narturwissenschaftlich-technische Exprimentierangebote als Ergänzung des Schulunterrichts in der Region Berlin-Brandenburg (Band 2 der TSB-Studien zu Technologie und Innovation) von Jana Huck, Gerhard de Haan und Michael Plesse

Role-play for self-awareness and participation in science education

Key-words

Secondary school, Science-Technology-Society, meaningful learning, nonviolent conflict transformation, sustainability

Problems addressed

The widespread use of a transmissive mode of science teaching contributes to building an image of science which is incongruous with reality. This way of teaching science is also unhelpful in raising students' interest in and awareness of the implications that science has for their lives as both individuals and members of a community. In this context, innovations in science education have been proposed by our group for the purpose of preparing citizens to make sense of the complex and controversial problems of our time, by developing self-awareness and confidence in nonviolent approaches.

Quality criteria

Fosters **scientific competencies:** stimulate argumentation and critical thinking; include decision-making activities.
Socially relevant: Promote actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues
Consider **developments in science education** and **science education research:** the innovation is baked by and contributes to research on science education.

Innovation appraisal

The innovation has been welcomed in principle by many teachers who were participants in continuous professional development courses held in previous years. While the number of teachers who used role-playin their classrooms and involved other colleagues (as was required) was limited, all students who took part in the trials have by and large demonstrated high levels of interest and involvement.

Relevant information in brief

Topic addressed	Study of 3 environmental controversies: water management in a dry country in Sahel; the intensive aquaculture of prawns in India; the contested aspects of a high speed rail line project in Italy.
Age classes	13-18 years old
Extent	Local level: experimental trials undertaken over many years with about 300 students International level: 3 classes of 13-14 year old students in a comprehensive school in England (Doctoral thesis)
Years of experimentation	Over 10 years, but with different topics, in different contexts.
Duration	Minimum time required is two lessons of 2-3 hours; optimum time would be four to five lessons of 2-3 hours.
Main innovation promoters	Science Education Research Group, Turin University.
Main innovation partners	Teachers involved in professional development courses organised through the Province of Turin and the Piedmont Region; classroom teachers in England recruited through the Association for Science Education and the OPEN University. Post-graduate students involved in teacher education programs at the University of Aberdeen, UK.
Website	www.iris.unito.it
Contact person	elena.camino@unito.it; daniela.marchetti@unito.it; l.t.gray@abdn.ac.uk

Curriculum relevance and connections to policy guidelines

This innovation is well aligned with thinking which has been developed over many years in the International context such as the Science, Technology and Society (STS) international movement and education for sustainability.

Description of the innovative practice

This innovation stemmed from the research and reflection undertaken by the Science Education Research Group. The Group had made connections with schools via the involvement of public bodies, or with individual teachers who had a personal interest. A series of role-play simulations dealing with complex and controversial socio-environmental issues were developed and trialled in a variety of educational contexts. The activities were aimed at introducing participants to decision-making processes involving an extended community of people (enacted through a variety of professional and social roles) with the purpose of finding a solution.

Theoretical framework

From an educational point of view, our research is informed by the concept of learning community, based on the use of participatory activities. These approaches are located within the epistemological framework of 'post-normal' science (www.eoearth.org/article/Post-Normal_Science) and 'sustainability science'. Another aspect characterising our work is the philosophical and ethical dimension of nonviolence as a key component to both education and sustainability.

Main aims, features and phases

Aims: the broader aim is that of creating a context of meaningful and active learning in the classroom providing students (and teachers) with a pedagogical tool which enables them to act within a community of inquiry focussed on real and topical problems. Subsidiary to this is the development of a broad range of linguistic, relational, cognitive and reflective competences (being able to express one's own ideas appropriately, to learn to listen and to value other people's points of view; to be able to apply scientific concepts and to elaborate interdisciplinary conceptual tools to deal with real problems; to learn to recognise one's own and other peoples' mindsets and worldviews)

Characteristics: students' involvement in and engagement with real, open-ended problems holding uncertain outcomes; making connections between the abstract notions provided by textbooks with the operational and practical competences that are required to deal with relevant issues; dialogue between different schools of thought and different worldviews (and related implications for the nature of science); attention to the relationships between local and global. For example, in the role play on shrimp farms students are engaged in studying the ecology of mangroves; the life cycle of indigenous and artificially selected shrimps and their nutritional aspects; in analysing the distribution of water reservoirs and discussing conflict about the use of water by the farms and the villagers; in calculating the ecological footprint of intensive farming; in questioning the role of western consumers, etc.

Phases of the activity include: the introduction, with a presentation of the problem and the main points of tension/debate. This is followed by a second phase in which each participant is given a role-card and joins in with a small group of peers to gather documentation and information in support of their shared position; a third phase corresponds to the debate between the groups who are supporting contrasting views and approaches to the problem; finally, a fourth phase consists of the decision-making process followed by a general reflection on the experience. This phase may be extended into the process of conflict transformation with the aim of creating a future scenario of nonviolent and sustainable situation addressing everybody's fundamental needs.

Methodology used

This innovation has been progressively changed and refined as part of a process of action-research with the characteristic, feed-back process of reflection and implementation leading to different levels of learning: the epistemological, pedagogical and cognitive levels. Students are required to work in different settings, carrying out individual activities (personal reflection and search for information), participating in small group discussions (collaboration within the group to prepare a strategy for the debate); performing in a debate between groups; undertaking collective reflection (as part of the debriefing) and individual reflection (on one's own perceptions and feelings during the simulation); and experiencing settings of conflict transformation (where groups of contrasting opinion engage in dialogue). A range of knowledge resources is used, from video projections (to introduce the geographical setting of the controversy) to posters made by the groups, web searches, work-sheets, etc. In some situations we organised meetings dedicated to reflect together with students and teachers on the various approaches that can be taken to deal with controversial problems – usually both students and teachers demonstrated to be rather unfamiliar with nonviolent means for conflict transformation.

Resources needed:
A researcher or a very experienced teacher to run the whole activity; the presence of 1 or 2 other teachers (not necessarily science teachers) or researchers as observers can be very useful to give way to a shared process of evaluation.
Other resources needed are the role-cards and briefing notes and fact-sheets containing additional information about the terms and context of the controversy; it might be helpful to give suggestions of web-sites to visit in order to get updates on the most current developments.
During the simulation it is necessary to have sufficient space for allowing students to work in groups.

Added value of an adaptation:
The opportunity to try out the same role-play in different countries (for example the role-play on intensive prawn farming) or starting from a local controversy and working with the students on uncovering similar situations in other countries (as it is the case with environmental controversies arising from large scale public works projects) would certainly add value to the innovation.

Forms of assessment/evaluation used:
Modes of assessments based on trans-disciplinary learning processes and changes of attitudes were proposed as a means to evaluate the activity but these were seldom taken up by the teachers who were mainly focussed on the acquisition of disciplinary concepts.

Information available

There is a range of materials available on these activities:
a) published volumes (in Italian) containing the actual role-play materials with teachers' briefing notes and role-cards e.g. Camino E., Calcagno C. Dogliotti A. & Colucci-Gray L. Discordie in gioco. Capire e affrontare i problemi ambientali (Controversies at play. Understanding and dealing with environmental problems). Ed. La Meridiana, Bari, 2008; Colucci L. & Camino E. Gamberetti in tavola: un problema globale. Gioco di ruolo sugli allevamenti di gamberetti. Edizioni Gruppo Abele, Torino, 2000; Camino E. & Calcagno C. Cerca l'acqua sotto terra - ferma l'acqua fermando la terra. Edizioni Gruppo Abele, 1991.
b) Undergraduate thesis and doctoral thesis: Laura Colucci-Gray.(in English) An inquiry into role-play as a tool to deal with complex socio-environmental issues and conflict. PhD Thesis in Science education, OPEN UNIVERSITY, 2007 (http://www.iris-sostenibilita.net/iris/docs/pubblicazioni/Colucci-Gray_PhDThesis.pdf).
Daniela Marchetti. (in Italian) Sperimentazione di attività didattiche interattive su tematiche complesse e controverse con studenti di scuola secondaria superiore (Interactive activities on complex and controversial topics with secondary school students). Degree thesis in Natural Sciences, academic year 2001/02.
c) Some materials used for the prawn farming role-play activity developed in the UK: 30 pages included role play cards and power point presentation (translated in English), published and unpublished research articles, both in Italian and in English.
e) Published and unpublished magazine articles and research notes for teachers (in Italian).

Critical features for sustainability

While the Research Group in Science Education has over the years gathered conspicuous information and evidence about the strength of this kind of activities to promote a scientific literacy for sustainability, it is increasingly difficult in Italy to find teachers who are prepared and willing to implement it.

Critical features for transferability

The innovation is very flexible and it has proved to be suited to many different contexts, but it almost certainly requires flexibility and awareness on the side of the teachers. They are asked to play a different role in the classroom and to value competences that might be different from what is offered by traditional teaching. Teachers' knowledge and awareness of the epistemological and methodological aspects plays a part in their willingness to try out role-plays in school: i.e. awareness of the uncertain and controversial nature of modern techno-science and the close interconnection between ecology and equity could encourage them to introduce this type of activities in the classroom.

Physics and astronomy for self-efficacy

Keywords

Secondary vocational school, science for 'dropouts from science', emotions in science, logical reasoning, communication competences

Problems addressed

Quite frequently students who would be attracted by scientific disciplines do not engage in their study because they fear they will not qualify. These students are often found in vocational schools, and despite the fact that they decide to study different subjects they keep the same curiosity and desire to understand scientific issues. Because of their vocational choice these students are not fully aware both of their capacities and limits and can even develop a negative attitude towards science.

Quality criteria

Pedagogically and **methodologically sound**: includes pupils that have been 'excluded' from science teaching but have still interest to science; the learning activities and teaching methodology are consistent with the Feuerstein pedagogical claim of the importance of emotions.
Fosters **scientific competencies** and scientific literacy, especially science communication competences.
Socially relevant: promotes public understanding of science.

Innovation appraisal

This innovation, proposed by teachers, was very well accepted by students who agreed to disseminate their experience among school friends and through a local newspaper, and who are preparing a show for an international Festival in Autumn.

Relevant information in brief

Topics addressed	Experimental activities in Physics and Astronomy presented in such a way as to convey emotion
Age classes	16-17 years (of different classes)
Extent	Local; 17 students involved , coming from 10 classes of two different schools,
Years of experimentation	1 year
Duration	One week, full immersion.
Main innovation promoters	Different Vocational schools (Centro Formazione Professionale "Arti e mestieri" of Suzzara), Lombardia Region
Main innovation partners	MASTeR (Permanent Interactive Laboratory) of Mantua, Association of amateur astronomers of Mantua.
Website	
Contact person	Riccardo Govoni (scientific director of MASTeR): r.govoni@mclink.it

Curriculum relevance and connection to policy guidelines

This proposal can be seen as an extension of the compulsory curriculum and is part of an empowerment plan implemented by two schools with the same headmaster. It can be labelled as 'non formal learning' using exhibits and 'spectacular' lectures.

Description of the innovative practice

Students from different classes and ages coming from vocational schools, not science oriented, but with still an interest for science issues are invited to follow a full immersion week, where logical games, 'spectacular' lessons, experiments and visits to the local astronomical observatory, are used to raise their interest and their attitudes of self esteem toward science learning.

Theoretical framework:
The background theoretical framework is related to a methodology of cognitive empowerment known as the 'Feuerstein method' applied to science learning. Emotional involvement and logical thinking are 2 main aspects of this methodology. Gardener multiple intelligence theory is another point of reference.

Main aims, features and phases:
The main aims are: empowerment of cognitive functions through emotions and amazement; acquisition of basic scientific concepts and scientific terms; activation of metacognitive processes so that students become aware of their way of thinking; devising and employing successful plans and designs; converting students from passive receptors into active producers of knowledge, and communicators of science.
Phases: observation during the lectures and after the lectures of the phenomena proposed; data gathering; enacting of problem solving strategies; visit to the astronomical observatory for observing heavenly bodies; preparation of similar 'spectacular lectures' to be proposed to the public of the International Literary festival of Mantua (where also scientific publications are presented). The need to communicate in a creative, amazing, way drives students to delve deeper into the concepts to be presented. In the observatory visit phase the support of families has been fundamental because the activity has taken place outside of the town. An outcome was that families have also developed a permanent interest in astronomy.

Methodology used:
An informal approach aimed at raising amazement has been followed. This is because in the two schools involved experimental scientific disciplines are rather marginal while social sciences in one and technical drawing and environment studies in the other are predominant.
For logical reasoning and self–esteem spatial 3D games were proposed (to reproduce different kind of knots they can see but not touch; to plan the best store up? of a given container with packages of different forms,...) .
Toys or gadgets and the interactive exhibits of MASTeR have been used for the physics topics.
Three different kinds of presentations have been used and students have been asked to reflect also on this choice. The first topic deals with colours and sight as a perception. The presentation in this case has been rather traditional albeit brilliant, interactive and aimed at building understanding. The second topic deals with the concept of energy. In this case the approach was narrative, almost a monologue although backed by practical examples and experiments which students could manage.
The third theme deals with rather heterogeneous topics from thermology with the 'Drinking Bird' to the chemistry of hydrophilic polymers with Instant Snow Polymer or Sodium Polyacrylate (Diaper Polymer), to the Lenz Law proposed by means of the falling of a magnet through a copper pipe.
As in all other 'shows' the scene's costume is a starting point: we used a T-shirt with physics formulae. At the same time the vision of the nocturnal starring sky is part of the contemplation and reflection on the greatest spectacle in the world.
Every phenomenon displayed has been explained starting from the students' previous knowledge in a very simple albeit correct language emphasizing the choice of the appropriate terms.

Added value of an adaptation
Students of different countries exchanging materials, toys and presentations could be an added value.

Resources needed:
This innovation requires a Physics teacher (with communication competencies), an Astronomy teacher and also an Arts teacher if the part on the perspective perception would be developed. A technician as a support for the laboratory. Scientific toys chosen according to the topics to be developed are necessary. The exhibits of a science museum and access to an astronomical observatory (even an amateurish one) are both useful although not strictly necessary. The observatory cannot be replaced with a planetarium.

Form of assessment / evaluation used:
Feelings of self-satisfaction and self-improvement can be drawn from the students reports at the end of their activities as well as a change in behaviours and cognitive processes and attitudes.

Information available

A power point (in Italian: 'le mirabil cose') presents the guiding principles (emotions in science), the various exhibits and their functioning.
About toys and their use in Physics teaching, a book. in Italian, has been used:
V. Zanetti. I giocattoli e la scienza, (Toys and science). La Fisica nella scuola. Quaderno 4, 1993.
The Italian Journal: La fisica nella scuola, offers, from 2007, a section dedicated to 'Play with Physics'.
In many countries publication on scientific toys are available and a starting point could be the study of the principles of their functioning.
Depending on the main teachers' interests about 20-30 pages could be translated .

Critical features for sustainability

Teachers should be ready to engage and experiment and to exercise their communication competences.

Critical features for transferability

Working in small groups is necessary. Teachers should also be good communicators. A scientific museum and a planetarium organized interactively are useful.

Nature, Life & Technology
Advanced science, maths & technology in upper secondary

Keywords:
Upper secondary school, integrated science, student preferences, school based curriculum development

Problems addressed

Interest of students in single science subjects in upper secondary was declining probably because of overloaded content based curricula and a predominantly teacher centred methodology. Students and teachers had very little choice to select content that suits their preference. In the Netherlands one remedy for this is the development of a new interdisciplinary subject: NLT (Nature, Life and Technology). This subject is offered to science stream pupils in upper secondary schools in addition to the regular subjects physics, chemistry, biology and mathematics. A set of more than 50 modules is being developed as teaching materials for national use.

Quality criteria

Pedagogically and **methodologically sound:** takes gender- and (multi)cultural issues into account.
Socially relevant: promotes public understanding of science.
Supports **teacher participation** and **professional development**: teachers are involved in designing and adapting the learning materials.

Innovation appraisal

The innovation has been developed in a well organised network according to strict procedures. A set of more than 50 modules has been developed as teaching materials for national use. Each module is developed by a team in which teachers of secondary schools and an expert of the subject work together. However this does not automatically lead to good teaching materials. For this reason a quality control procedure was developed for all NLT modules. In this procedure, teachers, pupils, scientists and science education experts all play a role in the evaluation of draft modules. Only after this multi-perspective evaluation procedure a module is officially approved and can be used by all schools. In spite of the fact that it takes a considerable investment on the part of schools and teachers, many schools have voluntarily introduced NLT as part of the school curriculum and the subject is popular among students.

Relevant information in brief

Topics addressed	Nature Life and Technology. For an indication of topics addressed go to : http://betavak-nlt.nl/English/then go to downloads and select: Description certified modules havo - 08-12-2008 (Word) Description certified modules vwo - 08-12-2008 (Word)
Age classes	16 – 19
Extent	Optional for all schools of secondary education in the Netherlands Some 40 % of all schools in the country offer the subject as part of their school curriculum in upper secondary.
Years of experimentation	3 – 4 Years.
Duration	A single module takes 40 hours to carry out: it includes time at school (lesson hours, lab time) as well as time for home work.
Main innovation promoters	The Ministry of Education; Science departments of several universities and polytechnicsThe National Institute for Curriculum Development. Schools that offer the subject in their curriculum are the best ambassadors for the subject.
Main innovation partners	Science departments of several universities and polytechnics The National Institute for Curriculum Development. Schools involved in the development process of modules.
Website	
Contact person	Ms J. Kruger (j.kruger@slo.nl)

Curriculum relevance and connection to policy guidelines NLT is an officially approved optional subject in upper secondary schools in the Netherlands. It is multidisciplinary in nature and flexible in content. The main domains are prescribed: within each domain the school can choose from approved modules that are available. In upper secondary students work on 8 modules in 2 years (360 hours) or 12 modules in 3 school years (480 hours). Most modules contain hands on activities..
NLT is fully in line with curriculum guidelines for secondary education in the Netherlands. In upper secondary schools have the freedom to offer school specific subjects on top of the national curriculum. These subjects need approval of the Ministry of Education. NLT has been approved by the Ministry and is assessed in a school exam. Both the curriculum as well as the school exams have to meet official standards.

Description of the innovative practice

The general aims of NLT are to make science and technology more attractive to students and to create coherence within the different science subjects. NLT is an optional subject within the science stream of upper secondary education, to be completed with a school exam. The development phase of NLT has started in 2006; the early adopters have implemented the first available modules from 2007 on. By 2010 the subject is available in full. Another 3 – 4 years will be needed to make it a self supporting full fledged school subject in upper secondary schools in the Netherlands.

Theoretical frameworks: NLT is based on a context-concept approach. The basic concepts in science are connected with contexts from science, the work place or every day life. The development strategy is participatory in nature since it involves teachers in designing learning materials and in evaluating them. The teachers are part of a community of learners. The NLT website for teachers is an important tool to support the communication within the community.

Main aims, features and phases: Main aims: to stimulate interest in science among students in upper secondary and in science careers. Features: NLT is a optional subject in upper secondary. It is multidisciplinary in nature and flexible in content. The main domains are prescribed: within each domain the school can choose from approved modules that are available.
Phases:
1. modules developed in networks of teachers and content experts;
2. modules tested and evaluated by students, teachers and methodologists; modules that meet the criteria get a certificate;
3. certified modules are published on the official website and are freely available for schools.

Methodology used: Teaching and learning methodology differs from module to module. The common denominator however is active student participation.
Resources needed:
Resources needed differ from module to module.
On the level of the network: the procedures and the support network is important both during the development phase as well as the implementation phase. There is a support structure in place for the development and implementation of NLT, for instance a special website with an area for teachers and an area for pupils.
Form of assessment/evaluation used: Each module has been tested in the classroom. In the quality control procedure teachers, pupils, scientists and science methodologists all play a role in the evaluation of draft modules. Only after this multi-perspective evaluation, that include pupils assessment, procedure a module is officially approved and is made available for schools.

Information available

There is a wide variety of materials available for developers of learning materials, for teachers and for students in Dutch. There is limited information available in English: http://betavak-nlt.nl/English/
No learning material has been translated into English. Individual modules vary from 20 – 160 pages.
Literature in English:
Eijkelhof, H. & J. Krüger: *Improving the quality of innovative science teaching materials* (paper presented at the ESERA Conference, Istanbul, August 31 – September 4, 2009)

Critical features for sustainability

NLT has been developed and implemented on a large scale in regular classrooms, with average teachers as a part of regular courses in upper secondary in the Netherlands. With some support in the next 4 years it is expected to be a full fledged science subject in upper secondary schools in the Netherlands.

Critical features for transferability

Critical features for transferability to other countries are:

- the support structure needed for developing, trying out, and implementing the modules and the quality control;
- some autonomy for schools to decide about a part of the school curriculum themselves.

It may be possible to try and develop an individual module and try it out, but effects of an isolated pilot project will be limited.

½ LC - Half Learner Centred

Keywords:
Secondary Education, learner centred, active learning, teaching methodology

Problems addressed

Many lessons in mainstream schools remain too teacher centred. To stimulate teachers to make their lessons more learner centred it takes a clear message and a very simple and flexible methodology.

Quality criteria

Pedagogically and methodologically sound: the teaching methodology take current theories about science learning into account; allows for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests; motivation/interest in science is stimulated.
Supports **the professional development of teachers:** teachers are involved in designing or adapting the innovation to their own specific situation; stimulates peer reviews and visits to classes of other teachers inside and outside school(s) to give each other professional feedback.

Innovation appraisal

The strategy has been applied on a large scale in secondary education in the Netherlands since 1993, mostly in the form of in-service training of teachers at school level.
The initiator of the strategy dr J. Zuylen has evaluated and upgraded the strategy over the years. Many others have adopted and adapted the strategy as well. Since it is so very flexible, low cost and easy to implement is has been well received by many schools and teachers.

Relevant information in brief

Topics addressed	any, chosen by the teacher from their own curriculum
Age classes	any, according to the teacher's choice
Extent	widely applied in secondary education in the Netherlands
Years of experimentation	17 years (1993 – 2010)
Duration	minimum 2,5 hours: 1 hour preparation, 1 lesson hour execution and half an hour to evaluate and make adjustments.
Main innovation promoters	Mesoconsult and other agencies and institutions involved in implementing educational innovations; many schools adopted ½ LC as innovation strategy.
Main innovation partners	idem
Website	www.mesoconsult.nl
Contact person	Dr. J. Zuylen, jvzuylen@mesoconsult.nl

Curriculum relevance and connection to policy guidelines

The Ministry of Education in the Netherlands does not interfere in teaching methodology. However, the ministry has funded implementation programmes to stimulate active learning. So strictly speaking, the innovation is not part of the official curriculum.
The ½ LC strategy is an implementation tool. It has proven to be a very efficient tool since it can be used in any subject for any age level.

Description of the innovative practice

Theoretical frameworks:

The ½ LC strategy is based on the constructivist assumption that in education knowledge is constructed by the learners. Therefore during lessons teachers should give learners time and activating assignments to acquire knowledge and skills. A range of activating teaching methods can be used.

Main aims, features and phases:
1. choose lesson to be transformed
2. substitute teacher centred approaches by learner activities.
3. carry out the lesson and evaluate
4. adjust the lesson on the basis of the evaluation

Methodology used:
Teachers redesign their lessons in such a way that (at least) half of the time the students are working on assignments that require them to actively acquire knowledge and skills.
This apparently difficult task proves to be relatively simple especially when done in cooperation with a colleague teacher who is invited to observe and evaluate.

Resources needed:
A minimum of resources is needed: just some time (2,5 hours per lesson hour: 1 hour of preparation, 1 hour delivering the lesson, half hour of evaluation) and some creativity. Materials may vary depending on the topic of the original lesson.

Form of assessment / evaluation used:
The strategy has been evaluated and upgraded over the years, mainly in the framework of in-service training for teachers.

Information available

There is sufficient material available about the application of the strategy. Most of it is addressed to teachers. Examples of lesson plans and learning materials are available, also for science.
A short description of the ½ LC strategy plus some examples of lesson plans and some suggestions to use it in in-service teacher training is expected to be sufficient to pass it on to other countries. All in all some 20 pages describing the idea, the procedure and some examples from the sciences will need to be translated from Dutch.

Literature:
J. Zuylen: *Het ½ NC-principe en de integratiekapstok,* Studiehuisreeks nummer 46, Mesoconsult, Tilburg, 1996

Critical features for sustainability

The innovation has been implemented on a large scale in regular classroom by average teachers to improve the teaching methods of regular courses.

Critical features for transferability

The strategy is very flexible and adaptable. However: when teachers are not used to redesigning some of their teaching materials and methods and not used to reviewing each other’s work, the strategy should be carefully introduced and support should be available.

Research & Development as a Subject in Secondary Education

Keywords:
Secondary school, inquiry based learning, procedural knowledge, autonomous learning

Problems addressed

The main motive to develop R&D as a subject in secondary education was to boost the interest in science and technology. Traditional teaching and learning in the science subjects was not motivating pupils and did not invite them to follow their interests, learn autonomously and use their creativity. The approach is appreciated by both girls and boys since they are allowed to choose projects that interest them and they may choose their own methodology of research and design.

Quality criteria

Fosters **scientific competencies:** offers inquiry based learning activities
Socially relevant: uses resources and teaching contexts from outside the school and students address real life problems
Supports **teacher participation** and **professional development:** in developing new content for R&D teachers of all schools in the network are involved in designing or adapting the innovation to their own specific situation; teachers are engaged in peer reviews and line reviews of the innovation.

Innovation appraisal

Most schools that offer R&D as a school subject are part of the *Technasium* network. The network has developed performance criteria. New schools have to implement R&D according to prescribed procedures and criteria. After 4 years of successful implementation a school is awarded a *Technasium* title. Every 4 years *Technasium* schools have to proof to a panel of external experts and staff members of peer schools that the meet the criteria.
The success of the *Technasium* formula and the growth rate of the number of schools and students show the appeal of the content and the methodology of the subject. Since the introduction of the R&D concept the number of pupils has doubled yearly.
Finally: R&D has been approved by the ministry of Education as an official subject for school based exams.

Relevant information in brief

Topics addressed	Any topic that lends itself for a problem based approach can be integrated in R&D. In solving the problems during R&D students draw on knowledge and skills from subjects as: physics, chemistry, biology, health studies, geography and mathematics.
Age classes	12 – 18 (year 1 – 6 in secondary schools)
Extent	58 schools, 5000 pupils have R&D on a regular basis.
Years of experimentation	R&D has been implemented for 6 years and is constantly monitored and upgraded. Participating schools keep adding R&D-assignments to the networks database.
Duration	To fully implement R&D as part of a longitudinal curriculum will take 4 to 6 years. Should a school or a school network wish to develop an R&D-derivate and implement it in one specific year of secondary education, 2 years is a minimum time frame needed. Although the full implementation of the innovation is curricular, it is possible to experiments the R&D method proposing projects with an approximate duration of 6 hours for week during 7 weeks
Main innovation promoters	The Ministry of Education, participating schools:
Main innovation partners	- Platform Beta-Tecniek (National platform that stimulates science education) (http://www.platformbetatechniek.nl/?pid=49&page=About%20Platform%20Beta%20Techniek); JetNet (national network that coordinates cooperation between schools and private enterprise); Metaal Unie (Union of Enterprises in Metallurgical Industry); Technical University of Eindhoven; University of Twente, Enschede; Hanze Polytechnic University, Groningen

Website	http://www.technasium.nl The following link has a video clip portraying an R&D project: http://www.scynet.eu/index.php?option=com_content&view=article&id=44&Itemid=48
Contact person	Ms Judith Lechner info@technasium.nl

Curriculum relevance and connection to policy guidelines

The school subject *Research & Design* forms the core of the *Technasium* school concept. In the course of their 5 or 6 year school career students get acquainted with the process of conducting research and with various aspects of the design process. Over the years the assignments get more complex and more emphasis is laid on research and design methods and skills. The competencies acquired are derived from the competencies that graduates of polytechnics and universities need at the workplace. Ideally R&D assignments are hands-on and minds-on. On a content level connections are made with relevant other subjects in the school curriculum: most R&D assignments are multidisciplinary in nature. Mono-disciplinary school subjects play a supportive role.

R&D is fully in line with curriculum guidelines for secondary education in the Netherlands. The guidelines for lower secondary allow schools to make their own interpretation of the guidelines. It is up to the inspectorate to check if these school interpretation meet the guidelines. So far R&D has met the approval of the inspectors.

In upper secondary schools have the freedom to offer school specific subjects on top of the national curriculum. These subjects need approval of the Ministry of Education. R&D has been approved by the Ministry and is assessed in a school exam. Both the curriculum as well as the school exams have to meet minimum procedural standards.

Description of the innovative practice

In lower secondary students work on 4 R&D project assignment every school year. An R&D project is a cooperative learning experience: a project group of student work on the project for 6 lesson hours per week during a period of 7 weeks. In the school year preceding graduation every student works on two extended R&D projects of her/his own choice. In the last year the R&D curriculum is finalized by a master project, which is part of the school exam.

In the course of their 5 or 6 year secondary school career students get acquainted with the process of conducting research and with various aspects of the design process. Over the years the assignments get more complex and more emphasis is laid on research and design methods and skills.

The real life assignments that students can work on during R&D hours come from a wide range of companies in the private and public sector e.g. an oil/gas-company, a zoo, the regional water board, a shipping wharf. Some examples: making cosmetics by using mud as resource material, design an interactive information game for young diabetic patients, design living quarters for apes in a zoo; design tools for physically handicapped; explore the possibilities for colonizing space; find ways to make hemp fibres supple enough to be used for producing clothes.

Theoretical frameworks:

The philosophy of education underlying R&D is the constructivist paradigm and the methodology used is Inquiry Based Learning. Students are presented with real life problems and have to come up with solutions for those problems. So R&D is problem based and it draws heavily on students own creativity to apply the knowledge and skills acquired in other (science)subjects and (if necessary) to acquire additional problem-specific knowledge and skills. In most cases students work on projects in small groups. But in upper secondary the emphasis shifts to individual projects.

Main aims, features and phases:

For students, ideally, R&D creates a learning environment that:

- stimulates curiosity and inquiry
- enables and facilitates students to discover and develop their preferences and strengths
- brings students into contact with interesting developments in the world of science & technology, S&T-professionals, their work and careers
- provides a curriculum that is both broad as well as deep

For teachers, ideally, R&D creates a school and work environment with new roles and competencies, allowing:

- the development of curriculum beyond the boundaries of traditional 'mono'-subjects and the school walls
- a new role as a teacher: facilitating the learning process of learners during R&D assignments
- new forms of assessing the learning process: evaluating both product and process
- cooperation with colleagues in higher education and in private enterprise

Methodology used:
The methodology is inquiry based learning and learner centred. The precise setting depends of the topic studied. Procedural knowledge (research & design skills) is more important than content knowledge. In the lower years most assignments are done in groups. In the final year assignments are carried out individually.

Resources needed:
A well equipped workplace for (groups of) students is desirable.
Additional resources depend on the content and nature of the issues being studied.

Form of assessment / evaluation used:
Formative evaluation: ideally the external client that provides the real life issue/problem gives feedback on the quality of the results of the R&D-project and the teacher on the procedural aspects. It is possible to involve co-students in some form of peer-assessment.

Information available

There is extensive material available in the Dutch language: on methodology as well as examples of R&D-assignments. There is material available for students, teachers and for school administrators.
For transfer to other countries basic information about the ideas underpinning R&D, some information on the development strategy and some examples of R&D-assignments for students should be sufficient to get started. In some 15 pages of basic information the ideas can be presented. An introduction by teachers executing R&D at their own school and/or a visit to a school offering R&D would be much more effective. The specific way R&D is developed and shaped depends highly on the local setting and circumstances. Available material on problem based learning, inquiry based learning and examples of projects and/or assignments from different sources can substitute the material in Dutch since no written material is available in English nor other languages. An instructional video is available from the website.

Critical features for sustainability

Research & Design is a school initiative that has proven to be sustainable. It has been implemented on a fairly large scale in regular school as part of the regular curriculum. All learning materials have been developed with a major contribution of schools.
Important factors for success are:

- teachers should be motivated and feel comfortable to facilitate an open curriculum that is primarily procedural in nature rather than content based
- full support of the school management in facilitating the development and implementation of R&D
- some freedom to make curriculum choices at school level
- the development and implementation of R&D works best if teachers form small networks or communities of learners and establish cooperation with private enterprise and institutions that help design and facilitate real life assignments.

When these conditions or not or only partially met, a pilot project may function well on a limited scale, but upscaling and/or long-term implementation will be very difficult to achieve.

Critical features for transferability

Transferability across borders of R&D as a subject may be difficult since in most countries it will involve a system change. It is much easier to adapt and transfer the R&D-approach as well as isolated R&D-assignments to other countries. Since the assignments deal with local/regional real life situations the approach is highly flexible and easy to transfer.

Working on a similar assignment with students from other countries and compare outcomes would add value to a project; issues that vary from place/country to place/country would be most suitable for such a comparative approach. It would allow to address cultural differences as well.

Enhancing Scientific Literacy

Keywords:
Secondary school, scientific literacy, language of Science

Problems addressed

National Context: need to raise the knowledge of how to understand popular scientific texts from a broad area of scientific disciplines; unsatisfactory critical thinking; scarce use of updated knowledge in science. International Context: slow progress towards a knowledge society (understanding novelties in science) and critical thinking; need to enhance use of mother language in science;

Quality criteria / indicators addressed

Scientifically sound: correct use of scientific content/knowledge according to the context; raise awareness of the Nature of Science; provides insight in the way scientific knowledge is constructed.
Socially relevant: Uses resources (popular scientific articles) from outside the school.

Innovation appraisal

International evaluation of the innovation efficacy has been done by university experts (as all tasks in ProBase project) and by two (UK and SI) secondary vocational schools. The outcome of this process, as well as the results of the quality check, were built into the final versions of the activities before putting them on the website.
The innovation has been received as important and useful by the teachers and as clear and interesting by the students. A problem could be an English version for non-English countries, because scientific English is not taught (rare in Slovenia).

Relevant information in brief

Topics addressed	Popular scientific texts
Age classes	Secondary school students (15 – 18 y)
Extent	International; Local; two full classes involved (in UK and Slovenia)
Years of experimentation	2 years of development (2007/08), quality checking and testing in schools
Duration	Original innovative practice 6 x 45 min.
Main innovation promoters	School teachers; the National Education Institute; the innovation was developed within the "ProBase" European Leonardo da Vinci project;
Main innovation partners	Schools and school teachers; research institute (IJS);
Website	http://www.petrik.hu/probase/files/b_talk_t_en_tg.pdf ;
Contact person	Tomaz.ogrin@ijs.si; Katie@4science.org.uk;

Curriculum relevance and connection to policy guidelines

The innovation is not a part of the compulsory curriculum or of the optional one. It is part of a special international project (ProBase), available now on the web.
The innovation is explicitly connected with International guidelines or suggestions: e.g. PISA descriptions of scientific literacy, and high correlations between outcomes in Science and in reading literacy.
Innovation helps especially secondary school teachers of different scientific subjects (chemistry, physics, biology, etc.) to enhance scientific literacy of students (also interdisciplinary), yet inside curriculum hours.

Description of the innovative practice

The innovative practice is an activity in which students get popular scientific texts by teacher or choose by themselves and work on understanding the contents. Understanding is presented as a report of the working group and the knowledge gained is evaluated by a questionnaire.
Subject and topics are arbitrary; examples of the texts used in the practice originally (link to website given) are from chemistry, physics and biochemistry; those examples were chosen for vocational (chemistry) students and could be too difficult for others.
Texts (articles) are first read several times, and then unknown scientific terms are classified to the difficulty of understanding (class level, curriculum). Words which are not scientific and which may cause problems for

some students are also labelled. The meaning of labelled terms is searched for in a group using different sources.
The practice is concluded with the presentation an interpretation of the text in a class, verbal and/or by a poster.
The practice allows for any language to be used, of the majority or minority, in which newspapers and popular scientific articles exist. For minority students practice could be organized for several classes in a school to achieve a larger number of students.

Theoretical frameworks:
Theoretical educational frame of the innovative practice is PBL- Problem Based Learning. Here the problem posed is to understand a definite popular scientific text, using a systemic method and present this understanding to others. Usually, popular scientific articles need an interdisciplinary frame to be fully understood. Also, many scientific news in newspapers need critical thinking because of possible illogical or erroneous information and terms used, which is not the case with school-books. In such a way students are educated to be more self-dependent and more competent citizens.

Main aims, features and phases:
Main aims are: Enhancing scientific literacy; Use of scientific knowledge/ language and understanding to solve problems; Working in teams to solve problems; Communication;
Main features of the innovation are: Learn to handle real life situations using science language; Adaptability of the innovation practice (to ages, complexity, minorities); Self search for texts (raise interest);
Main phases: Choosing popular texts on science (e.g. newspapers, magazines); using a systemic method to label unknown terms and then search for their meaning, the text is becoming more and more understandable. In conclusion its understanding is presented to others as a written summary or abstract and a poster.

Methodology used:
Students work in a group to search for understanding of the chosen article. In the text they label scientific terms they do not understand because they are out of curriculum or will become known later in a higher level education. Then they search for the meaning of unknown terms and explain the text at the end; ICT use (web).

Resources needed:
Teachers; Internet; very useful for finding a meaning of scientific terms is e.g. in English (and with some translations) Wikipedia and
http://hyperphysics.phy-astr.gsu.edu/hbase/HFrame.html ; also for chemistry, geophysics, biology
http://www.biologycorner.com/worksheets/language.html ; example of an useful tool to understand the meanings of the "little words" (prefixes and suffixes), National Geographic and similar popular science magazines could be used, but also newspapers.

Form of assessment/evaluation used: Questionnaires: Testing prior knowledge; evaluating skills gained.

Information available

The idea and basic instructions/description for teachers and students is available in English and Slovene at:
http://www.pro-base.eu/files/b_talk_t_en_tg.pdf
http://www.compacitypro.nl/Sloveniantranslations/tabid/371/Default.aspx
Texts in the innovative practice are not compulsory and should be taken as examples only. They are intended for vocational (chemistry) students, which gain more chemistry specialized knowledge as other secondary students.
Anyhow, students are free to choose texts from sources or the teacher give them as a task.

Critical features for sustainability

The innovative practice has been implemented in regular classrooms with average teachers, tested in schools with vocational students and evaluated from them as easy and understandable. Further applications depend on teachers as part of regular courses or optionally.

Critical features for transferability

The innovation is flexible enough to be adapted to different applications and contexts, chosen by teachers or students, which fulfil the needs and chosen level of complexity and curriculum level.
The added value of an adaptation on interchange brings diversity of texts tried out and experiences gathered in enhancing scientific literacy.

Lectures by Students

Keywords:
Vocational secondary school, learning by teaching, chemistry, mother language.

Problems addressed

Need to raise efficacy of learning; Need for more problem-based learning; Need for more use of mother language in science (cultural aspect, minority aspect);

Quality criteria:

Pedagogically and **methodologically sound**: learning by teaching; collaborative group work;
Socially relevant: inclusion of all pupils, including those with special educational and physical needs; multicultural issue included.

Innovation appraisal

The innovation has been received by students with great interest and enjoyment(feedback information from the organizer of workshops).
International evaluation of the effectiveness of the innovation has been done by university experts (as all tasks in ProBase project) and by two (NL and SI) secondary vocational schools. The outcome of this process, as well as the results of the quality check, were built into the final versions of the activities before putting them on the website.

Relevant information in brief

Topics addressed	Lectures prepared by students with hands-on experimentation included; Chemistry;
Age classes	Secondary schools students
Extent	International; Local; Two full classes involved; groups formed; The innovation was developed within the "ProBase" European Leonardo da Vinci project;
Years of experimentation	2 years of development (2007/08), quality checking and testing in schools; Now in public use;
Duration	Original innovative practice 270 min.; Enables all adaptations (e.g. duration) and changes, depending on age and other parameters;
Main innovation promoters	School teachers. The National Education Institute; The innovation was developed within the "ProBase" European Leonardo da Vinci project;
Main innovation partners	Schools and school teachers; Research institute (IJS);
Website	http://www.pro-base.eu/files/d_fun_t_en_tg.pdf
Contact person	Tomaz.ogrin@ijs.si

Curriculum relevance and connection to policy guidelines

The innovation is not a part of the compulsory curriculum or of the optional one. It is part of a special international project (ProBase), available now on the web (http://www.pro-base.eu/).
The innovation is explicitly connected with International guidelines or suggestions: e.g. PISA description of scientific literacy.

Description of the innovative practice

In this innovative practice students are asked to prepare and give lectures, mainly the experimental part with some theoretical background. Students should answer the problem-based question: How would you explain to classmates a chosen topic? They work in groups in preparing the lectures.

The role of a teacher is to help in the preparation of lectures, in choosing a subject and in evaluations. Some examples are described in the practice (web site), but are not compulsory. Instructions for students and for teachers are included in the innovation practice for those examples. The examples are from the following curriculum topics: Acids and bases; Chemical buffers; Oxidation-reduction reactions; Chemical rate; Budget task.

The practice allows students to prepare and carry out the task in his/her mother language. Minority students from several classes could be gathered to collaborate in their mother language if there are not enough such students in one class. When students are trying out the practice they should use the problem-based concept (pose questions and problems to the audience).

Theoretical frameworks: Learning by teaching gives high level of efficacy; PBL- Problem Based Learning is practiced.

Main aims, features and phases:
Main aim of the innovation is to maximise learning; lectures are chosen or suggested by students or by teachers.
Main features of the innovation are the adaptability of the programme (lectures, issues, topics); raising motivation of students and pupils; use of curricula contents;
Main phases: gathering suggestions/ proposals for lectures; preparing lectures together with experiments; carrying out lectures for their own classmates; evaluation.

Methodology used:
Group and lab work; indoor; ICT possibility (e.g. interactive board);

Resources needed:
Teacher; Materials: depends on lecture contents - topic (lab materials for experiments, lab kits, instruments), written materials are produced by students for the topic they have chosen; In case of new examples of topics, resources such as: books, work sheets, web sites are needed.

Form of assessment/evaluation used: Questionnaires: Testing prior knowledge; self-evaluation sheet (included in original innovative practice and ProBase project): http://www.pro-base.eu/files/evalskills.pdf);

Information available

The idea and basic instructions/description for teachers and students is available in English at:
http://www.pro-base.eu/files/d_fun_t_en_tg.pdf ; Examples are not compulsory.

Critical features for sustainability

The innovative practice has been implemented in regular classroom with laboratory and with average teachers. It was piloted by students in two different partner countries and the partners shared their experiences. It was evaluated as easy and understandable. Further applications depend on teachers as a part of regular or optional courses.

Critical features for transferability

The innovation is flexible enough to be adapted to different ages (classes) by teachers. Other problems than the original problems/ subjects could be used and adapted (or not) to different curricula.
For transferability of original subjects 1 page per original lecture/experiment is sufficient.
The added value of an adaptation is to disseminate learning by teaching internationally and to practice learning science in a mother language.

Didactic Differentiation Project: Food Digestion

Keywords:
Lower secondary school, inquiry based science learning, didactic differentiation, investigation skills, integrated science

Problems addressed
Deficiency (lack) of differentiation of pupils at lessons to optimally develop research skills, based on their capabilities and interests.

Quality criteria / indicators addressed
Pedagogically and **methodologically sound**: allows for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests.
Fosters **scientific competencies**: offers inquiry based learning activities.

Innovation appraisal
Teachers and pupils marked this activity very high. Teachers found out that interdisciplinary and experimental method of teaching in dealing with nutritive substances and digestion leads to better understanding and results in evaluation of knowledge both in biology and chemistry.

Relevant information in brief

Topics addressed	Food digestion;
Age classes	Lower secondary school 9th class (14 y)
Extent	Local; Two classes/groups of students involved
Years of experimentation	Two years
Duration	One school day (or 5 school hours successively
Main innovation promoters	The National Education Institute (introducing flexible curriculum in primary schools)
Main innovation partners	Lower secondary school Lucijan Bratkovič Bratuša (Renče), The National Education Institute
Website	-
Contact person	Mariza.skvarc@zrss.si

Curriculum relevance and connection to policy guidelines
This innovative practice is in accordance with the aims and contents of chemistry and biology curricula. It is carried out in regular courses, but not during classical 45 minutes school hours (sh) and separated (as 2 sh chemistry and 2 sh biology per week) as are standard lessons. It needs to be carried out as one school day or 5 school hours together. The reason is a need for continuous proceedings and organizations of lessons.

Description of the innovative practice
Innovative practice introduces a didactic differentiation in integrated science lessons (modules) composed of experimental work and presentation, on food ingredients and digestion for the 9th class pupils. Didactic differentiation is one of possible ways in teaching to allow for a diversity of pupils needs and interests. It is recommended that the selection of pupils to form groups should not be the same each time this practice is used, but should vary somewhat.

Theoretical frameworks:
IBST-Inquiry Based Science Teaching; Didactic differentiation (e.g. http://journals.indexcopernicus.com/abstracted.php?icid=888497); Interdisciplinary collaboration for integrated lesson.

Main aims, features and phases:
Teaching goals from chemistry and biology curricula (9th class) were joined in an interdisciplinary way(Slovenia among countries with separated science subjects in last triad of 9y compulsory schooling – TIMMS overview). Pupils learned about ingredients of various kinds of food; how food is ingested; how the digestive system works; how our body uses various ingredients of food.

Usually such contents are taught separately within each subject, chemistry and biology. Linking contents which are in real life inseparable enables pupils to recognize and easily understand the process as a whole.

Pupils experimentally established nutritive substances in various foodstuff and also substances which result in the body after digestion of food. So the presence of digestible carbohydrates (starch and sugar) and proteins are assayed by specific chemical reactions. The role of enzymes is investigated.

The didactic differentiation is introduced by grouping pupils in a class regarding to their prior science competencies based on teacher's knowledge. Basically two groups are formed, but in classes where the situation is more spread more groups could be formed. The group with lower competencies experimented, based on instructions; the other got the open-ended and problem-based task, stressing planning of experiments and developing research method. For better organization of experimental work subgroups are formed.

At the end of the activity pupils combined all new knowledge and presented it in a poster form, each group separately. In case subgroups were formed, each subgroup presents its findings. Using posters they explain how they understand and link together new terms and processes as a whole.

Methodology used:
Experimenting and presenting gained knowledge in groups;

Resources needed:
Worksheets for two experimental exercises; for each exercise two different worksheets for the two groups of pupils are prepared.
Laboratory accessories
Chemicals: Fehling's solution (e.g. http://en.wikipedia.org/wiki/Fehling%27s_solution), Biuret reagent (e.g. http://en.wikipedia.org/wiki/Biuret_test), Iodine/KI reagent
Samples of various foods; Capsules with pancreas enzymes.

Form of assessment / evaluation used: A questionnaire for pupils

Information available
Two different worksheets for pupils are distributed: 1. one with detailed instructions and a description; 2. the other as problem-based variety (open, low degree of teacher's monitoring). Eight pages all together in Slovene. Both kinds of worksheet are given to each pupil, but they are asked to use the one which belongs to the group.

Critical features for sustainability
The innovative practice was tested with an average population in a 9th grade (14 y) class with 23 pupils. The practice was tested in a school which makes use of novelties in a Slovene school space – flexibility of curriculum. This means that a predetermined number of hours for lessons (curriculum) could be arranged arbitrarily over a school year, for most of the subjects.
When forming groups, and in deciding upon which variety of experimental exercise will be tried out by the group pupils and a teacher collaborated. This collaboration allows pupils to express their preferences.

Critical features for transferability
The Didactic method introduced by this innovative practice could be transferred to all other contents and experimental exercises.
IBSE–Inquiry-based science education (e.g. http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf) considering differences among pupils and using didactic differentiation requires some level of qualification of teachers. The method to be applied successfully also requires some level of conviction (usually gained through practice) that the

knowledge gained by pupils through this method has higher level of quality and durability (retention). Many teachers share the view that that the method requires much more time and that pupils gained less knowledge. Prerequisite to successful realization of this problem-based experimental practice is some experimental investigation skills pupils gained in prior experimental practice.

The method practised requires flexibility in organizing lessons and some shift up of the number of hours per week per definite subject. Such flexibility is possible in Slovenia.
Added value of the activity is its capability to teach successfully a real class with differences among pupils in interests and talents.

The weekly "5 minutes of science news"

Keywords:
Secondary school, updated science news, integrated science, teachers collaboration, student interest

Problems addressed

Teaching of different science related subjects (mathematics, physics, chemistry, biology) in secondary school is not interconnected enough. This could lead to low interest in science and technology and distance from scientific practices.

Quality criteria

Pedagogically and **methodologically sound**: motivation / interest in science is stimulated
Fosters **scientific competencies:** fosters scientific literacy (identify scientific issues, explain phenomena scientifically, use scientific evidence)
Supports **teacher participation** and **professional development:** teachers are involved in designing the innovation and in peer collaboration and reviews.

Innovation appraisal

Inquiry based learning implies involvement that leads to understanding. This innovative practice implies that you seek for answers on what are scientific reasons for a described news event and to try to understand it in a scientific way. With previously acquired skills and attitudes students seek resolutions to questions and issues while constructing new knowledge, which is in turn also interdisciplinary, since they cover the same news in the scope of different subjects.
Teachers at first have some trouble accepting they are qualified for these procedures, possibly because extra work for communication among teachers is required. Also active thinking, joining different perspectives as interesting news, different subjects, how these subjects inter-relate, are required to carry out the innovation. A link to the scientific institution is established to report on interesting developments in science to make the work for teachers easier.
The students develop an interest in scientific issues and in reflecting on daily news through scientific issues. This leads to a direct impact on the way they accept the natural world around them. While some of the most able students possibly consider the discussions less meaningful, there has been a rising interest in the previously less involved ones.

Relevant information in brief

Topics addressed	All science subjects - chemistry/ physics /biology -
Age classes	1st and 2nd year of high school/gymnasium (15-16 years old)
Extent	Local: 3 classes of approx 30 students involved. Full classes.
Years of experimentation	Started in 2007.
Duration	The minimum time needed for experimenting the core of the innovation is 1x per week for 5 minutes in each of the subjects, for 1 month.
Main innovation promoters	Local educational authority/ school teachers
Main innovation partners	-
Website	-
Contact person	Sandi Medveš, Špela Stres, Borut Likar, aleksander.medves@gmail.com, spela.stres@ijs.si, borut.likar@ijs.si

Curriculum relevance and connection to policy guidelines

The innovation is not a part of the compulsory curriculum, it is optional and it is in an experimental phase. It connects formal learning with informal (through current scientific developments, news on TV etc). In TIMMS and in PISA a high correlation was found between performances and 'real life connection' made by science teachers and this innovation goes one step further, since it connects and synchronises not only real life connections to classroom teaching, but also different subjects as perspectives of the same real life case.

Moreover cases tend to be chosen from the most prominent daily paper's published news in order to enhance the importance of the connection between real life and science studies.

Description of the innovative practice

Theoretical frameworks: Community of learners and participative methodologies.

Main aims, features and phases:

Students and teachers are informed about what is happening in the world (of science) and create links between their teaching/learning process, science and reality. Awareness of science education as a key change driver is emphasized to the students and teachers.

Open to all teachers of science subjects (math/phys/chem./biol), who also hold weekly coordination meetings among themselves.

Methodology used:

Students in the classroom of chemistry, biology and physics spend 5 minutes in the first hour of the week in a panel discussion on innovations/news in science and the relationship between these developments and learning the basic concepts of each of these three subjects in a very basic way.. Since the lectures are well distributed in the first half of the week, in practice the students would be dealing with the subject introduced on Monday, also on Tuesday and Wednesday.

The issue is in coordination of the three teachers to cover the same topic/news from three different perspectives, always trying to include what other teachers in previous classes have already covered in discussion. The choice of the topic is made by the teachers involved in the innovation and is previously discussed among them in view of teaching plan, topics and level on which these topics can be discussed in a classroom.

Resources needed:

Resourceful, open minded and communicative teachers. No extra lab or other materials. Information on (scientific) issues in daily press.

Form of assessment / evaluation used:

No formal assessment tools. However, it can be estimated that the interest for scientific topics increases in the group of students that have previously been less involved and have lower grades. This increase is seen in number of questions and answers posed during the normal class hours.

Information available

No materials currently available. A list of issues dealt with is available, but details on discussions have not been written. If this innovation is chosen, a logbook of the presentations can be made in order to give basic information on how to carry out the presentations in more detail.

Critical features for sustainability

The innovative practice is implemented in a regular classroom, with average teachers and as a part of a regular course.

Critical features for transferability

The school where the practice takes place is particular, because the three teachers of biology, chemistry and physics are devoted to cooperation among themselves. To communicate about their plans for the week lectures and to coordinate the 5 minute scientific discussion from three different perspectives, is an extra activity. The innovation itself is flexible enough to be adapted in different contexts and different environments: the added value could be to include issues that are location/geography/politics specific and explain these issues from three different scientific angles.

The innovation tries not to interfere with the curriculum too much – there are topics teachers need to cover and spending too much time on coordinating the three different subjects is not one of the goals of our educational system. As a possible upgrade a no-limit time schedule could be introduced.

A View from the Different Window

Keywords:
Youngsters, internationally successful companies, exchange of experience, research and development

Problems addressed

The campaign addresses a poor integration of education/curricula with the economy, lack of knowledge and competences concerning the identification of challenges, research and development and innovation as well as the poor preparedness of youth for the labour market. As well as the youngsters, the problem tackles also their mentors.

Quality criteria

Pedagogically and **methodologically sound:** motivation/interest in science is stimulated
Fosters **scientific competencies**: stimulates argumentation and critical thinking, stimulates collaborative work, uses resources and teaching contexts from outside the school.
Supports **teacher participation** and **professional development:** teachers engaged in peer reviews and line reviews of the innovation

Innovation appraisal

This good practice has been remarkably accepted by the teachers - mentors, students and consultants. It is encouraging that consultants recognized the positive effects of the case and are therefore willing to participate in the future as well. For students, this represents a special experience - meeting with experts who they might not normally encounter in their daily lives. Some responses of young researcher/innovators and Consultants are presented below.

> **Participant of the contest Eureka! Innovation of Youth**: "I was pleasantly surprised when I won awards as part of a visit to internationally successful companies. In business, I was pleasantly taken and the host showed me the whole company. This was followed by extensive discussion with developers and researchers because they work in virtually the same areas as me, these are aerodynamics, electric motors, electric vehicles and even fuel cells. At the end we exchanged contact information, because I believe that we will in future cooperate on joint projects."
> **Consultant**: "Personally, I think that the visits of young researchers are very useful for themselves, they can see practical aspects. It is positive to hear how young people think about the problem and to see how the staff is now preparing to work. Also in the future we are willing to cooperate"
> **Consultant**: "The young inventors were skilled and highly motivated to achieve their research and innovation goal. I was able to offer them help at certain topics. I see a challenge in finding appropriate experts and organisations, which could be helpful for them. Within an in-depth discussion we identified some of the elementary problems and I believe the directions were useful. I also established some contacts with other experts, who could provide the additional support."
> **Consultant**: "I think it was useful. The candidate has been responsive; we agreed to date, he presented his work to me and I organised a short visit of our Agency. I think his idea is very good and has a potential, but it should be developed into some specific products or services according to the market needs. For the realization of such a complex idea he would need a "strategic partner" and a mentor, because he does not have any experience in business."
> **Consultant**: "With the young researcher we discussed her research topic, results and plans for the future. I presented her our research group and the laboratory at the faculty. We also talked about the possibilities of cooperation. Regrettably after some exchanged e-mails the contact died away. In my opinion it is interesting to establish contact in such a way among people who otherwise probably would never have met. In the future I am willing to participate in the campaign."

Relevant information in brief

Topics addressed	Cooperation among the most creative young people, and their innovative/research/technological projects, internationally successful companies, prominent researchers, professors and experts for intellectual property.
Age classes	Students from Secondary School, also Universities; minimum 16 year old.
Extent	Students from Secondary School, Universities from all parts of Slovenia who have been successful in a contest for creative young people Eureka! Youth 2009 (app. 5-10)
Years of experimentation	For 1 year
Duration	Arrangement of the meeting, meeting (app. 2 hours) – The duration of the activity was app. 3 months.
Main innovation promoters	The Ministry of Education, Ministry of Higher Education, Science and Technology, Public Agency for Technology of the Republic of Slovenia (TIA), educational authorities, research institutes, internationally successful companies, prominent researchers, professors and experts for intellectual property.
Main innovation partners	Educational authorities, research institutes, internationally successful companies, prominent researchers, professors and experts for intellectual property.
Website	http://www.inovativnost.net/, http://www.inovativnost.net/aboutus.asp
Contact person	assoc. prof. Borut Likar, PhD; Špela Stres, Ph.D.

Curriculum relevance and connection to policy guidelines

The National Curriculum partially supports students in developing basic understanding of key science concepts and connection between school science and real science. In the last years the so-called "open curriculum" has enabled activities based on the school/companies/regional preferences. Besides, the project work the concept represents opportunities for R&D and innovation activities, which are not exploited as they could be. Even though there are strong activities integrated into R&D projects of secondary school students, these are often "free time activities" which are not integrated into curricula. On the other hand, the innovation takes only an insignificant part of the regular educational curricula, even though the EU directions (Key Competences for Lifelong Learning – A European Framework, 2006) regarding LLL clearly state the importance of scientific, innovation and entrepreneurship competences. Therefore the competences obtained in the field of creativity and innovative use of R&D results of the youngsters are far too low. In last years the EU policy has influenced the national policy and consequently the curriculum was gradually upgraded using activities of scientific and innovative importance. The results in the students' competences cannot be clearly observed yet.

Description of the innovative practice

This good practice, was implemented for the students in Secondary School? and at Universities, and could be transferred to other Secondary Schools (also Universities). Innovative practice was implemented among the most creative young people - among selected pupils, but is not yet implemented as part of regular curricula. Nevertheless some mentors realised there were significant benefits for the individual students from the presented concept and are already trying to implement it "per partes" ?at their work.

Theoretical frameworks:

The purpose is to connect the most creative young people\researchers\innovators and internationally successful companies, renowned researchers and professors who are able to think differently. The intellectual property aspects represented an important part of the activity. The project was performed via: presentation of the projects prepared by young people, demonstration of good practice, exchange of experience, personal coaching, networking etc. Youngster and Consultants set up the meeting through email, and then the young people prepared the presentation of their project for the meeting and sent it to Consultants.

Entrepreneurs and academics listened to the Youngsters, showed them the laboratory/organisation and supported them with their vast experience, different points of views, with their intellectual capital and tried to open the door to the future. Afterwards it is up to the young person on the one

hand and companies, researchers or professors on the other to determine whether they can cooperate also in the future.
The campaign "A View from the Different Window" is a part of the project Eureka! Innovation of Youth. A more detailed description of the whole project is attached (Eureka-Innovation-of-Youth-short description.doc).

Main aims, features and phases:

- greater awareness and motivation of young people and their mentors,
- acquisition of R&D, innovation and entrepreneurial skills,
- support provided to young people and mentors in creating, research and innovating,
- improved co-operation between R&D, economy and education,
- better preparedness of youth for science and technology work.

Methodology used:
Indoor activity – a meeting. Students develop their R&D and/or innovation projects, mainly in cooperation with the school mentor. It represents the achieving of R&D and innovation competencies via "learning by doing" concept (e.g. . Later on they had a meeting with internationally successful companies, prominent researchers, professors and experts for intellectual property in order to get a "second opinion" and directions for further work from top experts.

Resources needed:
Youngsters with well prepared R&D project with clear innovation potential; Teachers-mentors, internationally successful companies, renowned researchers, professors who dare to think differently.

Form of assessment / evaluation used:
Feedback was collected concerning the usefulness of the activity, quality of cooperation, directions for future work. Feedback was received from both parties: youngsters and consultants – please see also Innovation appraisal.

Information available

Most information is available in Slovene language - materials reachable on our web site (http://www.inovativnost.net/). A short translation is available (Eureka-Innovation-of-Youth-short description.doc).

Critical features for sustainability

The campaign 'A View from the Different Window' is not part of regular courses, but part of special project. Our organisation has to obtain national or EU founds for such activities. This could be one of the critical features. The work of consultants was for free.

Critical features for transferability

The most critical point is awareness and motivation of young people and their mentors regarding R&D work, innovative approaches and innovation-entrepreneurial skills for identifying and solving challenges and the willingness of teachers for such work. The teachers are motivated mainly due to very good references they can obtain for their promotion and higher salary. The work in not paid, many of such consultants are enthusiasts. The experience is disseminated to other classmates either via mentors' activities or via students' work in teams.

Student innovation day in a museum

Keywords:
University level, creative thinking, motivation, science communication

Problems addressed

The first year university students of technical faculties are not aware of the importance of self involvement in the accumulation of competences. They are often unmotivated and follow the lectures and other mandatory obligations. Most of these obligations do not give importance to their innovation capabilities which will however be probably most important when they leave the university (graduate) and start working as engineers.

Quality criteria

Pedagogically and **methodologically sound:** Motivation/interest in science is stimulated
Socially relevant: Uses resources and teaching contexts from outside the university stressing the importance of the innovation process
Considers **developments in science education** and in **science education research:** The innovation contributes to research on science education and to research &development process.

Innovation appraisal

Although voluntary, quite a large number of students have decided to join the "Innovation day" and give their contribution. They loved the idea of being capable of identifying problems (phase Challenge/definition of the problem- Picture 1), giving ideas and being able to be creative (phase Idea creation and partially Evaluation and selection on Picture 1).
The museum staff were interested in this kind of collaboration: they also find it useful and have found some ideas contributed by the students directly applicable to museum.

Relevant information in brief

Topics addressed	Addressing importance of students creative thinking through organisation of an "innovation day".
Age classes	First year university students
Extent	100 students in class / 30 attending the event
Years of experimentation	1 year (in 2009)
Duration	1 day
Main innovation promoters	A lecturer in the faculty of electrical engineering
Main innovation partners	Slovene Ethnographic museum**,** http://www.etno-muzej.si/en
Website	
Contact person	Prof. dr. Dejan Križaj, University of Ljubljana, Faculty of electrical engineering, dejan.krizaj@fe.uni-lj.si. assoc. prof. Borut Likar, PhD; Špela Stres, Ph.D.

Curriculum relevance and connection to policy guidelines

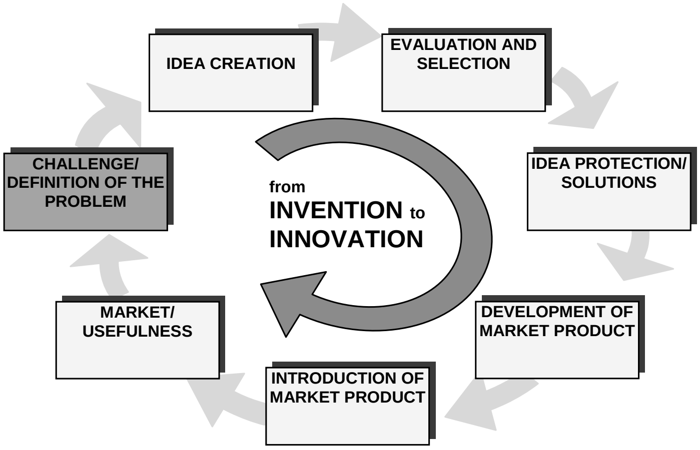
The innovation is not part of the compulsory curriculum, which is more involved in gathering basic theoretical competences. Nevertheless, through lectures we stress the importance of both: collecting theoretical knowledge that will be of importance to understand the phenomena analysed and being able to solve concrete engineering problems as well as the importance of being creative, innovative.

Description of the innovative practice

In the first years of engineering studies most of the students are not capable of solving engineering problems. However, they can be innovative in the sense that they see or find problems or they have a feeling how the problems could be solved but do not have enough competences and R&D experience to solve them. Nevertheless, the idea is that through the creative and innovative thinking they find some interesting problems and also see that with more theoretical and practical knowledge they would be capable of solving them. This might give them more motivation for studies and more active involvement in the learning process.

Theoretical frameworks:
In the picture 1 that follows the theoretical frame and the phases of the project are described.

The process of development from an idea to product and its recognition on the market or/and by the end user require efforts and creative work in all phases of the process. However, the first, most important step is acknowledgment of a new challenge or a definition of the problem. The phase of idea creation is the next one. Both were encompassed in the presented case.



Picture 1 (Likar, Managing Innovation and R&D Processes in EU Environment, 2007)

Main aims, features and phases:
During lectures the lecturer (teaching the class Fundamentals of electrical engineering) has addressed the importance of active learning which involves creative thinking and finding joy in looking for problems, trying to analyse them, looking for a suitable solution and at the end trying to solve them. As the classical engineering problems which are analysed by scientists, researchers or engineers in the industry are mostly too difficult to be understood by first year students and they would not be able to be creative and innovative, we decided to confront the students with more general problems. For that purpose we asked them to spend some time (two hours) in a local museum (Slovene Ethnographic museum**,** http://www.etno-muzej.si/en**),** going through and looking at the expositions. After that the students were asked to find some innovative ideas that could improve the operation of the museum, the visitors experience, etc. Several of them were connected to R&D activities as well, which could be performed at the faculty.

Methodology used:
The students were addressed during the lectures and given some basic ideas of the purpose of the "innovation day". They gathered at the entrance of the museum at a prescribed day/hour. Each student was given a A4 paper with basic propositions of the "game" which stressed the importance of being creative regardless of the required "high scientific/R&D content". Then, one of the staff of the museum made a short introduction of the purpose of the museum and their collections (half of an hour). Then the students were left to go around and see the museum and the collections of the museum. They were given about an hour and after that we gathered in a room where they were finalizing their impressions writing them down on the paper given in the beginning. After that they were given an opportunity to present their ideas to their colleagues, the lecturers and the staff of the museum. This was done in a relaxed atmosphere, where the students enjoyed their presentations and the discussion.

Resources needed:
No special resources, but a Museum interest and availability are needed.

Form of assessment / evaluation used:
At the end of the event the students were asked to return the paper with proposals and added innovative ideas for critical evaluation. It turned out most of the students were capable of producing at least one "innovative" idea and some of them even more. Most ideas were of engineering origin and mostly involved use of modern technologies (sensors, computers, vide, etc). Some ideas were really good and were also found interesting by the museum staff. Nevertheless, most ideas were such that the students would at the moment not be capable of realizing them due to lack of knowledge and technical experiences.

Information available

No written information – for further info pls. contact assoc.prof. dr. Dejan Križaj (see above).

Critical features for sustainability

This was an ad hoc event organized in order to evaluate the interest of the students for innovation process and also see their capabilities for creative thinking and production of innovative ideas. The regular curriculum does not cover such events and they are not in direct relation with curriculum. Nevertheless, they are consistent with an idea of forming engineers with different competences who are able to produce creative and innovative ideas (first year university students).

Critical features for transferability

This phase represents mainly the first part of the invention-R&D-innovation chain (picture 1). They were searching for problems/opportunities in "real life", which is important. Besides, they prepared some useful ideas with the potential to become innovations. The logical next step is R&D and other activities, leading to a concrete solution. They are connected with financial funds, knowledge and other activities.
The presented praxis is easily transferable to other institutions as well. What is most important, the concept seems to be easily applied in elementary and secondary schools as well. E.g. the students could do the same activity going around commercial centres, markets or other places where there are different kinds of exhibitions looking for challenges to innovate.

Human transformations in the landscape: Why has the sand disappeared from the beach?

Keywords:
Lower secondary school, coastal dynamics, authentic problems, STS perspective, argumentation, decision-making

Problems addressed

Low interest of students in geology and its practical applications. Lack of connections between the science curriculum and real life environmental issues. Problems with long-term perspective when approaching natural processes and cycles. Scarce use of analogical models in geology. Scarce presence of activities designed to promote argumentation about socio-scientific issues, to assess scientific claims using evidence, and to encourage decision making.

Quality criteria

Pedagogically and methodologically sound: allows for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests.
Fosters **scientific competencies:** offers inquiry based learning activities (including raising questions to investigate); stimulates collaborative work (with discussion, argument, and decision making by learners); uses Ict-skills.
S**ocially relevant:** Raises the awareness of social, ethical and cultural influence and implications of science and technology; address national problems in science education; promotes actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues.

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Innovation appraisal

The teacher has a wide experience in designing and implementing activities that promote argumentation in science classroom and encourage students' critical thinking about real life environmental issues. Students showed high involvement and interest in the proposal, and achieved science understanding goals. In some PISA science items assessing the development of scientific skills, the students had better results than Spain and OECD PISA average.

Relevant information in brief

Topics addressed	Use of data, construction of arguments, decision making and assessment about the degradation of the shoreline
Age classes	14-15 year old (9th grade)
Extent	Local. 4 courses involved, 79 students working in small groups (4-5)
Years of experimentation	One (2008) with this issue, more with other environmental issues
Duration	3 sessions, over two weeks
Main innovation promoters	The teacher, in collaboration with the research team of the Science Education Department at USC
Main innovation partners	USC.
Website	www.rodausc.eu (for references and research papers). Complete description and materials for the proposal will be available soon.
Contact person	Xulio Gutiérrez, teacher (xgutierrez@edu.xunta.es); Fins Eirexas, researcher at the USC (fins.eirexas@usc.es)

Curriculum relevance and connection to policy guidelines

The proposal is part of the regular program of Biology and Geology (compulsory subject), making part of the teaching unit "External Geological Processes". It is framed by the PISA recommendations, in order to promote the development of scientific competencies through the use of knowledge to explain real life phenomena, and to engage students in using evidence to support decision making and to assess scientific claims.

Description of the innovative practice

Theoretical frameworks: Socio-constructivist framework, work with authentic problems, contextualised practice of science, STS perspective, argumentation and use of evidence, research and education collaboration.

Main aims, features and phases:

Aims for the students: to assess the effects of human interference in the landscape, particularly in coastal dynamics. To explore the causes and consequences of the processes that transformed a sandy beach, in order to assess the decisions made and to consider alternatives based on evidence. To integrate in their own proposals other STS issues (tourism, fisheries, urbanism, conservation) that have influence on the issue.

Features: the initial problem is a real event: the loss of sand from a beach. The local authorities "regenerate" it by adding thousands of tons of sand from a quarry. The students are asked to write a report about what happened to the beach, answering questions as: a) Why the beach was so different then (60's) from what is now? b) What processes occurred in this area since then?; c) What is your opinion of the regeneration process ? Pros and cons; d) What are your proposals to restore the beach? Advantages and disadvantages.

The students are provided with information from several sources; opinions and proposals from administrations, environmentalists, fishermen and beach users, in addition of their own knowledge and experiences. They are asked to evaluate the interventions and to propose alternatives.

Phases:

Session 1) The teacher introduces the problem through a PowerPoint with diagrams, graphs and photos that show evidence of coastal dynamics contextualized in this particular area. The changes in the coastline morphology over time and the interventions made (commercial port, embankments, buildings, etc.) are shown, as well as the authorities' proposal to restore the area. Students analyze sand samples (from sea, river and quarry) with a binocular lens and describe their textural and compositional differences, trying to find out their origin.

Session 2) Working with an analogical model (tank, water pump, sand and stones/bricks) that reproduces the dynamics of the coastal area studied, students observe the differences (in the direction of sea currents, accumulations / loss of sand, barrier effect) between two configurations: the initial configuration without obstacles, and the final disposition with an obstacle that simulates a port in the path of the current. The students have a dossier with information (newspaper articles and technical reports) and are encouraged to take it into account and, using their own knowledge, to write a group report.

Session 3) Students complete their reports. Then, each group presents their findings and discuss them with the whole class.

Methodology used:

The teacher presents the proposal within the regular class and in the context of the science lab. Students work in small groups and discuss with the whole class their conclusions under the teacher's guidance.

Resources needed:

ICT materials (computer and video projector); science lab hardware (binocular glass, Petri dishes, etc). Glass aquarium with water pump, sand and stone blocks. Internet access.

Form of assessment / evaluation used:

continuous assessment for each group and student. Student's involvement and engagement in activities, the proposals emerging from the discussion and the contents of the reports are assessed by the teacher, and taken into account for the final mark.

Information available

Spanish:

Eirexas, F., Jiménez-Aleixandre, M. P., Gutiérrez, X. (2009) "Uso de datos, construcción de argumentos y evaluación de actuaciones sobre la dinámica litoral". Paper presented at VIII International Congreso de Enseñanza de las Ciencias (Research in Science Teaching), Barcelona 2009.

This paper can be downloaded from:
http://rodausc.eu/central/090522/index.php?option=com_docman&task=doc_download&gid=18&Itemid=7&lang=gl

Critical features for sustainability

The proposal was implemented by the regular teacher as part of "Biology and Geology" discipline along 2008 at the IES (Public Secondary School) Francisco Barreras, Pobra do Caramiñal (Galicia). The teacher Xulio Gutiérrez, has extensive experience in environmental education and the use of innovative proposals and methodologies in the classroom.

Critical features for transferability

The proposal could be adapted, with some modifications, to other contexts and areas where similar changes have occurred as a result of human interventions. The main critical point lies in the teachers' disposition to carry on an activity that needs some preparation and takes several classroom sessions.

Introducing the LHC Experiment in secondary school classrooms

Keywords:
Secondary school, Physics Teaching, motivation, REC – Research and education Collaboration, update experiments

Problems addressed

Low connection between curriculum contents and the real practice of science; scarcity of topics about current Physics research; teachers' lack of updated scientific topics; dissatisfaction with traditional ways of presenting concepts; ignoring the Galician or other national participation in international scientific collaborations.

Quality criteria

Scientifically sound: provides insight in the way scientific knowledge is constructed (presents the results of an experiment to students and try to find out how the theory/hypothesis and the experiment was constructed; uses authentic scientific datasets and publications, experts invited to school and classroom labs).

Fosters **scientific competencies**: stimulates the development of competences for science communication (students are able to engage in expert conversation with professionals, students present results of their inquiry projects through written reports and oral communication); stimulates collaborative work; uses Ict-skills.

Socially relevant: Raises the awareness of social, ethical and cultural influence and implications of science and technology; promotes public understanding of science; promotes actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues.

Innovation appraisal

The innovation is well received, both by students and by the educational community as evidenced for instance by: a) Award in "Science on Stage" (Spanish version) contest; b) Communications in Teacher Meetings organized by private and public institutions; c) Invited talks in Galician Secondary Schools about this issue.

Relevant information in short

Topics addressed	Introducing a 'great experiment' (LHC Experiment in Geneva)
Age classes	14-16 years (9th and 10th Grade)
Extent	Galician secondary school students and teachers, but spreading abroad the topic through different ways (website and publications)
Years of experimentation	The innovation has been implemented for five years and currently goes on.
Duration	The experience runs through the curriculum during the whole school year.
Main innovation promoters	Teacher (Ramon Cid): Initiated in 2003 after participating in the CERN High School Teachers Programme (CERN-Switzerland).
Main innovation partners	
Website	www.lhc-closer.es
Contact person	Ramon Cid Manzano – rcid@terra.es

Curriculum relevance and connection to policy guidelines

The innovation makes part of the regular science curriculum (compulsory). It supports students in developing a basic understanding of key physical science concepts. It follows the National Curriculum guidelines and orientations about connection between school science and real science. It also follows the guidelines about stimulating the students' curiosity. It also presents a powerful example of European identity and common European scientific enterprise.

Description of the innovative practice

Theoretical frame:

Inquiry approach; students are required to take an active role; the interest of making current science closer to students, particularly in Physics teaching.

Main aims, features and phases:

Aims: The main aim is to involve pupils and teachers in discovering the "greatest experiment ever carried out". In particular, its goal is to offer a tool that facilitates Physics teaching, improving its quality and providing resources about this topic (Website and papers). It also emphasizes the importance of the individual and collective effort, the value of an European institution and the results that the science provides to society.

It is intended to take one of the most important scientific institutions (CERN) to the classroom, making use of the presence of Galician (or other national) scientists in its experiments.

It also has the goal of upgrading teaching skills (about new Physics): learning new physics topics, using good Internet sites on these experiment, taking new technologies to classroom.

Features: Taking data and calculations from the LHC to the classroom to cover the Physics curriculum, making easier the introduction of new concepts by using the motivation provided by this huge machine and experiment. The activities help students in understanding the physical concepts underlying the LHC, as an example of the relationship between the "cold" equations of Physics on the blackboard and the exciting scientific research.

The website www.lhc-closer.es allows students to take some data (about the construction of the LHC and the magnitudes involved) and to perform themselves some calculations.

It is emphasized that the topic deals with important and controversial questions about the nature of matter.

Phases: The experience runs during all school year, either because it is connected with a particular part of the curriculum or because some specific achievement has been announced from CERN-LHC.

Methodology used:

Indoor activity in the classroom. ICT: Power Point Presentations, simulations and applets from the web are also used in regular classroom (also for dissemination in talks in teachers meetings.)

Resources needed

Besides video projector and Internet connection, no special resources are needed to work in the classroom

Form of assessment / evaluation used

Students and teachers discuss the utility of activities, website and classroom presentations.

The ideas, opinions and corrections received from colleagues, have been used to improve the resources.

Information available

The website: lhc-closer.es, and several papers in several languages, for instance (there are more available):

English:

- Cid, X. & Cid, R. (2009) Taking energy to the Physics classroom from the Large Hadron Collider (LHC) at CERN. Physics Education, 44(1), 78–83.
- Cid, X. & Cid, R. (2010) The Higgs Particle: a useful analogy for Physics classroom. Physics Education, 45(1), 73–75.

Spanish

- Cid Manzano, R. (2006) Cálculos sencillos para la máquina más compleja: Aprendiendo Física en la secundaria desde el LHC (CERN) Revista Española de Física, 20(1) 48-57
- Cid R. Cid X. (2009) Luminosidad: Luz al final del túnel (LHC). Lat. Am. Journal of Physics Education, 3(3), 638-642.

Galician

- Cid Manzano, R. (2001) As partículas elementais. Boletín das ciencias, 47, 43-61
- Cid Manzano, R. (2008) O LHC: recurso web para a aula. Boletín das ciencias, 66, 51-55

Critical features for sustainability

The innovation has been successfully integrated in regular classes over five years. A critical feature is the teachers' disposition to engage students in the issue.

Critical features for transferability

We believe that the innovation is flexible enough to be adapted to other contexts

Secondary school students' inquiry projects

Keywords:
Secondary school, IBL, competences, scientific practices

Problems addressed

Students have few opportunities to be involved in scientific inquiry, in scientific practices, and so few opportunities to develop scientific competences. In particular they are seldom given the opportunity to pursue their own research questions. School science often conveys naive images of science; related to these problems, students in rural areas often have low interest in science and technology.

Quality criteria

Be **pedagogically** and **methodologically sound:** The design, learning materials, learning activities and teaching methodology take current theories about science learning into account; allow for a diversity in learning materials and teaching methods in order to meet a variety of pupils needs and interests.
Fosters **scientific competencies**: offers inquiry based learning activities (students propose their own problems to investigate, students design projects and experimental procedures); supports the development of competencies for science communication (students present results of their inquiry projects through written reports and oral communication, using various presentation techniques, prepare talks and papers, in which a natural phenomena, processes and issues are described in a scientific way); stimulates argumentation and critical thinking in collaborative group work (learners plan and realize experiments, research cycles - theory, hypothesis, invention of an experiment, evaluation and analysis - together; learners work as a team when designing and analyzing an experiment, reporting their results and discussing them openly with others).
Be **socially relevant**: Promote public understanding of science.

Innovation appraisal

The teacher has been carrying out this activity for 13 years. Students engaged in this practices achieved a high grade of motivation and improved their academic results. The proposed innovation can be evaluated by: increase in the proportion of students choosing science related studies / careers afterwards; impact of some of the studies in the outside-school community; Students' research awards gained in Galician and National competitions; former students' feedback to the teacher about the impact of this approach on their interest in science.

Relevant information in brief

Topics addressed	Secondary school students' inquiry projects
Age classes	9^{th} to 12^{th} grade students (14-18 year old)
Extent	Local (rural & urban) Galician secondary schools
Years of experimentation	13 years and currently goes on
Duration	Six weeks (but using only about 20-30% of science classroom time throughout the school year)
Main innovation promoters	School teacher (Teacher-researcher)
Main innovation partners	University of Santiago de Compostela, Science Education Department, project RODA
Website	www.rodausc.eu
Contact person	Luis Fernández (luisfernandez@edu.xunta.es)

Curriculum relevance and connection to policy guidelines

This proposal can be part of the regular science curriculum. It is explicitly connected to the recommendations about development of competences in the Spanish National curriculum (2007) and it is framed by PISA guidelines about scientific competences, particularly: "identifying scientific issues" (recognizing issues that are possible to investigate scientifically); "explaining phenomena scientifically" (applying knowledge of science in a given situation and describing or interpreting phenomena scientifically and predicting changes); and "using scientific evidence" (interpreting scientific evidence and making and communicating conclusions).

Description of the innovative practice

Theoretical frameworks:

Constructivism, Inquiry Based Science Teaching/Learning; students as "science producers".

Main aims, features and phases:

The main aim is the students' engagement in scientific practices, such as generating research questions, designing investigations, collecting and analyzing data, interpreting evidence, drawing conclusions from evidence (argumentation), communicating science notions through oral and written reports & TIC.

Features: Some instances of the questions of the investigative projects carried out by the students are: "Blessed bread", or why does not get ruined the blessed bread from a religious festivity? (checking a belief about a bread that would not get mouldy); "Road safety", about how does noise affect driving safety; "Weather and health", about how the weather changes influence respiratory diseases; and "Moon cycle and plants", or does the moon cycle influence plant growth?

Phases:

1) Students generate their own questions (that needs to be agreed upon by the teacher).
2) Students plan and design the research project, write a proposal, including methodology, equipment and budget up to 60 euro, that needs to be supervised by the teacher and is then financed by the school
3) Students carry out the project, collect the data, analyze them and drawing conclusions.
4) Students write a research report about 5 to 10 pages long.
5) Students communicate their results and conclusions to the classroom using ICT, and to the school in poster format, in the context of a "Science conference".
6) Students communicate their results and conclusions to the outside community (family, neighbours, town) in the context of a "Science Fair".

Sometimes,

7) communicate their results and conclusions to the school or scientific community through a paper published in educational journals.

Methodology used:

Guided inquiry outdoor/indoor; students plan, design, and develop their projects working in small group (3-4), and communicate the results to the whole class and their community. The teacher guides all the process.

Resources needed:

Regular science teacher; laboratory and everyday materials, depending on the project; ICT.

Form of assessment / evaluation used:

Credit given to students: a 25% of the final mark (up to 2.5 points out of 10): up to 1 point for the report + 0.75 for the classroom presentation + 0.75% for the poster in the "Science conference".

Information available

Spanish: (a more extended explanation about the methodology is found in the first paper; examples of the projects in Galician or Spanish are available from the author)

Fernández López, L. (2009) Los proyectos de investigación del alumnado para la adquisición de las com petencias básicas. Aula de Innovación Educativa 186, 19-22.

Fernández López, L. & López Carracedo, J. (2005) Un pan eterno ¿ciencia o metafísica? Alambique, 45, 105–110.

English:

Jimenez-Aleixandre, M. P. & Fernandez López, L (2010). What are Authentic practices? Analysis of students' generated projects in secondary. Paper presented in NARST 2010 Annual Meeting

A summary & excerpts in English of one students' project (Does the moon influence plant growth?) is in chapter 6 of the booklet "*Resources for introducing argumentation and the use of evidence in science classrooms*", Danú Ed., 2009, that can be downloaded from our webpage www.rodausc.eu

Critical features for sustainability

Its sustainability is supported by the fact that L. Fernandez has been carrying it out for 13 years in three different high schools, some urban, most of the time in rural setting.

Critical features for transferability

The disposition of the teacher to use part of the time to develop these projects. We believe that the innovation is flexible and open enough to be easily adapted to other contexts (school levels, social environment, regional and local cultures and other countries).

Kitchen Chemistry: a teaching sequence for introducing scientific knowledge of women

Keywords:
Secondary School, Chemistry, women knowledge, science in everyday life.

Problems addressed

Most curricula in physics and Chemistry are androcentric, this means that a set of scientific knowledge, which have been traditionally held by women, are not considered as a learning object in the standard curriculum in most countries. In some countries, cooking is taught, but it is unclear if it is related to Chemistry.

Quality criteria

Pedagogically and methodologically sound: Take gender and (multi)cultural issues into account (androcentric curriculum change: introduction of a new curriculum paying attention to women's scientific knowledge, boys and girls cooperate).
Fosters **scientific competencies**: Fosters scientific literacy (identify scientific issues, explain phenomena scientifically, use scientific evidence); offers inquiry based learning activities; uses models to explain scientific concepts.
Socially relevant: Raises the awareness of social, ethical and cultural influence and implications of science and technology (links between technology, everyday life, and the results of scientific research are put in evidence).

Innovation appraisal

Initially the traditional chemistry teaching sequence was changed introducing examples of the phenomena in the cooking context, then a new teaching sequence was experienced as an optional subject and after it became a regular subject in the school programme.
The teaching sequence has been assessed using a model of formative evaluation. The results obtained by students in the same school, with the same teacher, with and without the teaching sequence, have been compared.
The reception of the students is warm, as discussed in the report about the experience (Solsona 2003).
The teachers may show some reluctance at first, feeling unsure about working with phenomena that are not common in a Chemistry class, but once they get involved, these problems are overcome.

Relevant information in short	
Topics addressed	Chemistry in the kitchen Lab
Age classes	10th grade, age 15-16
Extent	national, whole classes involved
Years of experimentation	10 years
Duration	3 months
Main innovation promoters	School teacher (Nuria Solsona)
Main innovation partners	UAB (Universitat Autònoma de Barcelona)
Website	http://www.inmujer.migualdad.es/mujer/publicaciones/catalogo/cuadernos_educacion.htm
Contact person	Nuria Solsona Pairó, nsolsona@xtec.cat

Curriculum relevance and connection to policy guidelines

The teaching sequence makes part of the compulsory curriculum of Chemistry. It means organizing the standard topics in a different way, working in a different context (the kitchen-laboratory). This does not mean to make Chemistry "light". The laboratory procedures, reports, and all the concepts from the official curriculum are taught. All this elements are necessary to achieve the model of chemical change, as indicated in the curriculum. Students following this teaching sequence - "kitchen Chemistry" - for learning the model of chemical change are prepared to pursue further scientific courses in high school or vocational training.

Regarding other policy guidelines, this proposal is framed by national and international guidelines facing gender issues, in particular the orientations about promoting girls' interest and motivation in science.

Description of the innovative practice

Theoretical frame: The innovative practice is framed in a constructivist perspective with a participative methodology. It is also framed in the Gender and Science studies and approaches, suggesting to value women's knowledge and experiences.

Main aims, features and phases:
Main aims for students: To participate in lab work making visible the connections between kitchen and Chemistry.
Main aims for teachers: Support teachers in addressing girls' interests.
Features: To organize the concepts of Chemistry changing the learning environment from the laboratory to the kitchen. Cooking is an excellent laboratory and a good setting to introduce women's scientific knowledge. Thus, instead of working with chemical substances and typical phenomena of the school lab, students and teacher work with chemicals and chemical phenomena involved in simple cooking procedures: to prepare breakfast, snacks, sauces, and three phenomena that involve a chemical change, such as preparation of cake, caramel and white cheese.
The teaching sequence includes conceptual topics as pure substances, physical change, classification of substances, properties, mixtures, solutions, colloids, atomic-molecular model, macroscopic/microscopic explanation, chemical change, reagents, products, reaction equation, open and closed chemical system, atomic rearrangement, principle of conservation of mass, chemical bond, etc. in addition to procedural and attitudinal contents and competencies guided by the curriculum.

Methodology used:
The teaching methodology is to organize the classroom in cooperative groups to conduct laboratory work and other inquiry tasks. The development and use of written texts (talking and writing science) is also paid attention.

Resources needed:
Innovation proposal takes place in a regular classroom with a regular teacher. It is better to have the infrastructure of a kitchen-laboratory with all cooking equipment.

Form of assessment / evaluation used:
Formative evaluation, regulation and students assessment tools. The results achieved by students involved in this activity are compared, in the same school and with the same teacher, with those obtained without the teaching sequence.

Information available (depending on how many activities are to be used, the number of pages to be tranlated could range from eight or ten, to twenty).

SOLSONA, N. (2001) Química culinaria y saberes femeninos. Aula para la Innovación Educativa, 106, 41–44.
SOLSONA, N. (2002) La química de la cocina. Educación Secundaria. Instituto de la Mujer. Cuadernos de Educación no Sexista, 13. It can be downloaded at
http://www.inmujer.migualdad.es/mujer/publicaciones/catalogo/cuadernos_educacion.htm
SOLSONA, Núria (2003) El saber científico de las mujeres. Madrid, Talasa.
SOLSONA, Núria; MARTÍN, Rosa (2004) Los cambios químicos: de los modelos del alumnado a los modelos escolares. Alambique, 42, 19-28.

Critical features for sustainability
The innovative practice of kitchen Chemistry had been implemented in the classroom, by three teachers, during 10 years, as part of regular courses, in Catalunya. Another larger group of teachers has experienced it in other parts of Spain, and in Santiago de Chile (Chile).

Critical features for transferability
The critical points for the success of the innovation are:

First, the disposition of teachers to change their approach and to spend part of the classroom time to develop the activity.
Second, it is better to have the necessary infrastructure of the kitchen-laboratory in the school. Some schools began with a kitchen oven and a traditional laboratory.
Third, the experience requires specific teacher training in kitchen Chemistry as most teachers do not know the scientific explanation of the cooking phenomena in the sequence, even simple ones, such as making candy. It can be noted that some books give conflicting interpretations of the same phenomenon: making caramel either by oxidation or decomposition.
To implement the kitchen Chemistry some teachers, supporters of a traditional approach, may have difficulties. Also, the importance of the labwork and language in Chemistry learning, must be taken into account.
Pitfalls to avoid: there are some experiences, as for instance the one about boiling water and jam, that may be a source of misconceptions. So it would be necessary for the teacher to clarify questions as the connection between being composed of the same kind of particles and having a fixed boiling point; how the microscopic entities relate to the macroscopic properties, and on what basis; or the connection between mass of particles and energy to be given to a substance to change its state. It is not easy to explain at this grade why a solution boils at a higher temperature than pure water. Actually it is only water that can evaporate (as can easily checked observing that the 'vapour' (droplets of water) is the same when pure water is boiling). The challenges raised by going back and forth between two contexts need to be taken into account (one familiar context where we use everyday language, the other not familiar because developed in a more limited and artificial way). It is not at all straightforward to go from one to the other.
The innovation is flexible enough to be adapted in different contexts, although in certain social settings with gender bias a detailed justification of the proposal may be required.

Oral bioavailability of bioactive substances – an integrated topic from chemistry and biology

Keywords:
Upper secondary school, integrated science, pharmacology, team teaching, oral bioavailability

Problems addressed

a) When school science is taught as separated subjects (biology, chemistry, physics) this does not reflect the interdisciplinary character which research questions and applications in S&T often have.
b) The educational board of Switzerland for upper secondary level (Schweizerische Maturitätskommission) requests that students are also taught in an interdisciplinary style. At the Gymnasium Liestal, interdisciplinarity has been a focus of school development for 4 years, as subtopic of the overarching theme 'collaboration'. This way, interdisciplinary teaching and learning has become a distinct feature of the school culture. Students have to choose two courses as compulsory subject choice. Each year, 6 to 8 interdisciplinary courses are offered, besides disciplinary courses.
Here, we present the introductory part of the interdisciplinary course 'Poisons, pharmaceuticals and illegal drugs'.

Quality criteria / indicators addressed

Scientifically sound: correct use of scientific content/knowledge according to the context; raises awareness of the Nature of Science; provides insight in the way scientific knowledge is constructed.
Socially relevant: address national problems in science education; promotes actions, reflections and debates concerning science responsibility towards health, environmental and sustainable development issues; uses resources and teaching contexts from outside the school
Supports **teacher participation** and **professional development:** stimulates peer reviews and visits to classes of other teachers inside and outside school(s) to give each other professional feedback.

Innovation appraisal

The interdisciplinary and integrated courses are highly appreciated by the students. Many are repeated because of the large number of students signing up.
For the course 'Poisons, pharmaceuticals and illegal drugs' the teachers asked their students for feedback. In addition, education researchers compiling a manual on interdisciplinary teaching interviewed the teachers and students.
Student answers to the added value of interdisciplinarity: looking at a topic from several sides enhances the understanding of the interrelations, knowledge in one discipline enhances understanding in the other discipline, interdisciplinary courses are closer to real life.
The teachers' experiences:

- *We adopted a new view on certain issues. This will change how we teach certain topics in the basic biology or basic chemistry classes.*
- *The interdisciplinary testing is difficult, no satisfactory solution has been found yet.*
- *In the beginning, the coordination takes a lot of time. After several runs, we are a well functioning team. The teamwork and the team teaching are a personal gain.*
- *We can refer to sound knowledge of our students in biology and chemistry.*

Relevant information in brief

Topics addressed	Tissues, epithelium, oral bioavailability
Age classes	18-19 years old
Extent	Local (one school), full classes involved (compulsory subject choice)
Years of experimentation	4 courses in 3 years (90 students)
Duration	Basics of pharmacology: 5-6h; entire course: 67h in 30 weeks
Main innovation promoters	Individual upper secondary school (Gymnasium Liestal BL)
Main innovation partners	Individual teachers upper secondary (Johannes Hoffner, Peter Schoch)
Website	--
Contact person	Dr. Johannes Hoffner, Gymnasium Liestal hoffner.johannes@gymliestal.ch

Curriculum relevance and connection to policy guidelines

Part of the optional curriculum.
The course implements a requirement for the Matura exams (matriculation exams of grammar school): students get acquainted with interdisciplinary methods (Maturitäts-Anerkennungsverordnung MAV 413.11 article 11)

Description of the innovative practice

The course 'Poisons, pharmaceuticals and illegal drugs' covers 5 topics: Basics of pharmacology, Morphine – pain and addiction, cancer, antibiotics, student presentations about a subject of their choice. Here, we present the introductory basics.

Theoretical frameworks:

Interdisciplinary teaching and learning

Main aims, features and phases:

Interdisciplinarity: both teachers are present in class and add their view as a biologist or chemist, respectively. The teachers point out these views explicitly when they feel that a question can only be answered taking both disciplines into account. To make the students aware of the different disciplinary approaches, the respective teacher gets up in front when joining the discussion. The students appreciate interdisciplinarity being visualized in this way.

Objectives (entire course):

- Students can apply basic terms of pharmacology and toxicology.
- Students have an in depth knowledge about biological and chemical interrelations in the human body.

Transferable skills:

- Students use the appropriate biological or chemical model, according to the problem.
- Students differentiate the biological approach 'From big to small' from the chemical approach 'From small to big'
- Students realize that complex issues can/have to be explained through different, complementary views
- Complex problems are solved in a team

Basics of pharmacology: How does a chemical compound get into the body?

1. Tissues (2 lessons)

- Different tissues, e.g. muscles, liver, intestine (histology, molecular structure). As students have had practical classes earlier, there is no practical activity with the microscope. However, this could and should be added if students lack this experience.
- Special emphasis on: epithelium (polarity, border inside-outside of the body)

2. Oral Bioavailability (5-6 lessons)

- Definition, importance, ways of determination
- Prediction models: standard technique from Pharmaceutical industry (canine cell cultures). For technical reasons, students cannot perform any bioavailability tests themselves.
- Lipinski's 'Rule of Five' (1997): A rule of thumb to determine if a chemical compound has properties that would make it a likely orally active drug in humans (based on characters such as hydrogen bonds, molecular weight, lipophilicity).
- Prediction of a chemical compound's oral bioavailability: Students interpret data from bioavailability tests (individually/in pairs). Here, the advantages and disadvantages of experienced data ('Rule of Five') vs. data from scientific experiments are discussed.
- Comparison of oral bioavailability data of dogs, rodents and humans.
- A special topic: uptake of vitamins, which is not following the 'Rule of Five' (active transport)

Throughout the entire course, the teachers refer to these basics and have students apply the prediction of bioavailability to other compounds discussed.

Methodology used:
After input of the teachers, students solve problems alone and in pairs. The results are discussed with the whole class.

Resources needed:
A team of a biology and a chemistry teacher (however, see Critical features for transferability below), worksheets

Form of assessment / evaluation used:
Assessment (entire course): Presently, the tests are divided into a biological and a chemical part and count for the respective subject grade as a tribute to the necessity of receiving distinct credits in the individual disciplines. Students can opt for a final exam in this course.

Information available

The personal teaching and learning material from the two teachers could be provided: descriptions of the lessons, worksheets, PowerPoint presentations, etc. (in German, ca. 25 pages)

Critical features for sustainability

Team teaching:

- Teachers have to get along with each other and trust one another.
- Developing and coordinating the course so that it is coherent for the students is time consuming.
- Ideally, both teachers are paid fully for the teaching. At least when developing such a course being paid fully is important.

Student choice of the compulsory subject choice courses assures their interest in the topic.

Critical features for transferability

Team teaching is time and cost intense. Committed teachers and the back up of the head master and the educational system for interdisciplinary teaching are needed. Furthermore, teachers have to be open for the way of thinking in another discipline and to see this as a personal enrichment rather than competition. However, the lessons on 'oral bioavailability' could also be taught by individual chemistry and/or biology teachers. Team teaching is an added value. (While for the parts on cancer and antibiotic substances team teaching is a must, according to the authors of this course.) Alternatively, a teacher teaching both chemistry and biology, would face little problems in terms of organisation, personnel costs, etc. Important would be in this case to makes the different approaches of the two disciplines explicit.

For the topic 'Basics of Pharmacology', teacher expertise in pharmacology and its methods is helpful. If not given, teachers have to be willing to acquire this knowledge. Students need to have a basic knowledge of both biology and chemistry. However, it is not necessary that they have taken Advanced Placement classes in these subjects.

An appropriate form of assessment taking the interdisciplinary character of the course into account is still being looked for.