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Permanent EuropeaN resource Centre for Informal Learning

Structuring the European Research Area

Science & Society – European Science Education Initiative

Specific Support Actions

D24: PROJECT OUTCOMES
WP5-18

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Executive Summary

This deliverable presents the outcomes of the fourteen Pencil Pilot Projects under four broad headings: the objectives of the project (both overall and specifically in terms of learning), the learning activities used, the methodology employed and the results of the project. Annexed material and online references show the materials produced through the projects.

1 Marine Issues with Climate Change, WP5

This pilot project is the result of WP5, coordinated by the National Marine Aquarium, UK.

1.1 Objectives

The project's objectives are as follows:

- To determine the current inclusion of the topic of climate change in the formal education system of the UK and participating European partner countries.
- To appraise the approach to 'informal teaching' using 'climate change' as a model for broader scientific principles.
- To create Climate Lab – an online interactive resource for use by teachers and pupils in investigating the science behind climate change as applied to marine systems.
- To encourage a greater understanding amongst the young people in the project of climate change and its impact on the oceans and the environment.
- To present the justification and suggested methodology for incorporating the topic 'climate change' as an element within National Curricula of participating countries.
- To investigate and draw up proposals for the use of 'climate change' as an example of basic scientific principles.
- To encourage a greater understanding amongst the young people in the project of climate change and its impact on the oceans and the environment.

Intended learning outcomes include:

- Knowledge of the causes of climate change and the impact upon ocean systems.
- Understanding of the role of the individual in contributing to climate change and alleviating the effects.
- Understanding of the role of scientists in investigating climate change and the use of predictive modelling.
- Appreciation of the complex systems approach to understanding climate.

On the whole, the general objectives of the project have been achieved in that the research has been carried out, the website has been created and the proposals have been drawn up.

In terms of the learning outcomes, some progress has been made. The website and associated activities have been designed to enable teachers and pupils to fulfil the learning outcomes but, so far we have no evidence that teachers are using the resource to its full capacity. The evaluation results suggest that pupils are not learning a great deal when exposed to the website in school and learning is far greater in sessions facilitated by our own staff. This suggests that either the website approach is incapable of providing for these learning outcomes, or that teachers are not using the resource correctly.

Work with teachers is being carried out to enable full use of the resource, in order to achieve the desired outcomes.

1.2 Learning activities

The project illustrates the variety of ways in which climate change might be expected to affect marine systems and investigate the disputes and debates involved in the study of these issues. Climate change has the potential to affect marine systems in fundamental ways. The ocean itself might expand and lead to sea level rises, the ice caps may retreat, adding to the amount of water in the oceans, whilst evaporation from sea surfaces will result in increased precipitation. Working together these effects will have a profound impact on world climate as a circular feedback mechanism. Extreme weather conditions such as storms followed by floods, or droughts will increase the effects of the inevitable flooding as coastlines recede. Islands may disappear as coral reefs become a thing of the past. More disturbing is the threat of switches in giant ocean current systems, which artificially maintain some of Europe's temperatures. These switches could plunge the continent into heat waves or winter snows. Changes in distributions of organisms will follow too rapidly and extinctions will be one extreme whilst at the other will be an influx of unwelcome pests and diseases; fish stocks will certainly change or decline. The magnitude and impact of the effects of climate change are subjects of much dispute in the scientific community and opinion is constantly shifting. The project aims, through demonstrating the uncertainties and disputes in the climate change debate, to present science as a dynamic process rather than a collection of static facts.

1.3 Methodology

The website provides for an element of enquiry based learning which prepares the students for a number of "projects". These projects vary in approach from investigative learning to discussion, from learner-centred to facilitated. They are all intended to stimulate ideas and debates in class. The "Think Tank" allows for pupils to develop projects in their own way and one group of pupils created their own website to communicate with other pupils (peer-to-peer).

In addition, the website is linked to a themed aquarium visit which is conducted as partly learner-led time on interactive exhibits with a facilitated tour and discussion session.

Extension projects that involve pupils creating their own film about climate change to load onto the website have been trialled and are being added to the climate lab offer as an extension of the pilot project.

Students' are involved in upfront evaluation through a concept mapping exercise. A small number of students were consulted during the web design element and finally, a larger number are involved in the summative evaluation. In addition to their involvement in the upfront and formative stages of the project, students in the summative phase are asked to participate in lessons and aquarium visits. They have to complete surveys and develop concept maps.

The concept mapping exercise was devised using participating teachers and developed throughout the project. It offers a simple method of assessing learning and enables metacognitive function of students.

Teachers' involvement is mainly in the curriculum research element of the project and consulted through a focus group on the design and content of the website. They are involved in the summative evaluation process – they assisted in designing the tools for evaluation.

Activities take place both at the aquarium and at school.

In the aquarium, there is an Initial Assessment of Student Interest and Knowledge: Students are introduced to the new climate change exhibitions at the Aquarium and observational studies are carried out on their interest and attentiveness. As part of the same session a concept mapping activity is carried out to identify current knowledge levels and misconceptions.

There is also a Teacher Focus Group to assess relevance to teaching and to establish resource preferences. Two focus groups of six teachers to explore where climate change would fit best into curriculum and what resources would be most useful in their teaching.

At school, there is a formative evaluation. Teachers are interviewed to establish the current coverage of climate change issues in their classes. Aquarium staff visit all partner schools and interview staff from all departments to ascertain the scope of climate change coverage within curriculum teaching.
In the later summative evaluation, pupils complete pre test knowledge and motivation surveys and create concept maps. They then have either:

- Aquarium visit only
- Online lessons only
- Online followed by visit

Then post test knowledge and motivation surveys are completed and students are asked to look at their concept maps and identify any changes to their thinking. The pre and post-test motivation and knowledge tests are completed in school – pre-test is moderated by aquarium staff, post test is moderated by teacher.

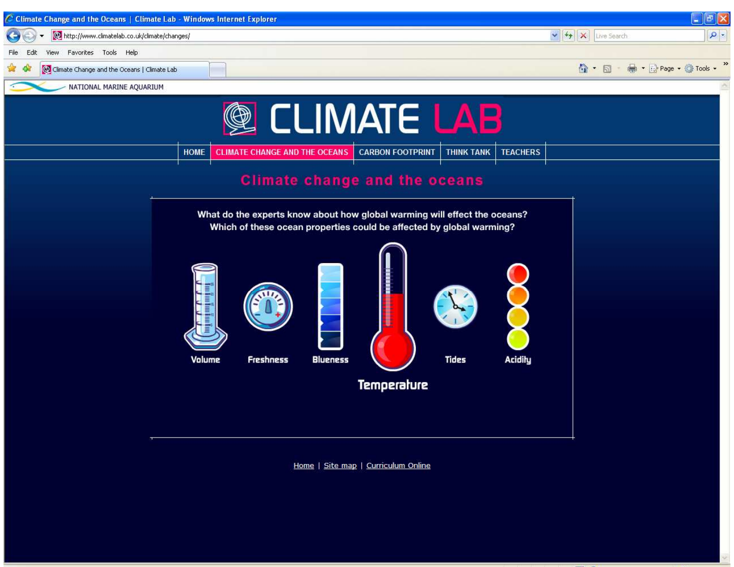
1.4 Results

The final product of the student activities is the website, the "spin-off" website and the concept map results.

The major output is the Climate Lab website and all of the associated resources www.climatelab.co.uk. The website contains flash animations describing the causes and effects of climate change, a carbon footprint calculator and activity, a resources area with images, links, news items, podcasts and student challenge packs and a teachers' area with advice on teaching climate change as part of the curriculum.

1.5 Screenshots

Screenshot 1: Climate Lab Homepage



Screenshot 2: Climate Change and the Oceans

Screenshot 3: Climate Lab Think Tank

2 On-line Access to History of Science Museum's "Objects", WP6

This pilot project was the result of WP6, coordinated by the Istituto e Museo di Storia della Scienza, Italy.

2.1 Objectives

The objective of this Pilot Project was to establish a set of tools and practices using materials which a museum of the history of science has to offer to improve the informal learning processes. This involved:

- producing multimedia "objects" by the making of virtual tools with pedagogical purposes modelled on instruments in the museum's collection;
- creating a didactic experiment centred on Galileo's early research on the basic laws of natural motion.

2.2 Learning activities

This pilot project aims at showing a perspective of science that takes into account its history, not from a positivist point of view, but by focussing on the dynamic processes that lead to scientific discoveries and the building of new knowledge: significant intuitions often come out in paths strewn with errors; and many erroneous theories open up the way to reliable results.

The birth of modern science, linked to the figure of Galileo Galilei, was the focus in terms of content. His scientific work, in the context of his times, is used to show how scientists create new patterns in unknown "territories", often overcoming current and established traditions in knowledge.

The project also casts light on the relevance of the "objects" (in the sense of instruments) for the development of science and emphasizes that each instrument has a complex network of meanings, both historical and scientific.

More generally, the didactic contribution is in conveying the idea of the complexity of scientific development from a cultural point of view and in showing that a deeper understanding of the history enhances our comprehension of the world around us.

2.3 Methodology

The methodology was established as follows:

- To develop the multimedia activities, the IMSS cooperated with scholarly experts to ensure the quality of the contents of the application and their correct transfer to educational purpose. The didactic efficacy of the prototype was tested with the help of teachers and students.

- an interactive activity with students was created with the laboratory sessions of “Galileo and experimental science”.

Seminars were run for teachers to explore the contents of the project, to discuss the methodology and to qualitatively evaluate the results.

Our Pilot Project aimed at integrating some contents of school curricula with a historical and philosophical perspective on development of science. In particular the contents of our PP were linked to physics (especially basic mechanics) and mathematics (especially basic geometrical calculation).

Concerning the multimedia activities, students were asked to evaluate the effectiveness of the “Galileo Compass” by working with it at school.

Concerning the activity “Galileo and experimental science”, students participated in the laboratory in a “leading role”. In fact they were invited to solve an initial problem, and were encouraged to use their intellectual creativity, critical thinking and manual dexterity to construct an experimental path and – possibly – demonstrate by themselves the law of free fall.

Historians of science collaborated on the design and development of the project - both science education specialists and science communication specialists with a background in physics or engineering.

2.4 Results

The final products of the project are:

1. The following multimedia tools with educational purpose:

- “Galileo’s microscope” (to be completed)

- “The life and work of Galileo: a virtual tridimensional exploration” (completed)

2. Realization of an e-learning feasibility study on how the multimedia applications of scientific instruments designed by the IMSS can be transferred onto an e-learning platform (completed)

3. Creation and implementation of a didactic experiment entitled “Galileo and Experimental Science”

Material available on the IMSS web site:

1. The life and work of Galileo: a virtual tridimensional exploration
http://brunelleschi.imss.fi.it/pencil/eng/index.html
2. Galileo’s microscope (to be made available soon)
3. Description of “Galileo and Experimental Science”:
http://www.imss.fi.it/istituto/egalsci.html

Material available on the Xplora web site:

NOTE: where not specified the files can be found by following this path: Xplora → My community → Pencil → Folders → Materials → IMSS

1. Pilot Project Template

(http://www.xplora.org/ww/en/pub/xplora/nucleus_home/pencil/imss.htm)

2. Description of the IMSS

(http://www.xplora.org/ww/en/pub/xplora/museums/xplora_partner_museums/istituto_e_museo_di_storia_del.htm)

3. Link to "Galileo's compass" (Path: Xplora → Resource)
4. Link to the educational application Court Scientists - The art of experimentation in the Accademia Galileiana del Cimento (1657-1667) (Path: Xplora → Resource)
5. Feasibility study for transferring onto an e-learning platform the multimedia applications developed according to the same structure as the "Galileo's Compass"
6. Report on the prototype developed by Laboratory – Percro, Scuola Superiore Sant'Anna, Pisa, to get a tridimensional representation of various aspects of the Galileo's life, with a special attention to his scientific work and the instruments he designed and used
7. Description and link to the tridimensional representation of Galileo's life and scientific work created in collaboration with Laboratory – Percro, Scuola Superiore Sant'Anna, Pisa
8. Copy of the leaflet to illustrate to teachers the activity "Galileo's and Experimental Science" (in Italian)
9. Description of the implemented activity "Galileo and Experimental Science"
10. Images from the activity "Galileo and Experimental Science"
11. Bibliography of immediate sources for "Galileo and Experimental Science"
12. Overview for the teaching activities of "Galileo and Experimental Science" (in Italian)
13. Contribution to the Xplora Newsletter, June 2006: "The IMSS Pilot Project: On line Access to the History of Science Museum's objects"
14. Power Point presentation of the IMSS Pilot Project prepared for the Pencil meeting held in occasion of the Ecsite Director's Forum in Toulouse, November 2005
15. Poster of the IMSS Pilot Project presented at the Ecsite Conference 2006

Presentation at the Science Teachers Conference, Cern, June 2006, "Exploring Scientific Instruments through ICT" (Power Point Presentation + text)

2.5 Annexed material

Image from "Galileo and Experimental Science"

3 Middle school students' use of ICT in science learning, WP7

This pilot project was the result of WP7, coordinated by Exploradôme, France.

3.1 Objectives

This Pilot Project's aims were:

- to set up a teaching style based on hands-on science activities integrating ICT,
- to measure its impact on science teaching, in comparison with regular school teaching style,
- to get some validation and/or revision of it.
- To acquire scientific content
- To train expression skills
- To share ideas
- To reformulate knowledge and to reinforce what they have learned
- To transfer knowledge to application situations
- Enable students to appropriate concepts by reformulating them
- To discover and practice some ICT tools.

All the activities were run and all the objectives have been achieved. The study, conducted by the University of Nanterre's laboratory of cognitive psychology, shows the good performance of the museum's teaching style combining science hands-on activities and multimedia activities, in terms of transferring the knowledge to application situation, and in terms of representation.

3.2 Learning activities

The Explor@mobile programme is a combination of science and multimedia activities proposed to middle school teachers and set up in their classroom during the school year. For many students, science lessons still mean equations and diagrams, which – particularly for students with learning difficulties – can be hard to understand. On the other hand, science lessons consisting purely of practical work and experiments would be difficult to provide and would not allow students the chance to assimilate what they have learned. In the Explor@mobile, multimedia activities offer an innovative alternative.

Scientific concepts are introduced to students through two workshops, run by mediators from the Explor@dome.

The second workshop involves multimedia activities to reformulate and reinforce what was learned in the scientific workshop. Students may develop a slide-show presentation, create a website, exhibition panels or a video film. The laptops brought in the Explor@mobile allow the use of equipment and software not necessarily available in schools.

The topic is chosen by the teachers from a varied list proposed by Explor@dome (optic, meteorology, environment…). The contents and activities are defined by teachers and educators according to the curriculum and the school objectives.

Students are very active during the sessions: hands-on science activities and multimedia workshops, while the teachers' role resides in the definition of the contents / activities in collaboration with the science & multimedia educators from Explor@dome, alongside support for the educators during the workshops.

3.3 Methodology

The main principles behind the methodology were as follows:

- collaborative learning,
- group work,
- enquiry-based learning,
- learning by doing/hands-on,
- reformulation of knowledge with the help of ICT.

For these projects, the Explor@mobile visited the schools to provide students with six scientific and six multimedia workshops, each of one-and-a-half to two hours. Other projects involved up to 20 sessions with a group of students. Every week, 2 educators come in the classroom and split the class in two groups or keep the whole number of students > the students take part alternatively to science or multimedia sessions.

The general objective is to create a multimedia product on a science topic.

For the multimedia part of the project the students usually work in pairs. Each pair builds a part of the general collective production.

For the science hands-on activities they are often invited to work in small groups (2-5 persons)

3.4 Results

The report from the cognitive psychology laboratory of the University of Nanterre, Paris, describes and analyses the impact of Explor@mobile scientific and multi-media workshops in classes.

Examples of projects conducted in 2005-2006 with local secondary schools include:

• The production by 12-year-old pupils of a CD-ROM investigating the links between art and mathematics, covering optical illusions, paving, and geometric constructions

• The creation of an illustrated novel and an exhibition on pinhole photography, by a class of 12-year-olds with learning difficulties. Photographs were taken using a pinhole camera made out of a tin can

- The design of exhibition posters about energy, by a class of 15-year-olds who intended to enter vocational training
- The production of a scientific documentary on a DVD by a class of 13-year-olds with learning difficulties.

3.5 Annexed material

See website: www.exploradome.com/html/enseignants/realpeda.htm

4 Chemistry for Primary Schools, WP8

This pilot project was the result of WP8, coordinated by Heureka, Finland.

4.1 Objectives

The main objective was to create new methods for teaching and learning chemistry and science by using the science centre laboratories and exhibitions as an open learning environment combining informal learning and formal school education.

The purpose of the R&D pilot project was to find out how the primary school pupils explain some concepts of chemistry. The project gathered information about different types of motivation and their appearance in science centre learning. The pragmatic goal and result was also to describe how the pupils experience working in the laboratory under guidance.

4.2 Learning activities

Before the visit: Introduction to the subject at school, specific tasks for each programme.

During the visit: Programmes done at the Children's Laboratory at Heureka, also additional tasks to be done at Heureka after the lab programme.

After the visit: school groups are advised to do some tasks via Internet.

4.3 Methodology

The students' role consisted of researching additional information, planning activities, evaluating, reporting activities, making presentations to peers, taking on the role of expert, communicating results and making websites.

The teachers contributed through planning, giving advice, leading activities and evaluating results.

The test teachers of the test group classes attending the project during 30 months were given practical feedback about the content and how to make it most suitable for the school curriculum, as well as giving also an alternative way to learn.

4.4 Results

The results of the project are five laboratory programmes with PDF manuals in Finnish, Swedish, English and Estonian for teachers. These are available online at: http://www.heureka.fi/portal/englanti/about_heureka/research/pencil_project/.

Other results included the Lab programmes at Heureka, science students training, visits of science teachers to Heureka and science teachers events.

4.5 Annexed material

bubbling_chemistry.pdf (3810 kb)
colourful_chemistry.pdf (3391 kb)
from_large_to_small.pdf (3630 kb)
mineral_examination.pdf (5558 kb)
water_analysis.pdf (4187 kb)
available through Xplora and at
http://www.heureka.fi/portal/englanti/about_heureka/research/pencil_project/.

5 Science Centre at School, WP9

This pilot project was the result of WP9, coordinated by Nemo, Netherlands.

5.1 Objectives

The overall objectives were as follows:

- Developing new hands-on science teaching methods for primary schools
- Doing curriculum analysis on national, local and school level by combining formal education through school authorities and informal learning through science centre experts leading to European synthesis
- Implement the new hands-on methods both in student teacher programmes and in-service education.
- Forming a structural European network for dissemination and sustainability of the results of several European science education projects.

The specific objectives in terms of learning outcomes for students can be defined as follows:

- Bringing about fascination with science and technology
- Acquiring an investigative attitude
- Acquiring technical skills like carrying out a work plan, building an exhibit, using tools, investigating how the exhibit works and investigating the applicable technical principles.
- Acquiring problem-solving skills
- Learning to work in pairs

5.2 Learning activities

The Science Centre at School project challenges pupils aged 11/12 years in primary education to design and create their own exhibits. An employee at a real science centre oversees the construction of the exhibits. To round off the project the pupils set up a science centre in their own school. They present the results of their research into the science behind the exhibit, both verbally and in writing. Fellow pupils and parents try out the exhibits.

Science Centre at School consists of eight mornings and afternoons, spread over at least five weeks:

1. Start in a science centre

The pupils visit a real science centre and are given an inspiring introduction to the project.

2. Choosing a topic and making a technical drawing

The pupils choose a topic in twos from the design book. They make a technical drawing of this.

3/4. Building the exhibit
Now they actually build the exhibit.
5. Carrying out research
The pupils study how their exhibit works and try to find a scientific explanation for this.
6. Preparing a poster presentation
They make posters with information about the functioning of the exhibit and other information they have found out through their research.
7. Oral presentation
The pupils present their exhibit to their classmates.
8. A science centre at school!
Fellow pupils and parents try out the exhibits.

The Dutch Ministry of Education has defined a number of key objectives for primary education. This project links up seamlessly with the key objectives 42, 44 and 45 for nature and technology (The Netherlands, 2006).
The key objectives are:

> Key objective 42
> The pupils learn to research materials and physical phenomena such as light, sound, electricity, force, magnetism and temperature.
>
> Key objective 44
> The pupils learn to see relationships between the operation, form and use of materials in products from their own environment.
>
> Key objective 45
> The pupils learn to design solutions for technical problems and to implement and evaluate them.

The project also matches the key objectives:

- Key objective 2, oral language training;
- Key objective 4, 5 and 8, written language training;
- Key objectives 32 and 33, measuring and geometry.

5.3 Methodology

Didactics of inquiry-based learning and learning by design.

The students' role consists of carrying out a work plan, building a construction (exhibit!), using tools, investigating how the exhibit works, investigating the applicable technical principles, using problem-solving skills, working in pairs, consulting each other, discussing, dividing responsibilities, verbalizing observations, explaining, doing research (in books/on internet), presenting (both verbally and orally).

Most of the project takes place at school. The teachers play a key role in the project. Therefore they get a training course in advance consisting of one full day. The elements of the training are:

- Information about the project;
- Getting to know the exhibits that the pupils are going to build;
- Building a number of exhibits themselves;
- Assistance in supervising the process of research- and design-based learning.

In this project the process –and not the end product- is most important. Therefore, guidance by the teacher focuses primarily on acquiring an investigative attitude and technical skills.

As part of the project a draft version of the lesson materials was developed by the science centre experts. These materials were tested at 10 pilot schools (by both pupils and teachers) by the AMSTEL Institute of the University of Amsterdam, the Netherlands National Institute for Curriculum Development and the University of Naples.

Based on the evaluations and the experiences at the pilot schools the lesson materials were adjusted and finalized.

A training course for teachers was developed to enable them to support the project.

5.4 Results

The students' activities produced the following results:

- Exhibits and a science centre at school
- Poster presentation about the science behind the exhibits
- Oral presentations in the classroom

The overall results of the project were as follows:

- A design book for the pupils with the description of 20 exhibits
- A workbook with worksheets for the pupils
- A teacher manual
- A training program for teachers was developed to enable them to support the project
- A project website www.sciencecenteropschool.nl

On behalf of the project a website was created, www.sciencecenteropschool.nl. The website provides a lot of information for both pupils and teachers, in Dutch and in English (go to English at the top of the homepage). All the lesson materials can be downloaded for free. Go to 'teachers primary education' and click on 'lesson materials'.

A teacher's manual in Dutch and in English can be found at www.sciencecenteropschool.nl, go to 'English'.

6 Traffic and Climate Change, WP10

This pilot project was the result of WP10, coordinated by the Deutsches Museum, Munich, Germany.

6.1 Objectives

The overall objectives of the pilot project were to develop intra- and extramural activities for students on the topic of climate change and traffic in co-operation with schools, and to translate the internet reference site on that topic and amend it.

In terms of learning outcomes, the specific objectives were to develop:
1. a school program on climate change, linking to the curriculum of geography, chemistry, physics;
2. a school program on traffic with the same curriculum connections as given above; (Programmes 1 and 2 are to be developed in order to facilitate personal investigation experiences and individual options for students.)
3. a role play, linking to the above mentioned curriculum aspects plus cross-subject learning goals such as: reflection, presentation skills, development of a feeling of responsibility; and
4. a translation of the Climate reference site and addition of the climate and traffic topic.

All four objectives have been accomplished, the translation of 4 has been published, and the content of climate and traffic has been published.

6.2 Methodology

1 and 2 make up a school programme comprising the introduction to a research problem (1 to avoid climate disasters in Europe, 2 to find a vision for mobility in the future). Students split up in groups and get a work assessment being part of the general research problem. The groups get material to collect information, make an experiment, and develop a vision or to place chunks of in formation in a wider context. The activities vary to cater for different learning styles. After 20 minutes, the group meets again and performs a peer group tour (student “expert” groups presenting their findings to the class). The programme is conducted by a member of staff or an external biologist.

3 The roleplay offers a number of situations, each comprising 3-4 opposing roles. The situations should come from the students’ experience, (e.g. discussions about how to get to school, which means of transport to choose for a holiday trip, whether or not to buy frozen food, what car to buy) the in roles should provide crucial information from the experts’ point of view. These statements should be as authentic as possible; still, the language should be easily accessible. So, for some statements including technical terms or jargon, an easy to understand version should be compiled.

4 Online information is presented on three levels:

- a range of 8 topics with an inspiring introduction
- basic information on the chosen subject plus a range of topics in greater detail
- detailed information on the chosen topic and links to relevant research institutions.

There are a number of links to the curricula of all three types of schools in geography, physics, chemistry and biology. The different products of the project follow up on those links. For a detailed list, see file Pencil_Lehrpläne.

6.3 Learning activities

1 and 2: peer-to peer learning, learning by teaching, enquire based learning

3 role play

The students' role in the museum visits and roleplay can be outlined as follows:

Museum visits:
Students come to the museum and set out to solve a science problem. As "experts" in a small field, they have to contribute to the class's task by obtaining information from the galleries and feeding it back to the group. E.g. the class's task in the climate program is to find out, how hurricanes can be avoided in Europe. So one group of 4-5 students has to find out about hurricanes as such and the circumstances that support their existence in Europe. Then, they report in a peer group tour to their class and the next group can pick up this input and develop their presentation.
In short: reporting activities, making presentations to peers, taking the role of an expert

Role play:
Students adopt a certain role in a set scenario, use the information they get with this role and argue from this point of view in the following discussion. They are encouraged to formulate findings or recommendations from their discussions and pass them on to the appropriate authorities (e.g.: They find out about the advantages of regionally grown produce, they could pass this on to the school caterer or headmaster)
In short: planning a line of argumentation, communicating results, answer counter arguments, training communication results, apply formerly collected information

There were two workshops with all teachers and all museum staffed involved in the project, one developing the school programs, the other developing the general outline of the role play.

Together with 3 teachers, the final design of the role-play was fixed in a third workshop.
All teachers and their classes visited the museum several times, took part in the three steps of evaluation (being part of observation, filling in questionnaires pre and post visit, volunteered for interviews, sent in additional comments and constructive criticism)

6.4 Results

Two intra mural school programs for the museum in the environment and traffic galleries, one role play, discussing the information obtains in the museums visits of from other sources, a bilingual internet site on climate change and traffic: http://www.deutsches-museum.de/dmznt/climate/index.html.

7 Xciters, WP11

This pilot project was the result of WP11, coordinated by the Experimentarium, Denmark.

7.1 Objectives

The overall objective of the Xciters Pilot Project is to promote an interest in science in upper primary schools (in Denmark this means 12 – 15 year olds) and on a long term basis enlarge the amount of young people taking an education within science.

The specific objectives of the Xciters Pilot Project are varied and bridge over gaining precise science knowledge within the science curriculum - to acquiring teaching and communicating skills - to finding out that science can be engaging, interesting and fun.

The first two years of the Xciters project has been evaluated and shown that the pupils participating in the course at Experimentarium and the pupils in the schools using the Xciters method are taking a far more active role in their science lessons. Pupils comment that science has become a subject that is one of their favourite. Teachers comment that the pupils who have worked with the peer-to-peer method are more confident in science and more able to 'take the lead'.

7.2 Learning activities

The focus in the project is on science topics and science communication. The method used is based on a learning by teaching strategy – which means using peer-to-peer teaching where the pupils (who become Xciters) act as role models and motivators for their fellow pupils.

Experimentarium introduces the schools (pupils and teachers) to the project beforehand. Participating pupils (with aid from their teachers) work as Xciters between and after courses. Shortly after the first course, the pupils share their knowledge with their classmates and the teacher explains basic communication tools. After this the whole class performs experiments and sessions of science communication for at least two younger classes. Representatives of Experimentarium visit all participating schools between courses.

All educational materials can be downloaded from the Xciters website and project-description, important links, etc are also on the website. A log-book element was part of the start-up phase.

All the science topics cover science areas within the school curriculum. The communication and presentation aspects appear in many subject areas in the curriculum – also within physics, chemistry and biology.

The students become Xciters – young science communicators. They must share their knowledge with their yellow class pupils and all the class must teach some science topics to younger classes (1 – 2 years younger).

The teachers' role is to facilitate the Xciters pupils and also to help the pupils pass on their acquired communication knowledge.

7.3 Methodology

The methodology behind the activities is mostly based on peer-to-peer and collaborative learning theories. Pupils and teachers are engaged and take part in group work, lectures, enquiry-based learning, learning by doing and hands-on experimenting, laboratory work, feedback and supervision of the teaching/communicating process.

Students take the role of planning new science communicating 'lessons' and 'activities' using the Xciters method. Pupils have an active role in evaluating – they take part in focus group interviews and questionnaires, but also actively evaluate the teaching material developed for Xciters. Students make presentations to peers, where they take on the role of 'experts' communicating science. Students take part in town festivals, demonstrations at libraries, and more, where they display and show science experiments and demonstrations. Finally some students are in charge of a pupil-to-pupil part of the Xciters website.

Teachers and experts from Experimentarium developed the contents of the Xciters course together. Teachers have had an active role in developing and evaluating teaching material for Xciters. Teachers from participating schools and museum experts collaborated very closely before the course began by discussing how to work with Xciters in the school and especially how to keep the Xciters method a part of the school learning over the next years.

7.4 Results

The Xciters method was the key result, developed with the objective to motivate pupils in upper primary to engage in science. An Xciters course over a school year was the basis for educating pupils and teachers and this has also been refined and developed. Educational materials have been developed to support pupils and teachers.

Also all participating pupils and teachers are kept in contact in order to secure the continuation of Xciters in participating schools.

Finally – the project has been evaluated also by the Danish University of Education and reported.

The final products of the students' activities are not always measurable. Some of the final products could be called the peer-to-peer teaching – where pupils pass on their science knowledge through a combination of experiments and factual knowledge. The most important part of the final product the students acquire is the ability to 'teach others' and 'an interest in science', 'science knowledge' and perhaps most important 'confidence in learning science'.

Final products are teaching material covering a wide variety of science topics, a manual called 'Tips & Tricks' covering good science communicating skills and a 'Teacher's Manual' explaining the method in detail and describing how a teacher can use this method in school. There is also an Xciters website – www.xciters.dk where all materials can be downloaded, pictures and text describing and showing what Xciters is about.

The evaluation method used was a combination of qualitative and quantitative methods. The pupils were asked to submit a 'log-book' through a log-in on the Xciters website stating their expectations for the Xciters course and also stating why they had applied for it. Subsequently an evaluation expert from the Danish University of Education has held focus group interviews with pupils and teachers in order to highlight whether expectations for the course were met and if motivation could continue for the duration of the project (and after). Questionnaires were sent out to teachers in order to evaluate the contents and specific sessions in the course and the collaboration between schools and Experimentarium.

7.5 Annexed material

www.xciters.dk, accessible through Xplora, is where all material is gathered. There is also an Xciters video-film, pictures, etc taken from the courses at Experimentarium and also in action at schools. All the material is in Danish and is in the midst of being translated to English.

The Xciters video is called 'Xciters – the movie' and can be seen on the website www.xciters.dk.


8 ROAD, Teaching R&D in schools through hands-on activities, WP12

This pilot project was the result of WP12, coordinated by Ciência Viva – Pavilion of Knowledge, Portugal.

8.1 Objectives

The Portuguese Pilot project had as a main objective the use of interactive games, mathematical objects and "hands-on" activities in mathematics education. With this project, objects, exhibits, games and activities frequently found in museums and science centres were used in the formal classroom environment with a clear curricular insertion. Another main aspect of the project was the evaluation motivation: questionnaires were performed with students before and after the pilot project in each school and focus groups and in-depth interviews were done with the teachers.

The project aimed to increase motivation of pupils in the study of mathematics, fostering a more active and positive attitude, namely with the use of "hands-on" activities. This kind of activities tried specifically to increase the student's autonomy, dialogue and group work. Also, specific educational materials were developed involving the students' participation.

8.2 Learning activities

The activities were developed in schools and in the Pavilion of Knowledge – Ciência Viva. Visits to the exhibition "Live Mathematics" were prepared by explainers from the Pavilion, taking in consideration specific curricular objectives discussed with the teachers. The school visits were then performed by the teachers guided with the help of explainers. After the visits, teachers and students discussed what was learnt and the best way to apply the outcomes of the visit in the classroom context.

8.3 Methodology

The project involved peer to peer work with teachers, group work of students, and several work sessions with explainers and museum technicians in the preparation of the interactive activities and development of practical materials.

During the pilot project, pupils reported their work to their colleagues and teachers as well as making presentations and communicating the results. Pupils also did research about curricular contents and contributed to the evaluation process.

The teachers were deeply involved in the planning and development of the educational activities and materials. They were the responsible for carrying out lesson plans using these materials and also evaluated the success of these lessons. Some teachers were involved in the construction of new mathematical exhibit prototypes.

Teachers and museum experts met to prepare all the activities and to discuss the construction of some new exhibits. Those meetings took place both in the Pavilion of Knowledge – Ciência Viva and in the schools.

8.4 Results

The students produced a number of interactive exhibits and developed small exhibitions in the schools. They presented their work (interactive objects, posters and several other materials.) to other students and to the school community.

During the Portuguese pilot-project 43 interactive activities and lesson plans were developed as well as materials and guidelines for the thematic curricular exploration of the exhibition "Live Mathematics" of the Pavilion of Knowledge – Ciência Viva; a class project about Measurement Instruments was also developed, in which students constructed a number of these instruments. The schools staged exhibitions about mathematics to introduce the pilot-project in to the school community with exhibits from the Pavilion as well as exhibits produced by students. Exhibits suggested by teachers were developed together with the Educational and Technical Department of the Pavilion of Knowledge.

A specific webpage (http://www.pavconhecimento.pt/projectos/pencil/pt/home/home.html) was developed for this project is hosted within the Pavilion of Knowledge website. This webpage describes the Pencil project, the Portuguese Pilot Project, each school project and work, and has all the materials produced during the project. An English version of this webpage has been available since September 2007.

The outcomes of the project have connections to the Portuguese mathematics curricula:

- Successions and Fractals (Secondary School – 16/18 years old);
- Successions and Fractals, Infinite Concept, Terms Addiction of Geometric Progression (Secondary School – 16/18 years old);
- Geometry – Space and Shape, Largeness's and Measures, Numbers and Operations (Basic School 1st Cycle – 6/10 years old);
- Geometry – Length, Mass, Area, Capacity, Volume, Speed (Basic School 2nd and 3rd Cycles – 11/15 years old);
- Geometry – Cylinder of Revolution (Basic School 2nd and 3rd Cycles – 11/15 years old);
- Probabilities, Rational and Trigonometrical Functions, Inverse Proportionality (Secondary School – 16/18 years old).

As well as the external evaluation programmed in the Pencil Project, a specific evaluation of students and teachers motivation was performed. This evaluation resulted in two complete reports, attached as annexes, one regarding the students and the other regarding the teachers' interviews.

Workshops for teachers are being developed, not only about mathematics but also about other science subjects and areas of knowledge. These workshops are developed together with an enlarged network of school participants. They aim primarily on the exploration of science centres in curricular activities and formal learning objectives. The immediate aim is to increase the number of teachers working together with the Pavilion of Knowledge – Ciência Viva.

9 So…Science! Social Dimension of Science, WP13

This pilot project was the result of WP13, coordinated by Fondazione IDIS – Città della Scienza, Italy.

9.1 Objectives

The Pilot Project objectives were to experiment educational practices focused on the social dimension of science and its impact on everyday life in order to contrast the image crisis of science in the public and especially in young people and students.

In terms of learning outcomes, the objectives were to observe and manage the different styles of learning between girls and boys and between students from different social conditions.

9.2 Learning activities

In the lab-activities with students in Città della Scienza, teachers and science-centre educators are required to reflect on methodological questions related to teaching/learning and on the relationship between science and everyday social life.

The activities follow at school, investigating and analysing natural and human-induced hazards using evidence and strategies for developing or revising an explanation; also applying the critical thinking to discuss about decisions that involve assessment of alternatives, risks, costs, and benefits and consideration of who benefits and who suffers, etc.

Only topics that teachers usually have in their annual educational plan were chosen, as the aim was to experiment the effectiveness of the link among formal and non formal activities.

The students' role consisted of reporting activities, communicating results. The teachers' role was planning, giving advice, documenting activities and evaluating results. Teachers and science centre experts collaborated through sharing the planning and monitoring of educational programs.

9.3 Methodology

The methodology involves learning environments, personal exploration path, collective verbalization of experiences, connection between thoughts, emotions and sensations: didactic programs are evaluated in order to measure how much influence an informal situation can have on the learning process.

9.4 Results

- 66 didactic activities with about 600 students coming from the 11 involved schools;
- meetings between teachers/students and experts coming from universities on the fields of sciences and education;
- production of reports on activities and results by the involved schools;
- models of evaluation tools (questionnaires, interviews etc.);
- an evaluation report (first draft, not yet delivered on the platform, see below);
- a multimedia document collecting all school reports to be shown in the Science Centre of Città della Scienza

Outcomes in terms of documentation and evaluation materials are:

- Conceptual maps on contents and topics (made by high and middle school students);
- Questionnaires on the Pencil Project, contents and methods (by middle and primary school pupils);
- Drawings on content representations (by kindergarten pupils);
- Reports on contents and topics (by primary school pupils);
- Video recording of didactic activities (all activities where possible);
- Interviews with teachers, student groups and conductors of didactic activities (IDIS external collaborators);
- Multimedia reports by the involved schools;
- a Flash multimedia tool.

10 Health Matters, WP14

This pilot project was the result of WP14, coordinated by the Bloomfield Science Museum, Israel.

10.1 Objectives

The principle objective of the Health Matters Pilot Project was to bridge between researchers and teachers of science and to encourage teachers to present scientific research in a more realistic manner in their classrooms.

The Pilot Project interacted directly with teachers rather than pupils. The learning objectives for teachers were:

- To be able to expose their students to current research and technology used in modern research labs.
- To acquire basic tools enabling them to develop “computerized learning objects” to enrich classroom teaching methods.
- To learn how the results of scientific research are published and to become acquainted with the guidelines for various forms of publication, such as scientific posters, articles for popular science magazines, and articles for professional science journals.

10.2 Learning activities

The learning activities at the Museum were the following:

- Lectures from researchers in academia and medical industry.
- Tours in the museum Health Matters exhibition with gallery based discussions
- Training sessions on Scientific Literacy.
- Workshops on Scientific Literature including writing a scientific poster.

The learning activities outside the Museum were the following:

- Teacher visits to research laboratories in the academic and industrial sectors.
- Sessions training the teachers to produce Learning Objects.

10.3 Methodology

Peer-to-Peer/collaborative learning, group work, lectures, hands-on learning, visits to laboratories.

The project connects to the school curriculum on three main levels.

Firstly the subject matter Health relates to Health Education and Life Science throughout the curriculum.

Secondly, the stress upon biomedical technologies connects with technology sections of the curriculum.

Thirdly the project emphasises scientific methodology and literacy which is an important aspect of the general science curriculum.

The students' role in the project was limited to their interaction with the participating teachers. Teachers' role was extensive as participants in the project, developers of learning objects, subjects of the research and producers of scientific posters.

Teachers participated in a long term professional development course run by the museum where they received training and enrichment. As outcomes of the course the teachers produced teaching materials based upon their experience and new found skills. Teachers also participated in interviews and focus groups to evaluate the project.

10.4 Results

Teachers produced three Modular computer learning objects, three posters to present the research carried out at the laboratories they visited.

The content of the teacher produced materials were used as the basis of the accompanying website for use by other teachers.

www.mada.org.il/pencil (HEBREW)

www.mada.org.il/pencil/english.html (ENGLISH)

The evaluation focused on two phases of the project: 1) The teacher training course and 2) The website for teachers.

For each, three stages of the evaluation included Front-end, formative and summative evaluation.

The website accompanying the project is designed to both maintain our contact with teachers who participated and to extend the network beyond those teachers.

10.5 Annexed material

See www.mada.org.il/pencil/english.html

11 Future technologies for science learning, WP15

This pilot project was the result of WP15, coordinated by La Cité de l'Espace, France.

11.1 Objectives

Within the framework of the Pencil project, the Cité de l'Espace studies how the educational devices used in the centre complete those used at school.

The Pilot Project is devoted to the visits from 8-12-year-old pupils. It takes a keen interest in the part played by innovative technologies in the centre to make some scientific notions accessible to these children get more attractive.

The starting point of the project was a study of the temporary exhibition "Biospace Mission." This exhibition first intended for the public, shows many futuristic interactive units, using innovative technologies. We aimed to study how children react to this innovative museology: is it as interesting for children as for adults? Does it make learning easier?

- Assessing the value of the different teaching aids used with 8-12 year-old pupils at the "Cité de l'espace."
- Measuring what is brought by the "new technologies" in the learning process
- Developing evaluation tools and methods in our work

11.2 Learning activities

The aim was to make this assessment study improve and run 3 popularization projects, each one using a mediation support specific to the science centre :

• Hands-on exhibition support : within the framework of the new continuous exhibition intended for 6-12-year-old children at the Cité de l'Espace..

• Planetarium support : within the framework of new planetarium educational show intended for 8-12-year-old children

• Educational workshops support : within the framework of the workshops designed for 8-12-year-old children.

The achievement of these 3 programs has been assessed within the framework of the Pencil project, by identifying the weak points and the strong points of each one. The aim was to determine which teaching methods are used in each case, how to measure and compare them, and how they complemented the methods used at school.
To make the comparison of these different methods easier, we focused on the study of 3 astronomical concepts taught differently by each support and accessible to the age group : day and night, the seasons, the phases of the moon.

The final aim is to assess how visiting the Cité de l'Espace can change the way children perceive science, to offer the pupils new educational tools and to define new assessment methods.

The 3 astronomical notions (the phases of the moon, the seasons, the day and the night) studied in the framework of the evaluation are integrated in the curriculum of primary school "cycle 3" (8-11 years old).

The following experimental activites took place in the science centre:
- 3 Hands-on exhibits in "Base des enfants" exhibition, designed thanks to prototypes testing with pupils
- "Base des enfants" sessions : pedagogical workshops in the exhibition "Base des enfants" for 8-12 years-old-children.
- "Marcus Notebook" : pedagogical notebook for children, that could be used during the visit and before/after the visit in school
- "Seasons" sequence in the pedagogical workshop "Sun-Earth-Moon"

The following experimental activites took place in the school:
- "Marcus Notebook" (see description above)
- "Resource documents" : documents to prepare the visit for teacher and pupils

11.3 Methodology

- Hands-on in specific exhibitions ("Children's Base")
- Enquiry-based learning in exhibitions thanks to an personal handbook for each pupil ("Children's Base" with the "Marcus's handbook")
- Group work in workshops with pupils ("Pedagogical workshop")
- Planetarium shows

The students' role consisted of:
- Testing prototypes of new exhibits
- Making presentations to peer during session of visit of the Children's Base

The teachers' role can be summarised as follows:
- Assisting the conception team in designing exhibitions
- Running workshops with the conception team

One cooperative experiment was run with a school: 10 year-old-pupils teach 5 year-old pupils the "Base des enfants" contents, during a specific visit. The 10 year-old-children have already visited the exhibition with this objective.

11.4 Results

- 1 Report on the evaluation of the exhibition “Mission Biospace,” based on high technology exhibits, with 8-12 year-old children

- 1 Report on testing exhibits prototypes with children in the framework of the conception of the Children‘s Base

- Several tools to help pupils in the discovering of the exhibition “The children’s base” : 1 handbook, 6 worksheets.

- 1 Report on a comparative evaluation of teaching the topic of seasons in la Cité de l’espace with 3 different ways: Planetarium, Hands-on, Workshops

- 1 Report on the evaluation of all the exhibits of la Cité de l’espace, based on collaboration with a University: method and results

- 4 Ergonomic and Didactic Guidelines to help the conception of 4 types of exhibits: hands-on, multimedia, video, showcase

12 Interactive forensic science: Whodunnit? WP16

This pilot project was the result of WP16, coordinated by Technopolis, Belgium.

12.1 Objectives

The overall objectives of this Pilot Project were as follows:

- To familiarise children and teachers in an interactive and informal way with different aspects of forensic science.
- To increase via an exciting story the attractiveness and relevance of studying science and technology
- To give pupils a broad view of forensic science, including its social context.

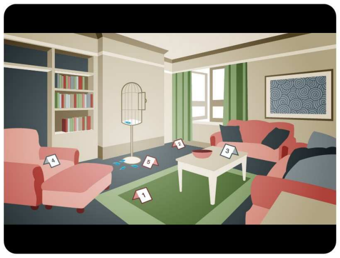
The specific objectives in terms of learning outcomes can be summarised as follows:

- The participants are carrying out hands-on experiments
- In all projects pupils are working towards a certain goal

12.2 Learning activities

During the visit the activities involved analysing, comparing, thinking logically, working together (against the clock).

After the visit, the main activities focused on the workshop and the educational package.



Name of the online game: 'The Mystery of the missing blue canary'

The story: the rare blue canary bird of the family Vandervelde is missing. What happened? The pupils have to discover by performing different tasks what happened to the canary. Has the canary been stolen? Did the canary escape? Or did the cat Tinkerbell eat the canary?

First the children get to know all the persons involved in the game. Then they can go to the crime scene and perform 7 different tasks:

- Footprints: On the carpet footprints were found. Do they belong to a known housemate?
- Fingerprints: On the cage fingerprints were found. Make them visible and discover to whom they belong.
- DNA test: After extensive investigation, hair was found on the carpet. By means of a DNA test, the pupils discover to whom they belong.
- Recognize materials/clothes: In the sofa, a piece of fabric was found. The children have to find out what fabric it is.
- Voice recording: on the ground lies a dictaphone. Somebody recorded a message. One of the suspects?
- Blood type: some blood stains were found. Type the blood group … maybe it will lead you to one of the suspects.
- Pollen: On the carpet pollen has been found. Discover the plant the pollen is coming from.

Based on the results of the different games and the alibi of the suspects, the pupils are able to discover who the perpetrator is.

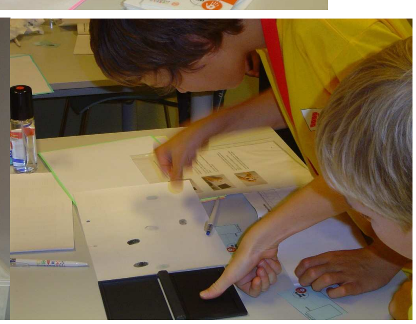
Exhibits about forensic science that are integrated in the Science Truck MysteriX®:

•Exhibit n° 1: Decipher the obscure characters! Is the patient infected? Do the unknown inscriptions in the box contain valuable information? Decipher all the strange characters by means of the foreign alphabet.

•Exhibit n°2: A little girl is lying in quarantine in the hospital. Is she already infected with the virus? Her life is in your hands: type her blood group and examine all her organs.

•Exhibit n° 3: Are there any witnesses? Track them down! Who has seen the box at the beach? There are several witnesses. In classifying the clues in a logical way, you will be able to track them down. Perhaps they know more?

Houd de dief



'Catch the thief' is a workshop in the school guided by an edutainer of Technopolis®.

Duration of the workshop: 90 minutes

Target group: 10-12 year old pupils

The workshop starts with an introduction. There was a burglary in the school and the money for the school trip has been stolen. The pupils have to perform 5 experiments (duration 35 minutes) to discover who the thief is:

- Experiment 1: identifying a piece of fabric
- Experiment 2: finger print
- Experiment 3: robot picture
- Experiment 4: secret message
- Experiment 5: mud investigation

At the end of the workshop the pupils make a doormat alarm (duration 35 minutes) which will help prevent the crime will happen again.

After finishing the doormat alarm, the pupils draw some conclusions (10 minutes).

The teacher also receives an educational package for use in the classroom.

12.3 Methodology

The methodology involved can be outlined as follows:

- Teamwork
- Hands-on, learning by doing
- Online learning

All the projects are linked to the school curriculum.

12.4 Results

Technopolis developed 3 exhibits about forensic science that are integrated in the Science Truck MysteriX.®

The film of MysteriX® for the working platform is now available through the Xplora portal.

- Online games. Available in Dutch and English: www.experimenteer.be ('detectivespel')
- A workshop 'Catch the thief' and an educational package linked to the workshop.

The online games have been developed.

13 Learning for a Sustainable Society, WP17

This pilot project was the result of WP17, coordinated by Universeum, Sweden.

13.1 Objectives

To develop and test new ways to cooperate between science centres, schools and society with the aim to increase young peoples individual motivation to study science and technology.

13.2 Learning activities

The Swedish school has an assignment to contribute to a social, economical and ecological sustainable society. Learning for sustainable development involves: Democratic processes, a critical attitude, interdisciplinary cooperation and diversity in pedagogical methods.

13.3 Methodology

Several teachers worked closely with the science centres to develop and decide how to work together. School program has been offered according to the wishes of the teachers and teacher training in sustainable society has been offered. The teachers have different needs and backgrounds and it was decided to give each individual teacher what they wanted. They were offered to use the science centre as much as needed. Since this is not a sustainable solution for the science centre the results of the evaluation gave recommendations on how to work with teachers in this subject.

The Swedish curriculum includes contribution to a social, economical and ecological sustainable society. Learning for sustainable development involves: Democratic processes, a critical attitude, interdisciplinary cooperation and diversity in pedagogical methods. (The Swedish agency for school improvement http://www.skolutveckling.se/in_english/)

13.4 Results

Outcome 1:
A paper with a selection of examples, questions and ideas that can be a start or an input for teachers work with sustainable society. The paper “learning for sustainable society” with ideas and input for teachers working with the subject has been written and uploaded on Xplora.

Outcome 2:
Results and conclusion of the evaluation with teachers and students. Recommendations for how to work on sustainable society for teachers.

Material to be used by teachers when working with the science centres has been produced and uploaded to Xplora.

Dr Claes Andrén has given lectures; one for teachers and one for students on biological diversity and devastation of the rainforest. Dr Andrén was employed as zoologist at Universeum at the time. Inger Björneloo from the Department of Education at the university of Gothenburg has discussed the evaluation strategy.

13.5 Annexed material

Document: Evaluation of students' attitudes towards the project and issues sustainable development
http://resources.eun.org/xplora/Learning%20for%20a%20sustainable%20society2.pdf

14 Virtual Observatory, WP18

This pilot project was the result of WP18, coordinated by Ellinogermaniki Agogi, Greece.

14.1 Objectives

The Virtual Observatory (VO) Pilot Project aimed at evaluating the educational perspectives of the use of robotic telescopes in secondary education and furthermore at proposing an innovative method for science teaching to create renewed enthusiasm with youngsters.

The project also had an equally important goal at the level of the social dimension of learning. It attempts to overcome the limits of the classroom by having a network of schools gathering and processing the same type of data and asking the students to compare their findings and exchange their ideas.

The VO project's consortium took advantage of the common work platform that will be developed in the framework of the Pencil project for exchange of best practices, demonstrations, on-line conferences etc. among the rest of the pilot projects.

The VO pilot project challenged the most difficult objective of the development of a better understanding of the opportunities, which are associated with e-learning methods, contents and resources as well as their impact in education.

14.2 Learning activities

The VO Pilot Project reinforced interdisciplinary approaches. The main link usually missing in the learning process is that students do not learn sufficiently through experience but through a systemic model based approach, which should be the culmination of learning efforts and not the initiation. A particularly disturbing phenomenon, that is common knowledge among educators, is that students fail to see the interconnections between closely linked phenomena or fail to understand the links of their knowledge to everyday applications. Therefore, in recent years, there is a clear focus on interdisciplinary education. This approach supports that educational experiences should be authentic and encourage students to become active learners, discover and construct knowledge. Authentic educational experiences are those that reflect real life, which is multifaceted rather than divided into neat subject-matter packages. The Educational context of the D-Space service (which is the face of VO PP) is not transmitted in a theoretical way but rather in a biomatic way in the form of a real life experience. Observing the sky and using the telescopes of the D-Space service is a highly interdisciplinary subject and its implications give topics for discussion in Astronomy, Cosmology, Physics, Chemistry, Mathematics, Mechanics and clearly expanding the learning resources for students.

- The VO uses the Discovery Space (D-Space) service, a network of robotic telescopes around the world (www.discoveryspace.net).
- The VO brings to students, teachers, researchers and individuals (amateur astronomers, visitors of science parks) all around the world the opportunity to use remotely controlled robotic telescopes in real time giving accessibility to unique resources as the sky is a vast and unique laboratory of science, always in operation, accessible at all times from everybody from everywhere, where all sorts of interesting physical phenomena take place most of which is impossible to reproduce in any scientific laboratory. It supports the provision of key skills to the future citizens and scientists (collaborative work, creativity, adaptability, intercultural communication).
- Development and adaptation of scenarios of use. As the VO system is open for different categories of users (students, educators, researchers and the wider public) the scenarios of use vary significantly in order to cover the different users' needs. Each scenario is accompanied with supportive material for the users. The scenarios were optimized after the first phase of the pilots with the users. The scenarios were redeployed during the second phase of pilots and according to the users input, the scenarios took their final form.
- Launching of the VO project users' groups. After the development of the VO scenarios, the specific users' groups taking part in the project were launched. The main users' groups participated in the VO project's activities were students and teachers across Europe, researchers and scientists, as well as individuals (visitors to museums and science parks).
- Teachers' Training. An effective training is offered to the teachers and the science centre's staff of the participating institutions. The training includes the teachers' workshop, where the VO service is presented and a series of on-line seminars through the Internet.
- Implementation of the VO activities in real environments. The implementation of the VO activities takes place in real environments (schools, museums, science centres) in repeated cycles of user centred trials. Each cycle includes the design, the development, the implementation and the evaluation. During the project's life cycle the VO system is been deployed at schools, museums and science centres. During the implementation of the educational activities, users will be provided with the needed pedagogical and technical support through the project's web site. The members of the VO Users Group will be involved in different kind of activities. In this framework workshop, seminars, contests and open days are organized in the schools as well as in the science museums and science centres.
- Evaluation / Validation: The main objectives of the validation work were a) to adapt a tried and tested methodology to validate the system of VO project and b) to implement the validation procedure in situ in a pan-European setting.

14.3 Methodology

The methodology of the learning activities of the VO is provoking the students intrinsic motivation of learning through hands-on experiments. The VO also provokes enquiry-based learning for the students.

The VO service demonstrates an innovative approach that crosscuts the boundaries between schools, research centres and science thematic parks and the wider public and involves users in extended episodes of playful learning. The VO looks upon informal education as an opportunity to transcend from traditional classroom based teaching, to a "feel and interact" user experience, allowing for learning "anytime, anywhere", open to societal changes and at the same time feeling culturally conscious.

The new technology offers the students a unique possibility to use a scientific instrument remotely. Through VO the students are able to observe the sun, the planets, the stars, the galaxies on line. In this way their classroom is transformed into a scientific laboratory. Students can come to view the astronomical observations as a craft that rewards dedication and precision but simultaneously encourages a spirit of creativity, exuberance, humour, stylishness and personal expression. In particular a student can interact with the D-Space system in 2 ways: autonomously or guided by a teacher.

When acting autonomously a student can have a goal in his mind, and using the D-Space service can realize one or more observation in order to fulfil his goal, participating in this way in a biomatic and investigative learning approach.

When guided by a teacher, the student should follow the steps and realize the observations requested by the teacher following a specific teacher's scenario of use and thus following the teacher's pedagogical approach.

After the familiarization of the students with the use of the telescope, projects are assigned to them. They are let free to approach the phenomena and the astronomical objects (sun, planets, stars, galaxies, etc) they want to study. The students are requested to develop real problem solving practices, letting themselves free to handle situations and study them. By using the telescope and the user interface in order to compose their own scientific inquiring strategy, the partnership expects students to be able to engage in more meaningful and motivating science-inquiry activities. In this way the assigned projects promote creativity through new forms of content combining highly visual and interactive media with the use of innovative ways of design, delivery, access and navigation.

Students can in this way find new approaches to teaching science, and be in this way an "educator" when presenting their inquiry-based learning project to the other.

Finally the student actually became experts/researcher, and taking an active role on conducting research as researcher usually do.

14.4 Results

While using VO the students designed and developed projects on science matters. Some example of students projects are:

- Algorithmic solar shot system
- Observation of sunspots and their moving
- Birth and Death of Stars
- A Proposal of Asynchronous On-line Learning of Astrophysical Topics With the Use of Remotely Controlled Telescopes
- HELIOS-SUN
- Asteroids attack the Earth - myth, speculation, or real danger?
- Lunar eclipse
- Astonishing Arcane Of Astronomy
- Solargraphy-Global Photographic Project
- Grand fireworks in the Whirlpool galaxy
- The Characteristics of the Surface of the Moon
- GRBs As Targets Of Robotic Telescopes
- Islands of the Universe

Two scientific contests were organized from VO, and material was produced by the participants (teachers and students). In addition, material was produced for the workshops, and the educational material (training courses, newsletters etc). All the above can be found in VO pp web site, called D-Space: www.discoveryspace.net, also accessible through the Xplora portal. Finally a strong final "product" is the users group that formed related to D-Space, and now linked to Xplora portal.

In the lifecycle of the Pencil project workshops (for teachers and students), scientific contests, newsletters, user guide, leaflets, announcements have been developed in order to achieve the objectives. In the workshops and the training we made a slight change in users' perception about science teaching and learning is measurable.

Teachers and museum experts found VO very interesting and promising. They liked the fact that they could develop creative, hands-on interactive astronomy lessons over the internet using our network's robotic telescopes, to meet the needs of school curricula.

They liked actually at first that they found a way to have the students more interested in their science lesson, but also the liked it as an activity for them.