

## DOCUMENT OF CONCLUSIONS



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## 1 Introduction

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### 1.1 General considerations

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This document presents a summary of the development of the Project, describes some of the most relevant PEC products and considers some of the key outcomes of the Project. These include the mobility experience, project transference possibilities, project dissemination and finally, professional and personal partners' experience.

We now live in a global 'knowledge society' which demands the incorporation of ICT into all aspects of human interaction, including education and teacher development. However, the outcomes of results of numerous International research projects, as well as international comparisons (e.g. the Programme for International Student Assessment [PISA]<sup>1</sup>) have shown that science understanding and competence of pre-university students from several European countries is generally low. Various explanations for this situation are offered in the literature, which may be summarised as three broad factors.

Firstly there exists a prejudice against scientific subjects among many young people, who perceive that studying science to be more difficult than other subjects. Secondly, a great number of secondary school pupils experience literacy difficulties concerning both comprehension and expression which hinders understanding in science, as in other subjects. Thirdly, there is a perceived lack of correspondence between the science taught in schools and 'real world' scientific practice.

A combination of these factors potentially contributes to the current deterioration in the number students opting for science courses at University level, or going on to take up science-related careers. Overall, this has led to a general decline in both

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<sup>1</sup> PISA 2006 Science Competences for Tomorrow's World. Organisation for economic co-operation and development, 2007.

interest in and understanding of science and scientific concepts – what might be thought of as ‘scientific literacy’ – among many young people across Europe.

At the same time, there is a growing body of evidence which shows young people to be progressively familiar and expert with information and communications technology (ICT), which is itself increasingly embedded in scientific processes and science education.

In the light of these findings, a group of academics from seven European Universities set out to develop a project which would investigate these issues, with a view to developing teaching and learning approaches and materials which could remove some of these barriers. The project was to focus in particular on scientific knowledge, linguistic skills and digital media. The PEC Project proposal was presented to the European Commission in March 2005, and was accepted and financed by the European Commission under Socrates Comenius 2.1. The Project commenced at end of 2005.

## 2 PEC Project

### 2.1 Project Partners

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Seven higher education institutions were involved in the project; these are *Alcalá University* (Spain), *Comenius University* (Slovakia), *University of Leicester* (United Kingdom), *Lisbon University* (Portugal), *Gävle University* (Sweden), *Helsinki University* (Finland) and *Karadeniz Technical University* (Turkey). An interdisciplinary team of scientists and experts in linguistics and ICT, each of whom was involved in initial teacher education, was formed from academics in these seven Universities. The team members had considerable experience of international collaboratively. Several (Spain, Portugal Slovakia and UK) had worked together in previous projects, while the others (Finland, Turkey and Sweden) had previously worked with British and Portuguese partners.

### 2.2 Project Aims and Relevant Outcomes

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The title of the Project, *PEC: European Science teachers: Scientific Knowledge, Linguistic Skills and Digital Media*, reflects the main objective of the Project which was to improve science learning by means of developing linguistic skills (comprehension and expression) supported by Internet-based teaching and learning resources. The focus of these developments was to be on student teachers. The team's focus on web-based material emerged from a recognition that the not only has internet become an essential resource for teachers across all subject areas, but also of the integral role that ICT plays in the lives of today's young people, for whom the use of technology for communication and for acquiring and transferring information is now commonplace. Although the primary focus of the Project was on science, the intention was to develop a pedagogical model which had the potential for transfer to other subjects and educational contexts in Europe.

The two main aims of the PEC project were: to improve Initial teacher Training in order to teach Science, and to use an innovative methodology including Language and Internet as classroom tools, methodology which can be transferred to other subjects, educational contexts and European countries.

The project specific aims were to:

- ❖ elaborate and implement materials to facilitate significant learning in Science
- ❖ develop reading comprehension and written expression skills concerning scientific texts through linguistic strategies
- ❖ promote common and scientific language, and in this way to contribute to scientific literacy
- ❖ use Internet to approach Science to Secondary School pupils (scientific web sites as authentic material to develop didactic activities)
- ❖ promote mobility actions of student teachers
- ❖ evaluate and disseminate obtained outcomes

The key outcomes of the Project were:

- ❖ a comparative study of science curricula of the participating countries
- ❖ selection and analysis of web sites with science learning content
- ❖ the development of scientific and linguistic didactic activities
- ❖ the production of two educational CDs, one of them addressed to student teachers, and the other to Secondary School pupils
- ❖ a mobility programme for student teachers among participating countries
- ❖ a course addressed to in-service teachers of science
- ❖ a range of dissemination products, including articles, papers, posters, Project website and seminars
- ❖ document of conclusions

## 2.3 Project Development

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The PEC Project was organised following the different phases set out in the proposal. All Project activities were collectively designed and discussed in the team meetings, which took place in each of the partner institutions, where all partners actively participated. Meetings also served to review Project progress and to plan the future tasks. (This can be seen in the agendas/menus of each meeting). Meanwhile partners were in regular contact either by e-mail.

The typical pattern of activity development was for the respective co-ordinator for each stage or action to circulate, prior to each meeting (via email), a discussion document to team members for consideration. This was followed at the meeting by a presentation of a revised proposal for discussion and eventual agreement on the content and form of the activity.

In the majority of cases planned activities were conducted by all partners following an identical procedure - for example the process of selecting and analysing website materials. For some activities, however, a degree of flexibility was appropriate. For example, while the mobility programme was common to all partners, and was implemented in each country simultaneously following the same basic structure, each partner was free to organise specific mobility activities in schools depending on the particularities of the individual schools and education systems in each country.

### 3 Description of Relevant Outcomes

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This section briefly describes the most significant outcomes of PEC Project. Some of these are available as examples on the Project website<sup>2</sup>. Alternatively they can be accessed directly from the Project coordinator or the respective Project partner in each country (contact details available on the website)

General aspects of mobility and dissemination programmes will be presented here as two distinct elements, in order to reflect the professional and personal experiences of the partners. Some of the outcomes have been subject to a specific evaluation, while all appear in the final report.

#### 3.1 Comparative study of science curricula of participating countries

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This involved a comparison of secondary school science curricula in each of the partner countries. The criteria for this process were established by the Project team and followed a model template structure.

This revealed a number of similarities across the seven education systems. A number of science or science-related subjects were found to be common, these being: Natural Science (NS), Physics (PH), Chemistry (CHM), Biology (BIO), and Technology (TECH). In some countries other subjects were included under the general umbrella of science education. These included Geology (GEOL), Biochemistry (BIOCH), Astronomy (AST), Environmental Studies (ENS), and Health Education (HE).

More detailed information generated by the comparative study was compiled in a report, produced by the University of Alcalá, which identified a common topics and issues which served as the framework for the subsequent phases of the Project. These were:

- ❖ Science subjects taught: in primary and secondary schools
- ❖ Goals for learning:
  - subject matter,

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<sup>2</sup> <http://www.edu.helsinki.fi/pec/index.htm>

- aims,
- scientific method,
- nature of science
- ❖ Goals for personal social and affective development:
  - interest, motivation,
  - becoming familiar with society,
  - ability for further studies,
  - cooperative skills development,
  - using different information sources (textbook, internet),
  - ICT in the curriculum (especially science education)
- ❖ Evaluation
- ❖ Common fields and topics in physics, chemistry, and biology.

This outcome was a priority for the development of the project as it gave the required information about every country and it was used to identify the list of common topics to be worked with.

### 3.2 Selection and analysis of web sites

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The set of topics and issues identified in the comparative study of science curricula provided a basis for the selection of WebPages. In order to provide a structured approach to this activity, key criteria for the selection process were established, namely:

- ❖ Content:
  - Relevance to the Curricula,
  - Language suitable for secondary school pupils,
  - Suitability of conceptual level,
  - Motivational aspects,
  - Prompts for discussions, writings, further studies, research etc.,
  - Links to other related sites

- ❖ Pedagogical properties of the Site (Prompts for learning):
  - Reliability of the information provided,
  - Scientific accuracy,
  - Amount of reading content, including downloadables
- ❖ Both content and pedagogical properties:
  - Use of multi-media,
  - Relation to daily life, experiences, other contexts
- ❖ Usability:
  - Easy access and navigation
  - Easy to learn use,
  - Pleasant to use

Using these key criteria, a selection and analysis template – ‘Model A’ – was developed. Previous to application of these criteria we had identified the subject, selected topic, objectives of the topic and pupils to whom materials were addressed, and then, we started looking for WebPages with all these requisites.

It was essential that a selected site met all of these criteria. In practice, some criteria were found to be easier to apply to sites than others. In particular, material appropriate to the levels of scientific knowledge and linguistic competence of secondary pupils proved to be the most common difficult to locate. Thus while numerous sites met other criteria (for example relevance to the curriculum, scientific accuracy, ease of navigation and so on), they were rejected if they lacked these core elements relating to comprehensibility.

### 3.3 Scientific and linguistic didactic activities

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Having selected appropriate web-based resources, in this phase a range of the scientific and linguistic didactic activities were developed which took advantage of the properties offered by those materials. Each of these activities were based on a comprehensive set of linguistic, didactic and scientific abilities selected and agreed by the team. These were:

- ❖ Linguistic activities: reading comprehension and writing

- Reading comprehension, developing the abilities of:
  - Extracting the main idea,
  - Extracting secondary ideas,
  - Distinguishing secondary ideas from main ideas
  - Skimming
  - Scanning
  - Inferring information
  - Predicting information
  - Role-playing
  - Concept mapping
- Didactic activities to develop reading comprehension
  - Direct questions
  - True/false questions
  - Multiple choice
  - Text structure
  - Find the word referred to (relative pronouns, personal pronouns, demonstrative pronouns, etc.)
- Didactic activities to acquire and reinforce vocabulary:
  - Matching words with definitions
  - Defining words
  - Synonyms and antonyms
  - Find the odd man out
  - Guessing unknown words
  - Word formation: prefixes and suffixes, compounds words
  - Solving puzzles
  - Collocation

➤ Didactic activities to improve writing:

- Summarizing
- Paraphrasing
- Writing conclusions
- Describing devices
- Re-writing a text
- Transferring non-verbal language (graphic, tables, etc) to verbal language or vice versa
- Mind mapping
- Writing stories (using scientific concepts, events, or objects)

❖ Scientific activities

➤ Developing the abilities of....

- Being aware of scientific concepts
- Being aware of scientific procedures
- Establishing, relationship among different concepts
- Comparing different scientific procedures
- Data interpretation
- Graphic interpretation
- Solving problems
- Designing experiments
- Formulating hypothesis
- Controlling variables
- Predicting
- Drawing evidence-based conclusions
- Identifying questions
- Using scientific language precisely

Linguistic activities were designed so that pupils could understand the webpage, then scientific activities were created in order that pupils could acquire scientific knowledge. We prepared a template “Model B”, which summarized the type of every activity and helped student teachers or teachers to classify the activities.

We included some didactic reflections to exploit the activities in the classroom. For each activity, we described: the activity itself, abilities-skills developed within the activity, and suggested way/s to implement the activity. This information was included in form “Model C” as a tool for initial teacher training, but it also could be used by in-service teachers.

### **3.4 CDs: CD addressed to student teachers and CD addressed to pupils**

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The creation of two CDs was targeted at student-teachers and school pupils respectively which included the various scientific and linguistic activities by each partner group. As one of the main concerns of the Project is transferability, that is that teaching and learning resources should be useable in different countries and contexts, one of the CD topics was developed in English, while the other two appeared in original language. An agreed common structure for each type of CD was developed to guide the production of these materials. Each set of learning resources included:

- ❖ CD addressed to student-teacher included;
  - A brief introduction about:
    - the PEC Project
    - the Project team,
    - the Universities involved, including some details of town and country in which each was located.
  - A theoretical introduction concerning the interdisciplinary methodology through which the Project was developed
  - Three topics, with the following points:
    - Model A: web site selection and analysis: model proposal
    - Model B: activities for web page selected

- Scientific and Linguistic activities
  - Model C: brief description activities
  - Didactic reflections
- ❖ CD addressed to Secondary School pupils included:
- A brief introduction about:
    - the PEC Project
    - the Project team,
    - the Universities involved, including some details of town and country in which each was located.
    - scientific and Linguistic activities

### **3.5 The mobility programme for student teachers**

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The mobility programme took place over a period of two weeks in April 2008. This was designed as an exchange programme, enabling student teachers to gain experience of an alternative education system and approaches to the teaching of science. The programme was developed in response to the philosophy of the European Union to enable citizens of the Union to work in more than one member State. If student teachers are to have the opportunity to work in other European schools as full teachers in a near future, it seems fitting to help provide them with the required skills to work in another cultures – in this case as part of their initial teacher training.

The model for the programme was to bring together, in each host country, a group of students from the different partner Institutions. Thus each group was multinational, enabling the participating student teachers to learn both from their host country and from one another about other educational systems and pedagogical approaches.

The mobility programme was developed in secondary schools in each host country, and was supervised by the respective University and school-based mentors. On average, three schools acted as hosts for different members of each group.

A key element of the programme was to provide an opportunity for each group to trial the PEC teaching and learning materials in schools, providing an authentic 'test-bed' for the effectiveness of the methodology and products in improving science learning. In addition, within each group students prepared presentations about their own country and education system, with an emphasis on science education, to an audience comprising their fellow group members, PEC Project coordinators and faculty of the host University, and teachers from the host schools. The group also took part in cultural visits and activities.

Evaluation of the programme reveals that the main benefits for student teachers have been

- ❖ For the student teachers:
  - to use the PEC science learning materials
  - to learn about other educational systems
  - to know and contrast different methodologies in different contexts
  - to enhance their pedagogic skills
  - to share their experience and good practice
  - to engage with new cultural experiences
- ❖ For mentors:
  - to learn about alternative education and teacher training systems
  - to meet with educators from different cultures
  - to participate in a European project
- ❖ For schools:
  - a 'special occasion' on the calendar
  - an additional science teacher to support science learning with the whole class, small groups and individuals
  - an opportunity to explore innovative science materials and learning approaches are
  - an international dimension brought to a range of areas of the school curriculum

### 3.6 Training course addressed to in-service teachers

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This course, coordinated by Dr. Ana Freire from the University of Lisbon, took place between July 3 and July 9, 2008, in the University of Lisbon. The development of the course began at the Lisbon PEC meeting in February 2007 in which Dr. Freire presented a draft application and outline programme for the course. Discussions about the course programme continued throughout several months, the final version being approved by partners in Bratislava in June/July 2007.

The course was advertised primarily to secondary school teachers, mentors and tutors in charge of Initial teacher Training, but was also open to some primary teachers. The course attracted over eighty applications, from which thirty were accepted to attend the course. They came from the United Kingdom, Finland, Romania, Cyprus, Greece, the Czech Republic, Italy and Poland. Each participant was supported financially by the Socrates National Agency in their respective country.

The course centred on the exploration of the teaching and learning resources developed by the PEC Project. The main aims of the course were:

- ❖ the analysis of teaching experiences and teaching possibilities in the process of learning
- ❖ teachers' awareness about the possibilities of incorporating Internet in the process of learning, in this case science
- ❖ teachers' awareness about the possibilities of using linguistic strategies to improve the basic skills of reading comprehension and expression, and how these linguistic strategies can also improve the process of learning in science
- ❖ the presentation, analysis, study and discussion of the elaborated materials (CDs) by the members of PEC Project
- ❖ to explore the potential of developing a European network of science educators

### 3.7 Dissemination

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The main aims of dissemination have been to inform science educators about the key objectives, processes and methodology of the Project, and to make available outputs in the form of authentic teaching and learning resources designed to enhance

science learning. In essence the focus of the dissemination strategy is to introduce both materials and methodology associated with the PEC project to a broader audience of pre- and in-service teachers, to teacher educators and to researchers in the field. It will also provide an opportunity for a continuing dialogue between interested educators and the Project team, with view to further developments in this area. In essence, then, the approach is concerned with both dissemination of what the project has achieved so far, and with the development and maintenance of an ongoing community of interested practitioners and scholars.

A range of dissemination activities developed by the various Project partners have taken place and are planned at local, national and international levels. Many of these activities have involved not only educators in science, but also in related subjects (for example technology, mathematics, ICT, and language) providing evidence of the transferability of the Project. Many of the activities involved not just the Project coordinators at the respective partner Institutions, but also gained the interest and participation of Faculty colleagues, up to and including Heads of Department, Deans and Vicerrectors.

The products of dissemination activities to date are presented in the final report, with a selection available via the Project website – itself one of the main dissemination products. Dissemination is produced at three different levels.

### **3.7.1 Local dissemination**

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At a local level, these have included, in all participating institutions, seminars with student teachers, in-service teachers and University tutors, both to explain the PEC Project objectives and methodology, and to demonstrate and explore the science learning and teaching resources developed by the Project. Some of these seminars were organised before, during and after mobility to prepare and to evaluate this action. Other seminars, meetings or events, locally organised, included local Education authorities working with the University as well as in-service science teachers, headmasters of schools, academics in charge of teaching training courses, etc.

### 3.7.2 National dissemination

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At a *national* level, all Project partners have organised, or have planned, Project dissemination activities such as conferences and other scholarly seminars for invited researchers and educators from various Universities, educational agencies and authorities, and science institutions and organisations. In addition, several members of the Project team have presented Project-related papers at national conferences and symposia.

### 3.7.3 International dissemination

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While the Project itself has of course been an example of international collaboration, dissemination of its outcomes has also found a cross-national audience. In particular, a number of papers have been presented at international conferences for educational researchers. These have focused on the methodological and pedagogical aspects of the Project, as well as demonstrating the educational materials which were developed. Publications of articles in *Conference Proceedings* and *Journals* have been a relevant aspect of dissemination at both national and international levels.

## 4 Benefits of Relevant Outcomes

### 4.1 Activities and CDs: transference possibilities

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A key element of the Project design, and a requirement of the funding body, is that the outcomes of the Project should have the potential for transferability to other contexts. A broad range of such opportunities have been identified, and these are summarised below.

The activities developed in this project were planned according pre-established criteria in order to explicit address the promotion of linguistic and scientific skills as well the use of internet and other digital media. The criteria defined in this context can be used in the design and development of activities focused in other subject areas (for example History, Geography, Literature, etc.). The products also show how digital technology, especially the internet, would be integrated in science classrooms as authentic resources, texts, simulations and so on. It is clear that a number of the schools which participated in the mobility programme have shown interest in the various Project resources, which have in effect, therefore, already transferred to international educational systems, albeit at this stage at a relatively 'local' level.

The notion of developing 'scientific literacy' (in both teachers and learners) for example, which underpinned many of the Project's objectives, is readily transferable to other domains. Thus the products of the PEC project and the process by which they were developed could be help to inform teachers and prospective teachers in the preparation of learning environments and activities, in particular where these concern the underlying literacy' of these different subject. The use of internet and other digital media can be considered in similar way in other subjects. Examples of this already happening were identified in both the mobility programme and in various dissemination activities and outputs. There are also examples of post-project activity, for example teachers and student-teachers beginning to explore the CD and website resources in the science classroom.

The focus of the study was primarily on secondary/high school science. However, while the materials developed for the CDs were aimed at this age group, the process by which they were developed, as well as the pedagogical principles underlying the

methodology, are readily transferable to the primary/elementary sector or other sectors. Just as the basic concept of subject literacy is not confined to science, scientific literacy itself is not age-specific. Similarly, while the focus of the project was on initial teacher training, both the model and the resources can relatively easily be replicated in and/or adapted for continuing professional development contexts. It was noted by more than one partner that despite the interest shown in the Project products, embedding their use in real learning contexts requires more than 'one off' training events, and for the above actions to take place, thought needs to be given about how best to ensure that the outcomes of the project can be developed and sustained.

'Exchange' might be thought of as a process of 'mutual transfer', and in that regard the exchanges which occurred during this Project both between the Partners and during the mobility programme is a testament to the transferability of knowledge and understanding of science and science education – not to mention social and cultural awareness – which can occur when an appropriate framework is provided and opportunities to develop that framework are enabled.

## **4.2 The mobility programme**

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While the mobility programme can certainly be said to be a success, it is clear that the degree of organisation and support required to make it so was considerable for each of the Project partners who were in effect working independently from one another to provide a full programme of events for their visitors. In addition to the arrangements required to select and allocate students to each mobility group – which was typically determined according to language and academic competence - a great deal of 'behind the scenes' organisation was necessary in each country in order that the visits went smoothly. For example dealing with national funding agencies to provide financial support for the visits, ensuring that travel arrangements were complete and transport to and from airports was in place, arranging accommodation, language preparation, putting together local information packs, getting agreement from local schools and science mentors for the student placements (typically involving three or four different schools), organising social and cultural events and visits, and working with departmental colleagues to enable presentation and dissemination activities to be successful and well attended.

In terms of the mobility activities themselves, as noted earlier, while the framework for the mobility programme was developed collaboratively by the Project team, partners had flexibility in how this framework was to be most effectively used in the context of their respective country. This inevitably led to some variation in mobility activities in each country. The extent to which visiting student teachers had the opportunity to actually teach varied. To some extent this was related to the possibilities available in the host schools, but language issues also played a part here. In some countries science mentors were able to identify opportunities for the visiting student teachers to lead some aspects of a lesson, and this was regarded as a highly valuable experience, for both the visitors and the teachers and pupils in the schools.

Where there was not the possibility to take a class, student teachers nevertheless were welcome to observe science lessons, work alongside students, discuss curriculum and pedagogic issues with teachers and pupils, investigate the use of ICT in science learning and so on. In addition the student teachers were able to introduce the CD teaching and learning resources to pupils and teachers and to discuss their usefulness both generally and specifically relative to the respective national curriculum context. They also were able to explore their use for their own pedagogic understanding.

Whether visiting students actually led teaching or not, it was clear from their own evaluations and from the schools that the placements were perceived to be highly valuable experiences for all involved, the benefits being seen both in science learning and in terms of cultural awareness and understanding. As one partner noted, the key to these benefits was the contextualisation of these experiences in novel but authentic settings.

The fact that the visiting groups were composed of students from different partner countries also meant that these exchanges of knowledge and understanding were not just between visitors and hosts, but among themselves. It is clear that a number of potentially lasting friendships and potential professional partnerships were established during the two week period, which fits exactly with the European philosophy of developing cross-national understanding and exchange. On returning home, the majority of mobility students also presented their experiences, and the teaching and learning resources to their fellow students and tutors.

Mobility students were very positive about the entire experience, which they regarded as a unique opportunity to develop their own understanding as well as that of those with whom they worked – the latter including teachers and students in the placement schools, and in the host universities, as well as within the group itself, as noted above. Student evaluations were uniformly positive, with the majority of responses attaining a mean rating of 4.0 or above on a 5-point Likert-type scale, where 5 represented the most positive response. This outcome was consistent across all participating nation groups, indicating a high degree of coherence in terms of the quality of the programme in each of the host countries. All of the Project partners were equally enthusiastic, noting that this had been a positive learning experience for them also. All reported that the considerable efforts required to put the programme together were more than worthwhile investments given the outcomes.

In summary, the mobility programme was highly successful in promoting pedagogical/didactical reflection on the teaching and learning of science and the role of technology in that process. Additional – and important – benefits also included the development of intercultural understanding and the potential for a pan-European collaborative network of science teachers.

Given the scale and complexity of this endeavour, the difficulties encountered by the Project partners in making these arrangements were remarkably few. These tended to concern what might be thought of as ‘bureaucratic’ obstacles such as funding and visa arrangements. More ‘local’ organisational issues related to the degree of recognition and support offered by the University administration, which varied from institution to institution.

Another issues noted by some partners was the varying language competence of the student teachers, which in some cases limited their ability to fully participate in the various teaching and learning activities. Having said this, others commented that this had not proved to be a significant barrier, and that the visiting students all learned something of the host language during their visit. The variability in the cost of living in the different countries did also prove to be an issue, in the sense that those students from countries with a higher cost of living (and therefore income) were better placed than those where the cost of living is lower.

These were relatively minor issues, however, in an otherwise positive experience, and the mobility programme can be considered to have been a resounding success, having met all of its original objectives and beyond. All of the student teachers reported having an extremely valuable experience, and emphasised that this was on a personal as well as professional level, acquiring valuable knowledge and understanding about different European education systems, and approaches to science education, as well as developing networks and friendships across culture. Finally, there was a consensus among the Project partners that this was an extremely worthwhile learning experience for themselves too, which went well beyond expectations. This was not just in terms of the organisational aspects, but crucially that they learned from and with their visiting student teachers.

### **4.3 Training Course for in-service teachers**

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As explained above, the weeklong course ran between July 3 and July 9, 2008, and was held in the Faculty of Education, University of Lisbon. The course represented a unique opportunity for researchers, educators and practicing teachers from across Europe to come together to explore ideas and expertise over a sustained period. The structure of the course involved a mixture of tutor-led workshops, independent directed tasks and small group seminar-type sessions. Tutors from each of the partner countries collaborated over a period of several months in the development of the course curriculum.

The course took a 'social-constructivist' approach in that the emphasis was on collaboration, dialogue and discovery rather than on formal instruction. Each day had a different pedagogical focus relating to different aspects of the PEC Project. The various sessions were led by tutors from the partnership countries working together in a 'team-teaching' mode, so that the participants had the benefit of a range of perspectives throughout the course. One of the final sessions explored the potential of building and sustaining a network or 'learning community' among the participants with a view to growing this to include science teachers from across Europe, with an emphasis on communications technology to facilitate this development. The course had a strong cultural and social aspect also, with a full programme of cultural visits and social events as part of the week's programme.

The evaluation of the course by the participants was highly positive. As with the mobility programme, a range of benefits were identified, from new insights into the teaching and learning of science, the role of technology in that process, and the introduction of the concept of 'scientific literacy' as a guiding pedagogical principle. While, as with all such events, some aspects were perceived to be more useful than others, no individual element of the programme was identified as less valuable than another. All of the sessions and events were rated positively by a clear majority of participants.

The intercultural understanding which emerged from the interaction of participants from different countries and different educational systems was, again as with the mobility programme, a highly rated element of the week's activities. It is notable that a number of contacts made during the week have been maintained, and that these have involved didactic/pedagogical discussions and exchanges as well as social. The perceived benefits to the participants were such that there was universal approval of the proposal to run a similar course in 2009. It is also of note that the Turkish National Agency has already expressed an interest in supporting a similar initiative in that country, based on the PEC Course model.

#### **4.4 Dissemination activities**

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Among the main benefits of various dissemination activities have been firstly, the opportunity to reflect, to discuss and examine other points of view about the Project and its achievements, leading to the potential for an improved model. Secondly, the dissemination of the criteria developed for developing teaching and learning resources, and the design process itself, allows other teachers to use this as a foundation for the development of their own materials relevant to their particular subjects and learners. These and other general benefits may be summarised as:

- An increased general interest in developing science teaching with ICT as a tool and with a linguistic approach.
- Cooperation between the university and upper secondary schools about the use of ICT and linguistic approach to increase the students' scientific learning.

- A platform for an international collaboration between both students and teachers in the future through international networks which promote and stimulate further collaboration and different types of exchange.
- Exposure of the Project methodology and outcomes to disciplines other than science, both within and between institutions.
- Enlightening teachers about the methodology of developing new pedagogic material from existing resources

## 5 Partners' perspectives on the success of the Project

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The PEC project aimed to foster an innovative methodology in order to improve initial teacher education programmes regarding the teaching and learning science through reading linguistic skills and use of digital media.

As will be clear by this point that the general view of the Project Partners is that these main objectives have largely been achieved, and that their experience of participating in the Project has been a positive one.

In this section these perspectives are made more specific. Unless stated otherwise, these views are representative of all of the project partners.

The PEC-project has contributed to increasing knowledge of how to effectively integrate ICT into science teaching in a way that is both appealing and meaningful to the pupils. The learning and teaching activities developed represent a gain to all pupils, student teachers and teachers involved. The project and materials developed were illuminative, showing how reading, writing and digital media could be integrated into science teaching and learning in secondary science classrooms and made implications to transfer this new methodology to other education levels and subject areas.

The methodology of the PEC was regarded by all partners as innovative, described by one as a 'breakthrough' in terms of challenging science teaching and learning orthodoxies in that partner's country where issues of literacy in science were described as having been 'neglected'. Such responses were not uncommon among the teachers who participated in Project and those with whom the Project was shared through the various dissemination activities.

The focus on the linguistic methods in particular is seen promoting the pupils' development of understanding of scientific method and process. This has helped to stimulate a more inclusive view of science. This has been fostered by the production of innovative learning materials and products which themselves represent concrete evidences that confirm the achievement of these initial aims. From the initial teacher education point of view, student teachers who used and observed the project materials had experience of how active and meaningful learning could take place in science classrooms integrating reading, writing and digital media into science lessons. These

resources are considered to be potentially inspiring examples to those who are interested in the promotion of subject literacy both specifically in science and more generally in other subject areas.

The PEC project has, through its materials, its mobility programme, its training course and its national and international dissemination activities, extended debates about the teaching and learning of science, and the place of reading, writing and digital media in promoting science understanding.

Finally, the benefits of the Project extended to PEC Partners themselves, who, during the project design, development and implementation, were involved in reflection, discussion and collaboration, resulting in gains in both their own and partners proposals and competencies. The administration and coordination of PEC project by the Alcalá team was regarded as exemplary. All the PEC members were very committed to and enthusiastic about the project, resulting in highly effective collaboration and a strong collegial ethos. While the overall administration was centralised, the development of the project activities was organised on a devolved model, where partners in each institution took responsibility for hosting and organising at least one project meeting, during which proposals were discussed, tasks and activities defined and action taken forward. An additional benefit of this approach was the opportunity to visit other institutions of higher education, providing insights into other educational systems and cultures and reflections on home practice.

It is of interest to note that the list of difficulties is considerably shorter than the perceived benefits of the project. Indeed, all of the partners began their response to this enquiry by making it clear that these were relatively minor. Some of those which were reported included the difficulty for some partners of locating appropriate web-based resources in their own language. This could be seen as a reflection, perhaps, of the existing attitudes to science learning in those countries, which to some extent turns a negative into a positive, since the project enabled the identification of this omission and to provide some means of addressing it.

In relation to the production of the CDs and other digital resources themselves, this was a process which came more easily to some partners than others. Those with a technical/technological background were more comfortable with production, and as a result, this occupied less time and effort than for those for whom this was a relatively

new set of skills. The issue of time generally, however, was something noted by almost all of the partners. That is to say that while none considered it not to be time well spent, it consumed a great deal of time in an already very busy teaching, research and administrative workload. This in turn resulted in partners devoting considerable amounts of their own time to ensure the success of the project. The nature of the project targets meant that it was not possible to spread this load out, so that meeting particular deadlines sometimes mean very intensive periods of work.

As with one of the barriers identified with respect to the mobility programme, not all participating institutions had the infrastructure or experience to support partners in cross-national projects of this kind. On a positive note, at least one partner reported that this had led to their institution recognising the need to develop procedures for these kind of initiatives.

## 6 Conclusions

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What is abundantly clear from the various evaluations (Mobility programme participants and from those that attended the Lisbon Course and internal and external evaluation) is that the PEC Project has been both successful and effective

Successful in meeting its original aims and objectives, in bringing together partners from across Europe to work collaboratively and with coherent purpose, and in developing a set of resources, dissemination products, articles and events, and in facilitating the creation of sustainable networks of practitioners, educators and researchers.

Effective in bringing about change in both thinking and practice of all involved, in moving forward the way in which the teaching and learning of science is conceptualised, and in identifying the ways in which exiting and emerging technologies can enhance that process.

It is a rare project that claims to be 100% successful in every area, and certainly valuable lessons have been learned which will inform future developments. However, it is the firm view of all of the Partners - the authors of this Document – that the achievements of PEC Project are substantial, meaningful and important, and that the beneficial impact of the initiative in all of the participating countries will be sustained long after the Project formally concludes.

## 7 Annex 1: MODEL A

|    |                            |  |                                 |                      |   |                              |                    |   |   |  |  | Project number<br>226641-CP-1-2005-1-ES-COMENIUS-C21 |                   |                 |                         |                          |                  |
|---|----------------------------|--|---------------------------------|----------------------|---|------------------------------|--------------------|---|---|--|--|--|-------------------|-----------------|-------------------------|--------------------------|------------------|
| WEB SITE SELECTION AND ANALYSIS: MODEL PROPOSAL (MODEL A)   |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 |                         |                          |                  |
| SUBJECT:  |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 |                         |                          |                  |
| SELECTED TOPIC:   |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 |                         |                          |                  |
| ADDRESS TO SECONDARY SCHOOL PUPILS------(AGE):  |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 |                         |                          |                  |
| OBJECTIVES OF THE SELECTED TOPIC :  |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 |                         |                          |                  |
|   |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 | 1.                      |                          |                  |
|   |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 | 2.                      |                          |                  |
|   |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 | 3.                      |                          |                  |
|   |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 | 4.                      |                          |                  |
| VISITED WEB SITES:  |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 |                         |                          |                  |
|   |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 | 1.                      |                          |                  |
|   |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 | 2.                      |                          |                  |
|   |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 | 3.                      |                          |                  |
| AIMS AND CONTENT OF THE VISITED WEB SITES:  |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 |                         |                          |                  |
|   |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 | 1.                      |                          |                  |
|   |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 | 2.                      |                          |                  |
|   |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 | 3.                      |                          |                  |
| CRITERIA (each in scale 1 ... 3)  |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 |                         |                          |                  |
|   |                            | 1. Content                                   |                                 |                      |   |                              | 1 & 2              |   |   | 2. Pedagogical properties of the Site (Prompts for learning) |  |  | 3. Usability      |                 |                         | Evaluation Results       |                  |
| VISITED WEB PAGES   | Relevance to the Curricula | Language suitable to secondary school pupils | Suitability of conceptual level | Motivational aspects | Prompts for discussions, writings, further studies, research etc. | Links to other related sites | Use of multi-media | Relation to daily life, experiences, other contexts | Reliability of the information provided | Scientific accuracy  | Amount of reading content, including downloadables | Easy access and navigate                             | Easy to learn use | Pleasant to use | Total point (out of 42) | Total point (out of 100) | General comments |
|   | 1                          | 0  | 0                               | 0                    | 0   | 0                            | 0                  | 0   | 0                                       | 0  | 0  | 0  | 0                 | 0               | 0                       | 0                        |                  |
|   | 2                          | 0  | 0                               | 0                    | 0   | 0                            | 0                  | 0   | 0                                       | 0  | 0  | 0  | 0                 | 0               | 0                       | 0                        |                  |
|   | 3                          | 0  | 0                               | 0                    | 0   | 0                            | 0                  | 0   | 0                                       | 0  | 0  | 0  | 0                 | 0               | 0                       | 0                        |                  |
| SELECTED WEB SITE:  |                            |  |                                 |                      |   |                              |                    |   |   |  |  |  |                   |                 |                         |                          |                  |

**8 Annex 2: MODEL B**

|  |
|--|
| SUBJECT:   |
| SELECTED TOPIC:  |
| ADDRESS TO SECONDARY SCHOOL PUPILS _____ (AGE)                 |
| AIMS:  |
| SELECTED WEB PAGE:   |
| <b>LINGUISTIC ACTIVITIES</b>                                   |
| ACTITIVIES RELATED TO: <b>develop Reading comprehension</b>    |
| ACTITIVIES RELATED TO: <b>acquire and reinforce vocabulary</b> |
| ACTITIVIES RELATED TO: <b>improve writing</b>                  |
| <b>SCIENTIFIC ACTITIES</b>                                     |
| ACTITIVIES RELATED TO: <b>improve scientific knowledge</b>     |
| GENERAL OBSERTAVIONS (if any):                                 |
|  |

## 9 Annex 3: MODEL C

| OBJECTIVES FOR ACTIVITIES                        | LINGUISTIC ACTIVITIES (LA) |   |   |   | SCIENTIFIC ACTIVITIES (SA) | SCIENTIFIC SKILLS TO BE DEVELOPED THROUGH LA and SA | SUGGESTED WAY(S) TO IMPLEMENT THE ACTIVITIES |
|--|----------------------------|---|---|---|----------------------------|---|--|
|  | 1                          | 2 | 3 | 4 |                            |   |  |
| ACT1. <i>(brief description of the activity)</i> |                            |   |   |   |                            |   |  |
| ACT2. <i>(brief description of the activity)</i> |                            |   |   |   |                            |   |  |
| ACT3. <i>(brief description of the activity)</i> |                            |   |   |   |                            |   |  |
| ACT4. <i>(brief description of the activity)</i> |                            |   |   |   |                            |   |  |