GRID Project
Report of the reports and of the initiatives

31 December 2006
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A. PREAMBLE

This document represents the major production of the GRID project supported by the European Commission under the Action 6 of the SOCRATES Programme. The objectives of the GRID projects are as follows:

1. Inventory national initiatives by creating a compendium of the various initiatives carried out in the current and future member states of the European Union (Analytical reports, recommendations, action plans...) through the comparative analysis of all the actions.

2. Identify local experimentations under development, through a catalogue of all the experimentations carried out in current and future member states of the European Union.

3. Make available to decision-makers and the involved schools a virtual exchange and discussion space by developing a virtual community for cooperative work.

4. Choose a limited number of experimentations under development and capitalise them by organising work seminars gathering decision-makers and schools in order to enhance practice exchange and identify some operation patterns that could be diffused on a large scale.

5. Contribute to the writing of a memorandum on the obstacles generated by the upgrading of science teaching at school. The memorandum will be based upon former works and two surveys concerning decision-makers on the one hand and a sample of European schools on the other hand.

6. Implement diffusion actions on a large scale.

The structure of this document will comprise the following sections:

- A first section presenting the political context and more specifically some elements of the Lisbon strategy with regards to the disaffection on maths, sciences and technology.

- A second section which presents briefly the GRID project, its objectives and its various outputs expected.

- A third section presenting in a synthetic way the two major reports produced within the GRID project.

- A fourth section presenting the first major report concerning the analysis of national institutional based reports, action plans dealing with this issue of maths, sciences and technology.

- A fifth section presenting the second major report presenting the analysis of specific initiatives identified and analysed at school level.

- A sixth section proposing some recommendation on both reports described previously.
B. PREAMBLE – LISBON STRATEGY AND DISAFFECTION ON MATHS, SCIENCES AND TECHNOLOGY

B.1. THE LISBON STRATEGY – A NEW POLITICAL IMPETUS

1. A EUROPEAN CONTEXT AND A POLITICAL AGENDA QUITE FAVORABLE

Since 1999 (the Bologna declaration) up to December 2004 (Communiqué of Maastricht), and even up to 005 (Communiqué of Bergen), the importance attached at a political level to the development of European cooperation in education, training and youth have taken a very special dimension. As to the last five years, one may in particular highlight the five following developments:

- **June 1999** – The Bologna Declaration which has to be seen in the light of the wish to develop and build a European space of higher education.

- **March 2000** – The European Council in Lisbon in 2000 responded to the changing global challenge by announcing a comprehensive economic and social policy strategy: to become, by 2010, “the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth, with more and better jobs and greater social cohesion.” In the light of slow economic growth, an ageing society and the emergence of new competitors on the world market the Lisbon strategy is today more urgent than ever.

- **March 2002** – The high ambitions in the field of European education and training were also expressed in the wish of the Barcelona European Council of March 2002, that European education and training systems should become “a world reference for quality by 2010.” This resulted in the elaboration of a work programme for education and training 2010 with the aim to define the future concrete objectives of the education and training systems in Europe (the Council of Stockholm of March 2001)

- **November 2002** – As for higher education in 1999, the declaration of Copenhagen of November 2002, stipulates clearly the different elements concerning strengthened cooperation in vocational training. These activities are part of the follow-up activities of the Process of Bruges initiated in October 2001 and which were further implemented through the Maastricht Communiqué of December 2004.

All those elements mentioned above show that, contrary to what happened in previous years, of the first generations of community programmes in the field of education, training, youth and culture, all the action programmes of the EU which are running at the moment such as Socrates, Leonardo, Youth, Tempus and Culture 2000, are tools put at the disposal of the Commission to feed and nourish the reflection process at the level of the whole Lisbon strategy.

2. TOWARDS A KNOWLEDGE ECONOMY

Coming from an economy based on qualifications in the 70ties and the 80ties, up from the year 2000 we have to work within the framework of a knowledge-based economy being aware that the problems concerning ‘competence’ have received much attention and reflection around the 90ties. The importance given to knowledge, to formal and informal know-how are key elements in the
coming about of the knowledge society. Indeed, if it is true that the concept of the knowledge society goes beyond a mere commitment to invest more in research and development, it is, however, important to clearly mention that it also includes all the aspects of the economy within which knowledge is at the heart of the added value.

Even if the development of the information society is concerned which allows to encourage the dissemination of the technologies in relation with innovation and communication, even if it concerns the creation of a European Research and Innovation Area by increasing up to 3% of the GDP the expenses invested in R&D, the implementation of the knowledge society also requires an important investment in education, training and in human capital.

It is within this context that it is necessary to adapt the education and training systems to the knowledge society by favouring lifelong education and training for all on the one hand and by promoting on the other hand the transnational mobility in all its aspects.

3. THE FUTURE OBJECTIVES OF EDUCATION AND TRAINING SYSTEMS AND THE 5 BENCHMARKS

The Council has grouped the strategic objectives of European education and training systems into three broad categories, concerning:

1. the quality and effectiveness of education systems;
2. access to education;
3. opening up education systems to the wider world.

The first objective concerns the improvement of the education and training of teachers and trainers but it also concerns the development of the key competences for an easy integration into the knowledge society while not forgetting the need for everybody to have access to information and communication technology. It is also stressed that it is important to attach particular attention to the recruitment of learners into science and technology disciplines and to use the resources available in the best possible way. All these elements tend to improve the quality and the efficiency of the education and training systems.

The second objective which concerns the willingness to facilitate access for all to the education and training system, will give special attention to the creation of open education and training environments and will see to it that education and training become more attractive. It is stressed that within this process it should not be forgotten to promote citizenship, equal opportunities and social cohesion.

The third objective which proposes to open to the outside world the education and training systems, will attach a special importance to strengthening the links with the world of work, of research and with society. Attention should also be paid to the development of the spirit of enterprise or the entrepreneurial skills and also to the improvement of foreign languages. Finally the increase in mobility and exchanges and the reinforcement of European cooperation will be key elements to be implemented within this third objective.

In addition to these overall strategic objectives, the Council has set precise targets or "benchmarks," in five exemplary areas of education policy, namely:

1. By 2010, an EU average rate of no more than 10% early school leavers should be achieved.
2. The total number of graduates in mathematics, science and technology in the European Union should increase by at least 15% by 2010 while at the same time the level of gender imbalance should decrease.
3. By 2010, at least 85% of 22 year olds in the European Union should have completed upper secondary education.

4. By 2010, the percentage of low-achieving 15 year olds in reading literacy in the European Union should have decreased by at least 20% compared to the year 2000.

5. By 2010, the European Union average level of participation in Lifelong Learning should be at least 12.5% of the adult working age population (25-64 age group)

These benchmarks are not concrete targets for individual states, but rather "reference levels of European average performance." They are targets for the Union as a whole, and the collective responsibility of the Member States to reach the targets by 2010 is translated into action at national level on the basis of specific national policy priorities, fully respecting the principle of subsidiarity, as stipulated by the Treaty (Article 149 and 150).

It is within this special context that the present European programmes in education and training have to be seen. Indeed, a programme like Leonardo is considered to be a laboratory to experiment in the area of vocational training. Similarly the Socrates programme is the major programme of the European Union as to European cooperation in the field of education in all its different forms whether it concerns formal, non formal or informal education.

The support to innovative projects, which stimulate the reflections at the level of the thirteen subobjectives of the work programme of education and training 2010, represents an important inflection to demonstrate the links that exist between on the one hand the Lisbon strategy at the political level and on the other hand the contribution of the community programmes in the field of education and training in the field.

4. ENHANCED COOPERATION IN VOCATIONAL TRAINING

Similarly, strengthened cooperation in the field of vocational training as highlighted by the Copenhagen declaration invites to attach particular importance to the four following areas:

1. the need to strengthen the transparency in the qualifications, the information and guidance related to vocational training;
2. the need to attach special importance to the problems concerning the recognition of the competencies and the qualifications;
3. the need to promote cooperation in quality assurance in Europe;
4. the need to attach special attention and to strengthen the European dimension in vocational training.

All those elements defined in the Copenhagen Declaration are explicitly mentioned in the priorities in the calls for projects of the Leonardo programme which is the leading programme of the Commission in the field of European cooperation in vocational training.

5. TWO MAJOR EVOLUTIONS

For the last ten years, and especially during the last three years, a major evolution is taking place as to the contribution of the Community programmes to education and training:

- First, the concepts of education and training tend to progressively fade away to the advantage of the concept of lifelong learning. To this has to be added the change from the concept of ‘teaching’ to the concept of ‘learning’.
The second major change concerns the use of the Community programmes in education and training to contribute to the political agenda and in particular to the Lisbon strategy in general and more specifically to the 2010 programme for education and training.

It is within this context that the new Community programmes in the field of education and training which will be implemented up from the end of 2006 and the beginning of 2007, will develop. These new programmes will have to be part of this new political context of which the major challenges can be summarized in the following way:

- The need to continue to enhance and promote the development of transnational mobility in all its forms;
- The need to strengthen all the mechanisms to promote language learning and teaching;
- The need to take action so that all the means of the information and communication technology are used in the best and most appropriate way;
- The need to give an answer to the social changes within our society, while taking into account the rapid evolutions in the world of work and the development of the policies in the field of lifelong learning;
- The need to preserve social cohesion, amongst others in the field of the problems related to social inclusion;
- The need to take into account the large number of people that have low qualifications in Europe;
- The need to invest still more in vocational training systems and finally;
- The main importance to be given to the quality of the training of our teachers and trainers.

6. CONCLUSION

The challenges are numerous, diverse and varied in nature. However, more than ever the ambition is needed to respond to the challenges of the enlargement, to the one of the aging society, or to the one of the intensification of global competition without omitting the efforts to bring about the European labour market and to reduce the level of unemployment. All those elements can not be tackled without given special attention and importance to the education and training systems in Europe.

The European Union has up from now to face both internal and external challenges. As far as the internal challenges are concerned, one has to be aware of the ageing problem in Europe which represent, of course, a certain number of problems on the one hand on the other hand also offers great opportunities such as related to the challenges of the teaching profession as within the next ten years 1 million teachers and trainers have to be recruited to replace those who retire.

The second challenge has to do with the enlargement which on the one hand stresses inequalities and problems of cohesion within the Union but on the other hand also offers a lot of positive opportunities for the new Member States such as the perspective to increase strongly the GDP and the productivity while they are catching up with the other European Member states. This will no doubt result in the creation of an area of economic dynamism in Europe.

As to the external challenges, the internal competition intensifies and thus Europe has to take up the challenge from Asia and the USA. It is in this sense that Europe has to develop especially in areas in which it specializes, in which it excels and in which it is stronger than its competitors. This implies automatically a strong commitment to the knowledge economy in the largest possible sense of the term.
It is in this context that the Community programmes for education, training, youth and culture have to be understood. Responses have already been initiated by the European Union both at the level of the programmes of European cooperation within Europe and the new Integrated programme for lifelong learning and at the level of the European cooperation programmes with countries outside Europe such as Erasmus Mundus, Tempus Plus, and the initiatives and intervention tools within the programmes MEDA, CARDS, TACIS. These are all elements which will enable to tackle all those challenges in a confident way and with a possibility of real success in the near future.

B.2. CURRENT SITUATION - PROGRESS TOWARDS THE LISBON OBJECTIVES IN E&T (1)

Drawing on lessons learnt from five years of implementing the Lisbon strategy, the European Council in March 2005 decided on a fundamental re-launch of the strategy. It agreed to refocus priorities on jobs and growth within an overall objective of Sustainable Development and sought a stronger mobilisation of all appropriate national and Community resources.

The re-launched Lisbon strategy focuses on competitiveness, growth and productivity and strengthening social cohesion. Even more than in its first phase, the revised Lisbon strategy places strong emphasis on knowledge, innovation and the optimisation of human capital. The onus put on European education and training systems is immense. Investing in research, education and innovation play central roles in generating added value and contributing to the creation of more and better jobs. Education and training are seen as critical factors to develop EU's long-term potential for competitiveness as well as for social cohesion.

The Lisbon strategy and the open method of co-ordination (OMC) radically changed European policy co-operation in the area of education and training. It provided a platform to discuss education and training policies at European level, and the OMC offered the opportunity to build a coherent policy framework without impinging on national competences. Recognising the pivotal role of education and training in the knowledge society, the European Council (Lisbon) invited Ministers of Education “to reflect on the concrete future objectives of education systems,” and to concentrate on “common concerns and priorities.” Building on this and further mandates, the European Council in Barcelona in March 2002 approved the “Detailed Programme on the follow-up of the objectives of education and training systems” for 2010 and set the objective of “making [European] education and training systems a world quality reference by 2010.”

Following the adoption of the Detailed Work Programme, eight working groups were set up to focus on one or more of the 13 concrete objectives. Comprising experts from 31 European countries (EU member States, Acceding countries, Candidate countries and countries of the European Economic Area), as well as other stakeholders and interested EU and international organisations, their role is to support the national implementation of the common objectives set for education and training systems through exchange of good practice, study visits, peer learning activities, etc. A Standing Group on Indicators and Benchmarks was also set up to assess progress towards the objectives, and to identify models of successful policy practice.

The Joint Interim Report, “Education and Training 2010: the success of the Lisbon strategy hinges on urgent reforms”, adopted by the Commission and the Council in February 2004, was the first evaluation of progress on the Detailed Work Programme. It identified three levers as crucial to reaching the goal of making education and training systems in Europe a world-wide quality reference: firstly, focusing reform and investment on the key areas for the knowledge society; secondly, making lifelong learning a concrete reality; and thirdly, establishing a “Europe of Education and Training.”

In the 2004 Joint Interim Report, the Council and the European Commission furthermore undertook to review progress every two years on implementing the Education and Training 2010 work programme. Thus a second draft joint interim report was adopted by the Commission in November 2005. Negotiations with the Council (through the Education Committee) led to adoption of the joint report in February 2006. The report is based primarily on the 2005 national reports of the Member States, EFTA-EEA countries, and the acceding and candidate countries. It delivered a number of strong political messages to the European Spring Council of March 2006 in the context of its first review of the revised Lisbon strategy. These included:

- Education and training are critical factors if the EU's long-term potential for excellence, innovation and competitiveness, as well as for social cohesion, is to be sustained. The dual role - social and economic - of education and training therefore needs to be reaffirmed, as well as the need to ensure the development of high quality systems which are both efficient and equitable. There can be no trade-off between these two dimensions.
- Education and training must be viewed as a priority for investment. The high returns it provides substantially outweigh the costs and reach far beyond 2010.
- Reforms in education and training are moving forward, but more substantial efforts are required.
- Investments, coupled with relevant quality assurance mechanisms, should be targeted on areas where economic returns and social outcomes are high.

### B.3. MATHS, SCIENCES AND TECHNOLOGY (MST) - A KEY CHALLENGE FOR EUROPE

#### 1. SOME FIGURES

Europe's future competitiveness in the global economy will depend to a great extent on its supply of scientific specialists and on ensuring that they are put to good use. Mathematics, science and technology (MST), including computer sciences and engineering are vital for the development of the knowledge-based and increasingly digital economy. The EU has a higher proportion and larger absolute numbers of tertiary graduates in these areas than the USA or Japan. However, it does not fully capitalise on this potential, as it has fewer active researchers (both in absolute and relative terms) in the labour force than the US or Japan. Europe needs to develop and increase the attractiveness of its research labour market, in order both to retain and make use of its own talent and to attract researchers and scientists from outside Europe.

In 2003 the EU had 755,000 maths, science and technology graduates compared to about 430,000 in the USA, 230,000 in Japan and over 800,000 in China. The share of MST graduates (as a % of all graduates) was at 24% slightly higher in the EU compared to the USA (19%) and Japan (23%). However, measured per 1000 inhabitants aged 20-29 Japan (13.2) has more graduates than the EU (12.2) or the USA (10.9). EU countries with a high ratio of graduates in the population 20-29 included France, Ireland and the UK. While the European growth rates are impressive they might be overstated by double-counting of graduates in the move to a BA/MA structure (not considering short programmes/BA growth would reduce the growth rate 2000-03 by about 1%). Growth in the number of MST graduates is moreover even stronger in new competitors like India and China.
2. THE DISINTEREST OF YOUNGSTERS FOR SCIENTIFIC STUDIES – A WORLDWIDE ISSUE

The lack of interest of students to start scientific studies affects, so it seems, nearly all industrialised countries. This is worrying for two reasons:

- It could compromise or have a negative effect on the economic system that more and more depends on its ability to develop technological innovation. No one can doubt about the fact that in an economy which is bound to become an economy of intelligence, the scientific and technical / technological competencies are one of the cornerstones on which to build the economic system. Furthermore the strength of the countries will be measured through the number of innovators, researchers it has and the number of patents deposited.

- It is also an important problem and challenge for the public research which will have to cope, especially in the years ahead, with many scientists, technicians and researchers taking their retirement.

The development of Europe towards a knowledge society implies the need of a scientific culture with all its citizens so as to be active citizens also in the field of scientific and technological choices. Hence a high quality science education is vital on the one hand to see to it that the citizens can acquire the competences needed by the knowledge society and on the other hand to train enough scientists and researchers. To invest in knowledge and in innovation contributes to prepare the citizens especially as to their scientific and technological competencies and their potential scientific careers.

However, the interest for studies in scientific areas and the number of scientists, researchers and engineers is decreasing in the labour market. Moreover, the effect of the ageing population will only add a cumulative effect to this lack of human resources. To increase the recruitment in scientific studies, the motivation of the youngsters for sciences is the major factor together with better information about scientific studies and the creation of a scientific country within the different countries.

The pupils form themselves an image of science up from a very young age (in fact at the level of the pre-primary or primary school!) which has an impact on their positive or negative attitude towards science and technology. Youngsters very often perceive sciences as arid and sterile and without any visible links with the world that surrounds them. Recent studies show that motivation of youngsters is the fundamental element in the decision to be taken concerning scientific studies and concerning a career in this area. It is here that the school, the teachers and the education system have a major role in adopting a positive attitude towards science without forgetting the influence of the family and of society in this whole processes of choice and selection.

Certain European surveys point out that at the end of the primary school, half of the children say that they are not interested in sciences and technology and are not their thing. At the end of the lower secondary school 90% think studying sciences is not for them. A study carried out in Norway has lead to similar results. One could thus conclude that science teaching in the primary school and in lower secondary schools discourages pupils instead of motivating them for science.

According to the OECD, the number of scientists and engineers that graduate from university is decreasing just at the moment when they are greatly needed to support scientific and technological innovations.
To discuss the problem concerning ‘Women and sciences' one cannot ignore the European report « ETAN report ». This report was commissioned by DG research of the European Union in the fall of 1998 and it is destined for decision-makers in the field of scientific policies. During its elaboration several other documents were published by the EU on the same theme and in the same spirit such as the Communication of the Commission « Women and Sciences: mobilizing women to enrich the European research» which was published in February and the Resolution of the Council of Ministers of May 1999. It was discussed in the European Parliament in December 2000. 

It is a clear indisputable fact that the numbers of students are diminishing in scientific disciplines whichever the gender of the students. But it is especially the questions related the choices made by girls which raise major questions. The disproportion between boys and girls in certain technological and scientific areas of study worries both psychologists and educators. To raise the interest for women in the 'hard' sciences is seen as a major challenge in several recent publications and by numerous associations such as “Women and sciences” which have the ambition to promote sciences with women and the image of women in sciences.

If one analyses more thoroughly the situation of women in sciences, one can find several disparities. The report « She Figures 2003 - Women and Science » (2), shows very clearly that while the engineering professions are most severely hit by the imbalance men / women, the areas of literature, arts, health and social sciences maintain a high proportion of women. Next to this one can observe a real drop in the number of graduates in certain disciplines. Indeed between 2000 and 2001, the number of graduates having completed a first university cycle or degree (ISCED 6) has dropped with more than 14% or from 105 000 to 90 000. Even if countries like France are above the European average, the tendency is everywhere the same and those countries will also be hit by the same phenomenon.

The areas which are most sensitive and where, undeniably, the majority of men are male are engineering, sciences in general, mathematics and informatics. The area of research is similarly hit by a shortage of women: in 1999, only 20% of women graduated in research, engineering and technology in the majority of European countries. Even in the disciplines in which there are most women up to now, such as the medical and human sciences, have a majority of men researchers except for a few countries such as Sweden and Finland.

It would be useful to analyze more in detail certain data so as to explain, for example, why there are so few women researchers in medical sciences compared to the number of graduates in that area. Even if it is not clear if these women go for more technical professions, one can only see that women are not interested in research without one being able to explain why this is the case. One sector in particular, the one of industry is severely hit by the shortage of female researchers, as for the 50% of active researchers only 15% are women. Even in the public services where overall the percentage of women seems to be more important, it remains well below 50%

At European level, even if women represent half of the students in the first cycle of university studies, a progressive decrease of their numbers can be pointed out at each level of the university studies. Women tend to disappear in the universities before they have obtained a key post in their career. Looking from the other side of the mirror, one can point out that the higher one moves in the hierarchy, the less women are present. The presence (or one could better speak of the absence) of women is also very worrying when it comes to the post of teachers in the universities within whichever discipline. Even the Member states which have the highest proportion of women present are situated within a range of 13 and 18% as far women are concerned.

At the level of the European union, the Commission has set up in 1999 the Helsinki « Women and Sciences » and which is composed of national representatives who are directly in charge of working on this problem. It is this group which has drafted the report « She Figures 2003 ». The objective of this group is on the one hand to assist the Commission in the drafting of the next statistics and indicators common to all European countries so as to follow-up the participation of women in research and on the other hand to exchange information as to the policies implemented to encourage participation of women in scientific research at all levels (local, regional, national and European).

In 2001, the working document of the services of the Commission called « Women and sciences : the gender dimension, a lever to reform sciences» puts forward the first results of the Helsinki group such as the setting up of a pilot group in each country to participate actively in the promotion of women in sciences and to collect basic statistics as to the presence of women in scientific research in Europe.

The point of view that women are underrepresented has less relevance in ECE countries where participation of the two gender was equal in public education and the curriculum was centrally organized. (Participation in non-compulsory subjects of science was different, for the good of boys.)

4. A TEACHING APPROACH WHICH HAS TO BE REVIEWED

The education systems are confronted with the consequences of massification of schooling, which has not always been well prepared, and which often leads to changes without overall vision. The difficulty of taking into account the heterogeneous nature of the pupils but also the increasing discrepancy between the ideal of progress and equality to be achieved by education and its translation into facts, result everywhere in a certain disarray of the main actors, the teachers, pupils and parents.

In all the countries the top down approach applied in the education systems is challenged and efforts are being made to favour the emergence of more responsibility and autonomy which are given to the schools while avoiding too much competition between the schools. The top down approach is replaced by bottom-up approaches combined with mild top down approaches.

The crisis concerning sciences is not limited to the problem of ill-paid and ill-loved scientists. The teaching (learning!) methods of sciences are put forward by the pupils themselves as one of the key reasons why the interest for science is lacking or disappearing.

Sciences suffer also from the fact that they are perceived as abstract. This lack of popularity is very often attributed in different countries to the shortages in terms of the programs and the manuals (used in the classroom) that may lead to a purely mechanical learning or teaching process without enabling a real comprehension of the notions and concepts used.

Still too often education at secondary school level takes the form of teaching (ex cathedra) with a small amount of practical work. If experiments are carried out in the classroom, they are mostly carried out by the teacher and the pupils are ‘reduced’ to spectators watching what is happening. The acquisition of a scientific approach is abandoned in favour of learning (by heart!) definitions and standard procedures.

To promote enthusiasm of young children for science requires an important effort of the teachers who are usually badly trained to do this and who themselves have not studied or appreciated those subjects when they were at school. Teachers are confronted in their classroom with pupils who very often know more about information and communication technology than themselves while the teachers have no idea of the laws of physics that support them and have no interest in knowing them.
It is impossible to be complete on this topic. However, one has to mention the challenge of the renewal of the teaching force which is ahead of us in the next ten years. The development of the knowledge society is based upon:

- The creation of knowledge through research and development activities.
- The dissemination of this knowledge through education and training systems.
- The putting in practice of this knowledge through innovation and the development of new technologies in our daily lives.

In this context it is important to see to it that one has high quality teachers in Europe. This is one of the indispensable conditions for the development of the knowledge society. Simultaneously the teachers are invited and required to take more and more tasks on their shoulders. In a society which is in constant evolution, the expectations as to teachers are more and more numerous and more and more complex. This is why it is important to invest still more in the teachers and trainers in Europe.

Thus we have to face a double challenge as to the teaching force in Europe:

- First of all there is a quantitative challenge as over the next 5 to 10 years approximately ONE million teachers have to be recruited by 2015 (which means many more than the needs over the last 20 years).
- There is also a qualitative challenge as the future teachers have to receive a high quality (excellence) training so that they can face the challenges of the knowledge society.

This is a major challenge but is also offers a lot of opportunities. In relation with the problems concerning the lack of interest of pupils and youngsters for science and technology, one has to reflect on the implementation of specific positive actions to increase the visibility of the teachers involved in science and technology.

5. SOME KEY QUESTIONS

Hence some key questions are asked:

- How to make sciences more attractive for youngsters and how to promote the teaching and learning of sciences?
- How to encourage or incite young people and pupils to stake up or study sciences?
- Which pedagogical tools, changes in the curricula, extracurricular activities etc. are necessary to improve the quality of the teaching (and learning of sciences)?
- How to improve the perspectives of scientific and research careers and how to avoid that people drop out of those areas during their professional career?
- How to increase and strengthen links between research, the world of work (companies and industry) and society?

The ministers of Education and Research meeting in Uppsala in March 2001, have reflected on those questions: the debate focused on the tendencies and the challenges of the scientific and technological disciplines in tomorrow's society and a large consensus was reached on the need to motivate youngsters, in particular girls, to take up scientific studies and to embark on a professional career in those areas of science and technology.

This event in Uppsala has had an impact on later debates in this area and has introduced the concern to strengthen the scientific context in relation with the interest of youngsters and the
present challenges of society. The initiatives taken successively at the European level illustrate this approach. We mention, amongst others:

- The Resolution of the Council « Women and science » (June 2001),
- The putting in place of the Working Group on Maths, Sciences and Technology in the framework of the working programme Education & training 2010.

Within this context the European union has intensified its efforts in the fields of research, innovation, education and training and is putting in place this European knowledge space. This has also translated itself in the development of ambitious projects either as to the development of European networks and centres of excellence in the fields of research and education but also by putting in place working groups of which the objective is to implement the work programme « Education and Training 2010 » which is part and parcel of the Lisbon strategy.

6. **The MST Group set up by the Commission within the Education & Training 2010 work programme**

A synthetic analysis of the activities carried out since 2003 by the WG Maths, Science and Technology put in place in the framework of the work programme « Education and Training 2010 » shows clear evidence of a certain number of specific elements.

The following different aspects are especially pointed out:

- The importance to be given to under-representation of women in the study areas of maths, science and technology.
- The putting in place at the level of the Lisbon strategy of 5 key indicators (benchmark) one of which focuses directly on maths, science and technology as the objective by 2010 is to increase the number of graduates in those disciplines by 15% giving furthermore a special attention to reduce the imbalance between men and women.
- The importance to be given to the development of new pedagogical approaches for the teaching (and learning) of maths, science and technology.
- The need to reflect on the profile of the teachers of those disciplines and on the decisive role they have to play (at all levels of education) to do something about the increasing lack of interest and dropping out of science, maths and technology studies.
- The necessary re-enforcement of the relations between educational institutions (in the largest sense) and companies (school-industry links) which should contribute to give, inter alia, another image of science and technology.
- The involvement of the parents in this process.
- The need to develop new links and new mechanisms of cooperation between primary and secondary schools on the one hand and with higher education on the other hand.
- The diversity of approaches as to the practices used in different countries.
- It is imperative to be able to identify and bring together good practices concerning the different challenges mentioned earlier.

Within the framework of the Working group Maths, Science and Technology (Group MST), an important number of good practices have already been identified.

One of the major challenges is now to be able to classify all those good practices making use of a grid of analysis and of a specific methodology so as to better prepare the peer evaluation work which will be carried out in relation with those practices.
C. PRESENTATION OF THE GRID PROJECT

C.1. THE NECESSITY TO BE ABLE TO SHARE INITIATIVES AND EXPERIENCES IN EUROPE

Numerous national and international reports, which have been largely disseminated by the media, try to explain the lack of interest and the dropping out of scientific studies by mentioning ideological reasons (lack of confidence in the progress) and by mentioning even sometimes an anti-scientific attitude in our schools. This may be partly true as a certain lack of confidence is real (GMO – Genetically Modified Food and Organisms, Cloning etc. are real society problems) but one has to add to this the difficulty to be involved in science education which requires from the pupils major efforts. To make youngsters accept these efforts and this personal investment and to promote more interest in scientific jobs and professions/studies efforts have to be made to put forward all the advantages and positive aspects, such as the ludic or playful element, which should be part of science education.

However, it is important to point out all the reports commissioned by the different ministries and that all the proposals for action suggested by them and recommended to be implemented, are limited to the national framework and do not take into account or build on initiatives conducted in other European countries. This absence of the European dimension at the level of defining the facts, problems and challenges and of formulating the recommendations, results in not making use of certain opportunities or in undeniably losing (European) added value. It is important that convivial forms of exchange and cooperation are set up at the level of experiences and good practice which can result from the different national initiatives.

Moreover, at national level, a certain number of pilot projects and experiments have been set up but no cross-fertilisation activities have been put in place to analyse and compare situations and actions across different European countries when putting in place and evaluating similar activities to promote maths, science and technology.

C.2. GENERAL OBJECTIVES OF THE GRID PROJECT

It is in this context that the GRID project has been launched. The GRID project first aims at inventorizing, analysing, experimenting and validating the methods, techniques and best practice to improve scientific teaching at secondary school. Then it aims at diffusing these methods, techniques and best practice at European level with all the relevant means (conferences, seminars, workshops, publications, Websites...). The objectives of the network thus created will be to:

1. Inventory national initiatives by creating a compendium of the various initiatives carried out in the current and future member states of the European Union (Analytical reports, recommendations, action plans...) through the comparative analysis of all the actions.

2. Identify local experimentations under development, through a catalogue of all the experimentations carried out in current and future member states of the European Union.

3. Make available to decision-makers and the involved schools a virtual exchange and discussion space by developing a virtual community for cooperative work.
4. Choose a limited number of experimentations under development and capitalise them by organising work seminars gathering decision-makers and schools in order to enhance practice exchange and identify some operation patterns which could be diffused on a large scale.

5. Contribute to the writing of a memorandum on the obstacles generated by the upgrading of science teaching at school. The memorandum will be based upon former works and two surveys concerning decision-makers on the one hand and a sample of European schools on the other hand.

6. Implement dissemination actions on a large scale across Europe.

C.3. OUTPUTS OF THE GRID PROJECT

In terms of planned production, the various deliverables will be as follows:

- Development of a web portal to all national initiatives under way, including:
  - Compendium of institutional initiatives under way per country (one synthetic sheet per initiative).
  - Catalogue of innovating experimentations started in pilot institutions in all the countries.
  - Comparative analysis of the national institutional initiatives under way.
  - Exchange and discussion fora.
  - Case studies of specific experimentations.

- Reflection and work seminars (including the proceedings of the seminars) aiming at maximising and capitalising the actions carried out in the various countries.

- Memorandum on the obstacles generated by the upgrading of science teaching at school.

To sum up:

- Make an inventory, compile, test, try out and disseminate the most promising pedagogical methods to enhance science education.

- Provide appropriate existing tools and methods which have been tried out, to promote the teaching and learning of science and technology in well focused and multidisciplinary areas.

- Promote the exchange of knowledge and best practices between the partners of the project and at the level of networks of teachers.

- Enhance teaching (and learning) practices that integrate scientific culture.

- Disseminate at European level initiatives as to the teaching and learning of science that have already been implemented and tried out (successfully) in other European schools and classrooms.

Overall the objective of the project is to demonstrate that a mosaic of pedagogical approaches and methods are practiced across Europe at different levels – regional, national, pan-European – that complement each other more than that they are in opposition to one another and that it would be particularly relevant to make use of this rich diversity.

The quintessence of the GRID project is to contribute to strengthening the attraction of the teaching and learning of sciences in schools. Its is about the valorization, the capitalization and about focusing
on the added value of the actions programmes, initiatives and the study reports commissioned by the different ministries of education dealing with this problem of science education. The object of the report is mainly focusing on the comparative analysis of different national situations and on putting in place a network of cross-fertilizing exchanges enabling to valorise national approaches at European level.
D. PRESENTATION OF THE TWO REPORTS OF THE GRID PROJECT

D.1. TWO MAJOR REPORTS TO BE PRODUCED

As mentioned here above, the GRID project intends to produce two major reports:

- **Report 1**: This report will present the analysis of national reports, institutional policies at whichever is the level (Ministry, academy, schools...) which aims are to improve the learning and teaching of maths, sciences and technology in schools. It has been decided to tackle this issue as broadly as possible and to take as the key criterion the fact whether a document sheds a particular and innovative light on the issue of learning and teaching science. Hence the elements of this report will analyse the recommendations which are integrated in national reports, comments, national communication campaigns etc as well as any action plan which may refer to special measures to promote science education or which allocate supplementary funding or means such as pilot projects etc.

- **Report 2**: This report will focus on the description of initiatives and projects at grassroots or classroom level. Within those reference is made to actions or initiatives that are made possible by the reports, actions plans or recommendations mentioned in report 1.

In the course of the project, all the objectives remained valid and relevant. It was, however, important to clarify some elements:

- Most of the European countries are more or less represented in the study. It was difficult to identify in certain countries official reports, studies and recommendations on the one hand and field initiatives on the other hand. However, finally the data collected are largely sufficient to make it possible to give a clear image of the situation of science education at European level.

- Language problems can be backwards of proportional representation of innovative projects in many, mainly ECE countries. Innovation in science education is based more on mother tongue than in innovative collaborations in broad European issues like European citizenship. Teachers of these subjects have less foreign language competencies and can have less support from foreign language teachers who are lack of science literacy.

- The website, which will be operational at the end of the project, will present on the one hand a catalogue with a great number of elements of the two key studies of the project: the reports and studies as well as the examples of good practice.

- One of the main priorities of the GRID project has thus become to select the "good practices" answering the objectives of the project, to make them available on a website and to classify them according to relevant selection criteria.

- A particular effort will be made on the website as to the presentation of concrete field initiatives in order to make it possible for teachers to judge if he or she can implement a
similar initiative in his or her school. This transferability issue has been at the core of the case studies which have been selected.

D.2. METHODOLOGY ADOPTED FOR PRODUCING THESE TWO REPORTS

The methodology adopted has combined the techniques of investigation and observation (questionnaires, semi-directive interviews, participating observation and filmed observation allowing the analysis of the practices), and the techniques of experimentation making it possible to develop a comparative study of the mechanisms put in place to promote science education and making it possible to develop a typology of the initiatives and the mechanisms to enhance innovation in science education.

Annex 1 of this report presents in details all the different stages of the methodology used for producing this report.
E.1. METHODOLOGY TO PRODUCE THESE NATIONAL REPORTS

1. A VERY VARIED PICTURE

The overview herewith given doesn’t intend to be comprehensive for all countries involved in the Socrates programme. All countries were contacted through Ministries of education, through the inspectorate, through the members of the European Working Group on MST (Maths, Science and Technology) but information was not received or not available from all countries. In some cases no major policy reports or action plans had been produced over recent years and in other cases the people contacted did not react. Sometimes new reports were produced towards the end of the project as the Norwegian MST Strategy: A Joint Promotion of Mathematics, Science and Technology (MST) published in June 2006.3

The overview of reports shows clearly that reports are more popular in some countries than in other. Some countries have even no major official report in the area of science education for several years. Other countries have several reports.

In some countries key innovation actions are subseuent to a general or specific report drafted within the country by teams of experts. In other cases action has been taken subsequent to external evaluation reports such as the PISA reports (4). Subsequent to the PISA reports specific action was taken both in Germany and Austria which has brought about major innovations in sciences.

The methodology to draft the reports may differ according to the country but in most countries working groups or committees of experts have been created. In some cases large scale consultations have been held on education and which the future challenges of education are. This is the case in Malta, France, Belgium (nl) and Austria. In some cases specific consultations have been held with limited number of people: this is the case for the initiative “La main à la pâte in France” where 192 persons were auditioned. In other cases in situ visits, encounters with lecturers & researchers, seminars or symposia were organised to gather information for the reports or papers. In one French case the report is just a synthesis of several other reports.

It is interesting to point out that for the drafting of some reports (such as in France) there was an extensive auditing of schools, classes and teachers which means that the report is based on solid field work. Other cases, however, show reports drafted without any direct involvement of the grassroot level.

The Maltese consultation has resulted in the report “Creating the future together: national minimum curriculum”. The French general consultation on education which took place in 2003-04 under the title of “Eléments pour un diagnostic sur l’école: document préparatoire au débat national sur l’avenir de

3 The full text is to be found on the following website: http://www.naturfagsenteret.no/Strategiplan2006_eng.pdf
4 The Programme for International Student Assessment (PISA) is an internationally standardised assessment that was jointly developed by participating countries and administered to15-year-olds in schools. The survey was implemented in 43 countries in the first assessment in 2000, in 41 countries in the second assessment in 2003 and at least 58 countries will participate in the third assessment in 2006. Tests are typically administered to between 4,500 and 10,000 students in each country.
"l'école" (Elements for a diagnosis of the school: preparatory document for the debate on the future of the school). This resulted in 2004 in the report "Pour la réussite de tous les élèves" (Ensuring that all pupils achieve their full potential also called the Thélot report). The Austrian consultation started in 2003 on the topic of Klasse: Zukunft (The classroom: its future) and resulted in April 2005 in the report "Zukunft: Klasse: Strategien und Massnahmen zur Qualitätsentwicklung".

The report "Accent op talent" (followed by Accent op Talent: een agenda voor vernieuwing!) of the Flemish Community of Belgium which was published in 2003 was also the fruit of a large consultation but not as large as in the case of France and Austria.

The development of the Dutch Delta Plan Bèta Techniek (or Science and Technology) was the fruit of a long consultation and of several reports and other action plans to promote science and technology. The delta Plan is one of the rare plans which addresses all the levels of the chain of education from the pre-primary school to higher education also involving companies.

At the end of 2006 the Icelandic ministry of Education, Science and Culture is preparing major activities to promote maths, science and technology through a research study called Goals of the Intentions and reality research project in Iceland 2005-2007.

2. SUBJECT OF THE POLICY REPORTS

Some countries have specific policy papers, programmes or action plans to do something about science and technology. The SET programme in Italy (together with the Law 6/2000) is focusing on all disciplines related to science and technology. The new Norwegian action plan is focusing on maths, science and Technology and so is Iceland. Sweden is putting a major focus on maths through a.o. the activities of the National Centre for Maths Education of Bengt Johansson in Göteborg.

In the Flemish community the policy plan for science and technology is adopted for three or four years and is implemented through an annual action plan. The annual action plan foresees specific action in the field of education.

In several countries documents, reports or policy papers have been produced in recent years focusing on the need to change education in general. Within those reports specific attention may be given to science and technology. This is the case of the Italian report "How the school is changing", the Dutch report "Vooruit: innoveren in het voortgezet onderwijs!" and the report of the Flemish department of education "Accent op talent".

In Hungary teaching and learning, supported by ICT in any subject, is one of the stressed dimension of the overall content reform also so as to science and technology.

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5 For the full report in French see the website: http://www.debatnational.education.fr/upload/static/lerapport/pourlareussite.pdf
and for a synthesis in English see: http://www.debatnational.education.fr/upload/static/lerapport/syntheseVA.pdf
6 See website: http://www.klassezukunft.at/index.php
7 Full report Zukunft: Schule; see website: http://www.klassezukunft.at/statistich/zukunft/de/zukunftskommission_%20abschlussbericht_2005_langform.pdf
9 The full text is to be found on the following website: http://starfsfolk.khi.is/allyson/step/
10 For further information, see the website: http://www.ncm.gu.se/node/202
12 Accent op Talent; all reports to be found on the following website: http://www.kbs-frb.be/CODE/page.cfm?id_page=125&id=182&lang=NL
In some cases (Malta, France, NL, DE, UK) particular focus is given to specific levels of education such as the primary school as it is there that the basis for the interest for science and technology has to be laid.

### 3. Authors and Partners of Reports

Most official reports have been commissioned by a ministry that is dealing with education or science or with science and education. This is the case in France, Belgian NL, Norway, Sweden, Iceland, Italy, Portugal etc. Very often this is linked to the focus and the width or breadth of the study or report. Much depends upon the way in which the responsibilities are split over different ministries in the different countries. In some cases one has one ministry dealing with education and sciences in other cases these are separate ministries.

Usually, in the case of one ministry for education and science, it are sub parts of the ministry that have commissioned the study and those depend upon the structure of the ministry. In France some of the reports have been commissioned on the one hand by the Inspection Générale de l'Education Nationale" (Inspection general of national education) while other reports have been made through the department focusing on Research and which is in charge of developing policy in the field of research and scientific employment.

In some cases, Ministries may appeal to specialised institutes. This the case of the PISA report made by the IPN Leibniz Institute and on which subsequent specific action was built within the SINUS projects and the SINUS transfer projects in Germany.

Even if over recent years, there has been no major report on science education in Austria, this is also the case for the Austrian Ministry which has made use of the Services of the IFF/Institut für Unterrichts- und Schulentwicklung University of Klagenfurt to implement concrete action to promote Maths, Science and Technology (IMST initiatives) subsequent to the Austrian PISA report. The IFF will report regularly to the ministry on the progress made in the IMST initiatives.

### 4. Duration

It is very difficult to say what the duration is of the reports or policy papers or action plans. It would be better to speak of the duration of the impact of such reports and documents as this is much more important. A report made over one year may lead to actions over several years. Some of the reports mentioned were made at the end of the nineties or beginning of the 2000 such as the one of Malta or the LUMA report in Finland and they are probably only now generating a full impact. Other reports like the French general report (2005) - see footnote 4- and Austrian general reports (2005) - see footnote 5 and 6 - on education are probably too young and too recent to look at this moment at the impact of the possible changes.

In some cases an action plan may be embedded in a long term approach which is the case of the action plan for science information and innovation in Flanders which is part of the policy of the Flemish Government covering the period of 1994 to 2010.

### 5. Target Groups

The majority of the reports have as a primary target group policy makers, decision-makers and key groups such as universities, research centres, teachers, inspectors or even industrialists. In some cases the target are those groups in education in general but some of the more focused reports on science focus mainly on those involved in science education. Several reports (IT, Malta, IRL) also
focus on parents as an important target group. Some reports have as a target group a very specific group: this is the case of the Spanish manifesto of the Science centres, which addresses science centres and museums dealing with promotion, dissemination and popularisation of sciences and technology.

The majority of the Italian reports have as a target group both policy makers and teachers. In fact, as most of them are official documents enacted by the Italian Ministry of education, they agree addressing the school heads and directors of the Regional offices in order to be disseminated amongst teachers.

In all cases the documents do not address directly the pupils or the students. However some documents have been drafted bearing in mind students and families. This is the case of the Italian ‘How the School is Changing’.

Several reports are addressing researchers and the world of industry. This is the case of the Flemish action plans and of the Italian Agreement MUIR / COFINDUSTRIA. It is interesting to point out that in a few cases, such as the Flemish Accent op talent report’ people from business and industry played an active role in discussing the ideas put forward in the document. In that particular case the committee in charge of the report was even presided by the CEO of a major private company.

6. WORKING GROUPS – COMPOSITION OF WG AND PERSON(S) IN CHARGE OF WG

All the reports and policy papers have been drafted by policymakers, decision makers, experts in science or science education, researchers, scientists, inspectors, representatives of industry etc. The composition of the working group depends upon the focus of the report and its objectives. In a few cases teachers or pedagogical advisors (for sciences) are involved. In Ireland a special task force was set up composed of 44 members from industry, education, department of education and science and third level colleges; their work resulted in a report and recommendations. In several cases the composition of the working group is not expanded upon and the names of the people involved are not mentioned. The European reports of the WG MST mention clearly all the experts involved with detailed information which proves to be very useful.

It is not always clear whether trade unions have been involved in drafting reports, policy papers or action plans. Sometimes there is clear evidence there is no clear evidence that the trade unions are involved. They are involved in the case of the drafting of the Maltese report "Creating the future together: national minimum curriculum" and the report of the Flemish Community of Belgium "Accent op talent". The participation of the social partners, especially the trade unions, the professional organisations and the business world in general, is critical as changes in the curriculum and especially in the way in which the curriculum is delivered and changes in the role and assignment of the teacher have to be discussed and looked at in cooperation with the trade unions. There may be more involvement of trade unions but it is not always clear in the information given about who was involved in the consultation on which the drafting of a report was based.

In the case of the ‘Science Curriculum Review’ (England), the review itself was conducted by science students age 16-19 with only minimal assistance from the principal organisers.

In many cases it is not clear who has been in charge of the working group drafting the report. The composition of the WG is not always available. In other cases it is a leading scientist or industrialist who is in charge and the documents give the detailed composition of the working group.

It is only the Working group on Maths, Science and Technology set up within the framework of the detailed work programme of the European Union which gives all details of the WG members.
When making a list of possible members of working groups or groups of people involved in one way or another in collecting the information or drafting the reports, the following people can be said to be involved:

- representatives of ministries of education and/or science
- social partners especially trade unions (in a limited way)
- representatives of economy and industry: national federations or organisations, chambers of commerce etc.
- representatives of higher education
- representatives of associations (academies of science, association of (scientific) journalists, a variety of science and technology associations), associations of (science) teachers
- representatives of cultural institutions (e.g. Cité des sciences et de l'industrie, science museums, museums in general etc.
- teachers from primary, secondary of higher education
- the inspectorate
- pedagogical advisers
- representatives of the audiovisual sector and of publishers
- parents' associations (as observers)

It is interesting to point out that as far as the European WG on MST is concerned the Commission has always invited the major European NGO's as observers in the meetings. This is reflected in the presence of associations such as: OBESSU (school students), ESIB (university Students), SEFI (engineering education), EPA (parents), CLUSTER (universities of science and technology), EWM (Eur. Women in mathematics), STEDE (Science Teacher Education development in Europe), UNICE (employers' federations) and ETUC (Trade unions).

7. ACTORS AUDITED

For several studies or reports the different stakeholders were directly or indirectly involved. In some cases information was gathered through questionnaires, in other cases through interviews. In some cases there were ad hoc working groups or public or semi-public hearings organized on the topic concerned. In most cases reports are based on the analysis of available data to complement the information gathered through meetings and interviews.

The actors audited range from primary and secondary school teachers or heads, pedagogical advisers, pedagogical counsellors, teachers at initial and in-service teacher education institutions, inspectors, university experts, students from higher education institutions, external actors acting as volunteers, local or regional or national authorities, universities, companies, research centres or institutes.

8. IMPLICATION FROM THE VARIOUS STAKEHOLDERS

According to the nature and the scope of the report, policy paper or action plan different actors or stakeholders will be involved. And the impact at grassroots level may be different. The implication on the ground may differ according to the approach adopted to do something about education in general and science education in particular. The implication at grassroots level (teachers of primary and secondary schools and their heads) is the largest when the ministry implements a bottom-up approach inviting teachers, heads and schools to come forward with creative ideas. The implication on the ground is limited when there is a top down approach whereby the ministry makes legislation or action plans without involving the grassroots level. In most cases the bottom-up approach seems to be adopted these days.
When the actions proposed or described in the reports or policy papers concern science education the whole educational community is involved. In several cases this reaches from all the members of the school community, to members of the local community such as universities, research centres and companies.

In some cases science museums, scientific libraries archives and other institutions, organizations of associations (of scientists) may be involved.

Teachers sometimes are involved in a very concrete way and the impact on teachers is very large. This is the case in the Italian FORTIC programme focusing on the use of ICT by teachers. Teachers of all Italian schools at all levels of education are concerned by giving all of them - even those working in very remote schools - the occasion to acquire ICT skills from the basic to the expert level. ICT training is seen as the basis to improve science teaching quality as it contributes to use innovative teaching methodologies (digital acquisition of knowledge) and as it is the basis for the creation of a virtual learning community of teachers who are exchanging good practice across the country and even beyond.

Several reports or policy papers propose initiatives, which may have an impact on both the teachers and the pupils within the school community. This is especially the case for all policy documents or papers, which specifically address the issue of scientific and technological culture within schools.

**E.2. NATURE OF THE REPORTS, POLICY PAPERS AND ACTION PLANS**

The reports or documents available are very different in nature. They can largely be subdivided into three categories:

- **The first group are the reports, action plans and documents which focus specifically on science and the promotion of science in general.** Those documents very often address not only target groups in education but in all areas of the society. The objective is to reach on the one hand specific audiences and on the other hand the general public.

- **Linked and closely related to this category, there is a sub category which consists of those documents that focus on science education specifically.** This second category could be further subdivided into documents focusing on specific levels of education such as “La main à la pâte” (Hands on science) to promote science in the primary school. Those specific science documents do not necessarily refer to or expand on the more general documents about the promotion of science and technology.

- **Third category are those reports which focus more on education in general and which may also refer to science education.** However even when they focus on sciences they very often do not solely focus on science but simultaneously on maths and technology and sometimes also on ICT.

**1. REPORTS FOCUSING ON SCIENCE**

Hundreds of reports on science, aspects of science, science education or aspects of science education have been produced over recent years. The present study only mentions some of them and gives particular emphasis to those which the experts involved in this project have said to be important for the development of science in general and for science education in particular. The idea was not that
this project would give a comprehensive overview of all science and science education report as this should be the topic of a multi-annual in-depth research study.

1.1. Reports focusing on the promotion of science in general

The first main category consists of those reports which focus on the promotion of science and technology in the whole society. Most countries plus of course the European Union itself, are aware of the importance of innovation as a key element for the development of the economy and hence they have drafted reports focusing on all the issues or challenges at stake. Within those documents or reports focusing on sciences in general there are some focusing on specific topics such as the low interest for and low participation of women in science studies, science jobs and research jobs. Thus some studies were made by the Commission of the European Union, by France and by the French Community of Belgium focusing on the role and the participation of women in science. In the case of Spain there is a specific report – a manifest – of the Spanish Science centres. The latter is still useful even if it is 9 years old.

The English Government has published a ten-year investment framework for science and innovation alongside the 2004 Spending Review. The framework sets out the Government’s ambition for UK science and innovation over the next decade, in particular their contribution to economic growth and public services, and the attributes and funding arrangements of a research system capable of delivering this. It is a long-term strategy paper as to the actions to be taken in the field of science. The Government has consulted extensively with key stakeholders in drawing up this investment framework, including the scientific community, businesses, charities and regional and devolved bodies, as well as international contacts, and has received invaluable contribution from a wide range of individuals and organisations. At Budget 2004, the Government published a consultation document ‘Science & innovation: working towards a ten-year investment framework’. Many organisations submitted responses and consented to their publication.

France has produced in 2003 a report “Principes enjeux et verrous scientifiques au début du XXIe siècle : synthèse des rapports sur la science et la technologie». This is not a real report but a synthesis of several reports focusing on the recommendations towards possible action. The major topics have been brought together under several headings and issues for which sciences have to play a key role: Mathematics and their application, Environment and sustainable development, Research in support to nuclear energy of fusion and fission, From the molecule to society, From the knowledge of genomes to their applications, Organisations and functions of the living, Knowledge of the vegetal world and classification of the living and The measure of the universe.

Sometimes innovation reports in general may direct or indirect focus on science education. This is the case with the German report “Innovation: More Dynamic for Competitive Jobs” of the federal Ministry of Economics and Technology. In this report there is interesting suggestions as to promoting entrepreneurship in science and technology through junior companies (simulations of companies).

Sometimes innovation and science reports may take a special form. This is the case with the German Innovations report. The innovation report is a modern forum for science, industry and economy for promoting the innovation dynamics and for establishing new contacts for greater use of the available innovation and performance potential. Our editorial office researches and publishes our current messages of more than 6,700 content partners daily. Among these are colleges, research institutes, big enterprises, medium-sized companies, State and independent institutions from the whole world. In more than 13,000 reports and specials articles annually, innovation report provides current pieces of information about new technologies, highly interesting results from development and research, innovative products and services, scientific conferences and promotion projects, competitions and awards, trade fair news and many more. Short illustrations - with concise pieces of information about our partners from industry, economy and science - are found in the B2B domain, under Profile
& Short Portraits. With the b2b-service scientists and companies have a specialist fair with accurate pieces of information on products and services of future-oriented companies at disposal. Further pieces of information and further links contain the categories - Research, Job & Career, and Service.

Another example of science reports addressing science (and technology) in general and within this broad scope shows interest for science education, is the Action plan for science Information and Innovation of Flanders in Belgium. Within this general action plan attention is given to education. It is furthermore interesting to see that Flanders has developed a strategy since 1994 to promote science, technology and innovation. The last ten years can be subdivided into three periods: the seeding period, the maturing period and the consolidation period.

Sometimes reports focus on European comparisons such as the report Geographical and Lingual Preferences in Scientific Collaboration of the European Union (1994-2003) and are made by several key players in science and/or science education. This report is the result of project which was launched over several years to study the structure and mechanism of scientific collaboration among 15 member countries of European Union (EU-15) using bibliometric data (1994-2003). This paper presents the basic ideas, methods, and part of the findings. In scientific collaboration EU-15 gets more open over the past decade. The proportion of the collaboration within EU countries is decreasing, while the proportion of the collaboration of EU countries with also the co-authors from non-EU countries is increasing. There exist geographical and lingual preferences in EU-15 scientific collaboration. When the geographical proximity of the collaborative countries gets smaller, the collaborative strength negative-exponentially declines. When the lingual proximity of the collaborative countries gets smaller, the collaborative strength negative-exponentially declines as well.

1.2. Reports specifically on science education

In most cases those reports address all the sciences together without having special reports for specific areas such as natural sciences, chemistry, biology or physics.

All the French reports focusing on science education address sciences in general and not one particular discipline. Even if the lack of interest for sciences with youngsters is not to be seen in all separate disciplines of science, they are addressed together. The idea behind this being that science has to be addressed as a comprehensive issue. Furthermore interdisciplinary and transdisciplinary approaches are at the core of many innovative developments which explains why the different sciences are not split up.

The fact that several reports focus on science in the primary schools shows that interest for science has to be promoted at an early age. It is impossible to raise interest all of a sudden at secondary school level but efforts have to be made as soon as possible. This also explains some of the initiatives to promote sciences with children in the pre-primary school. It is important to point out that reports mention that there must be ‘sustained’ efforts throughout primary and secondary education to enhance the interest and motivation for science. It is not enough to stress science in one particular year and then to weaken the focus on it. The efforts to raise interest and motivation for sciences must be constantly present.

Examples of reports addressing specifically the promotion and the improvement of scientific and technological culture and education are: the Italian SET programme, the ‘Delta Plan Bèta / Techniek’ of the Netherlands (13) and the Irish Report and recommendations of the task force on the Physical sciences. All those reports have a specific focus on science education and sometimes also on technology.

The English report “Science Teachers: supporting and developing the profession of science teaching in primary and secondary schools”, is particularly interesting as it addresses the question which is valid in all European countries as to what would make a material difference in helping science teachers in primary and secondary schools develop and improve their professional practice, individually and collectively?

Similarly the suggestion that the Government should take full account of the particularly complex and demanding nature of science teaching in schools and that it should ensure that major action is taken to positively encourage, empower and enable science teachers to develop and improve their professional practice, is equally valid across Europe.

Most of the ‘science’ reports or policy papers or action plans are focusing on all disciplines related to science and technology such as natural sciences, biology, physics, chemistry. Some focus on one of those with maths. Sometimes they also focus on cross-curricular and interdisciplinary approaches.

Some reports also explicitly focus on ICT as they can be a major support for other science activities and for the creation of learning communities between science teachers across one country or across Europe.

2. REPORTS ON EDUCATION IN GENERAL WITH REFERENCE TO SCIENCE EDUCATION

Many reports focus on education in general and the improvement of education in general. Such reports may focus on different elements: most of them mentioned the acquisition of basic competencies in the field sciences as a key competence. The Austrian report “Klasse: Zukunft: Strategien und Massnahmen zur Qualitätsentwicklung” states on page 24 that the basic competences (reading and writing, competences in maths and in natural sciences, competences in ICT) have an opening up function as they enable to have access to the available knowledge so as to solve the daily problems of our life; they also build the foundations of lifelong learning and continuous education and training.

The French Thélot Report "Pour la réussite de tous les élèves" stresses on page 50 that during compulsory education each pupil has to be given the opportunity to master the common base of essential subjects and thus find his own route to full achievement. The report states that all pupils should acquire the essential elements of humanities and of sciences, of manual work, of physical and sports education, of arts, of languages, of technology and of the discovery of companies and the professions or trades.

Other reports also focus on restructuring the curriculum, the way in which teaching and learning have to be organised, the way in which evaluation has to take place and the way in which education contributes to lifelong learning and to the knowledge society of the 21st century. This is the case of Portuguese report ‘Sistema Educativo Portugues: Situacao e tendencies 1990-2000.’ This report highlights the particular stress which is given in upper secondary (3 years) education to scientifical and technological areas. Another Portuguese report “Strategies for action” focuses on new pedagogical approaches across the whole curriculum through contextualised application of the curricula, monitored study in small groups. This report also gives particular attention to the roles of teachers who can help to create better conditions for progress of pupils to professions in scientific and technological areas. A new approach can also be seen in the Hungarian report on the Vocational Training Development Programme (for ISCED 3CG) that highlights the importance of teachers’ role in motivating pupils of lower, generally handicapped social background (GRID report No 1121).

The Report ‘Accent op talent’ of the Dutch-speaking community of Flanders. Also focuses on the role of education in general in coping with the shortages in the technical and technological professions. It advocates that new ways of counselling students, new pedagogical methods in the classroom focusing on learning (and not on teaching) and new ways of organising schools are necessary to attract more pupils into scientific and technological professions.
The 14-19 Education and skills report\textsuperscript{14} of the DfES in England of February 2005 sets the future perspectives of education and training in England. This report stresses in several places the importance of promoting science education. Under item 3.16 at page 25 of the report, it stresses that "Throughout the 14-19 phase, it remains a priority that young people can pursue these subjects. In our increasingly scientific and technological world, we continue to put science at the heart of education as a compulsory subject in the National Curriculum in Key Stage 4 and have made it a priority to encourage more young people to take it up post-16. And we already have in place statutory entitlements to study modern foreign languages, the humanities, the arts, and design and technology. We will make sure that all of these are available to all young people."

The Greek report "A cross thematic curriculum for compulsory education" focuses on the development of the new cross curricular / thematic framework introducing a cross-thematic approach to learning. This innovative endeavour aims to the adjustment of teaching aims and methodology while focusing on the balanced distribution of teaching contents among all grade levels and the horizontal linking of all subject content, seeking thus to cover a greater variety of topics. Science and technology get in this report special attention. Sciences are strongly linked to environmental education and the teaching of science is linked to the systemic perception of reality. Major stress is on measuring the effects of science in everyday life. Science, technology and maths are basic skills and pupils must learn to reflect critically on the impact of those on their lives considering social, legal and moral issues. The horizontal linking between natural and social science should contribute to strengthen the holistic view of the world.

The Maltese report "Creating the future together: national minimum curriculum" \textsuperscript{15} is particularly interesting as it covers several issues related to science education even if it is a document covering all the aspects of the education system.

Several of those issues / challenges that the Maltese education system is trying to strategically address, are more than worth mentioning as they appear in several if not all the education systems education systems:

- Developments in science and technology and the ability to make use of the recent developments in these areas
- Digital processing of information and knowledge
- Developments in the cognitive sciences, with an emphasis on individual learning styles and their effect on pedagogical approaches
- Technology has to be made into a democratic tool, a force that generates social change and creates new forms of knowledge; to this effect all students have to gain access to and training in technology
- The teaching of design and technology will prepare suitably pupils to live and work in a technological world

Several of the challenges mentioned above are also reflected in the kind of projects that are described in the GRID database.

\textsuperscript{14} For the full text of the 14-19 Education and skills report, see the following website: \url{http://www.dfes.gov.uk/14-19/documents/14-19whitepaper.pdf}

\textsuperscript{15} See website for full text of "Creating the future together": \url{http://www.education.gov.mt/ministry/doc/pdf/curriculum_english.pdf}
E.3. OBJECTIVES AND MAIN TOPICS ADDRESSED IN THE REPORTS

1. OBJECTIVES

The objectives of the report are more or less similar according to the category to which they belong. Overall one could say that many policy papers or reports tend to strengthen the social basis for science, technology and technological innovation in a society that is constantly evolving further towards a knowledge society. Several reports and papers have as an ultimate objective the potential of the society to be able to cope with the technological and scientific changes of the 21st century that can contribute to sustainable economic development.

It may be the promotion of sciences in general, or the promotion of science education in particular. It may also be the promotion of the quality of education in general.
In most, if not all cases, the objective is to raise the interest for science and science education and to attract more youngsters into scientific, technological or technical jobs or professions.
In the case of the Dutch Δ-Plan: B (Béta) / Techniek report, one of the outspoken objectives is to attract more youngsters into scientific and technical or technological jobs.

Reports that focus on specific problems such as the fact that students do not select sciences as a field of study or that women do not choose to study sciences, all focus on three elements: the analysis of the present situation, the analysis of the possible causes of this situation and proposals for action to solve the problems. Thus one of the French reports starts by analysing the society context within which scientific, technical and industrial culture has to be situated and then proceeds to study how the different stakeholders analyse this situation and try to formulate answers to the challenges.

Several reports mention the improvement of the quality of the science teachers as an objective. This is the case of several of the Italian, Dutch, French and the Flemish reports. The teachers have a key role to play in the improvement of science education. Teachers are in some cases also linked to initial and in-service teacher education issues for science teachers.

Many reports and studies refer to the objective of the creation of databases with examples of good practice as a key element to promote innovation in education in general and in science education in particular.

One of the objectives of several reports is also that serious efforts have to be made to disseminate very largely the outcomes of the information mentioned in the reports and of the activities set up subsequent to the reports. However, little evidence is available that this has happened or is happening. In some cases it is clear that a database has been developed and examples of such databases are given further on in the present report. Bringing together information about science databases with examples of good practice and developing such a specific database was the main objective of the GRID project.

The objectives of papers or reports with a specific ICT focus stress the objective of promoting and disseminating with teachers and students the use of ICT to enhance the quality of science education. The use of collaborative multimedia tools (by pupils, students and teachers), the production and use of multimedia materials both by students, pupils and teachers is also very often an objective in those reports.

Several papers and reports put forward as an objective to fight against student’s disaffection for science by proposing the creation of more links between schools, universities, industry and/or research centres.
One of the French reports has to be taken separately as it focuses exclusively on the implementation of the action “La main à la pâte” (Hands on science) in three French departments. This « Main à la pâte » initiative is the spearhead of innovation in science education in the primary school in France. Hence it is very symbolic and very well illustrating the problems in that field. Through two key surveys the report tends to:

a) Measure the intensity and the nature of the commitment of teachers by comparing classroom observations made by inspectors (IEN or Inspecteurs de l’Education Nationale whose mission it is to organise the support and evaluation of primary school teachers) and the objectives defined in the ten principles of the implementation charter of the “Main à la pâte” action;
b) Give a quantitative and qualitative description of the teaching of sciences of two departments in France that are not much involved in this innovative action.

In most cases reports tend to explain the reasons why there are problems in science education, the constraints and obstacles that influence possible changes and innovations. Most reports refer to possible action through recommendations for various stakeholders.

2. MAIN TOPICS ADDRESSED

The different reports, policy papers or action plans address a variety of topics and issues which are listed below:

- Science Information campaign for the general public, for students and their families or for other specific groups to redress the imbalance between the lack of interest in scientific and technological education and the need to have more people in science and technology studies, professions and jobs;
- Promotion and improvement of scientific and technological culture and education within schools;
- Promotion and improvement of scientific and technological culture and education within initial or in-service teacher education institutions;
- Increase interest for and recruitment in science studies at secondary school or university level in general;
- Increase interest for and recruitment in science studies of women;
- Survey of attitudes of parents and teachers to science (IRL);
- Appropriation of funds for the promotion of scientific culture: science villages, didactic researches in science and history of science; promotion of technical and scientific culture in schools;
- The place of science education within primary or secondary school reforms;
- Surveys of attitudes of pupils to science (UK);
- Comparison of grades in leaving certificate science subjects against other subjects (IRL);
- Case studies of schools with high science take up to find out why this is the case (IRL);
- Improve quality and innovation in education through different means;
- Improve quality and innovation in science teaching and learning;
- Cooperation agreements between educational partners (regional in-set centres, teacher centres etc.) and/or other partners such as science museums, science centres, industry, research centres etc.;
- Create more and better links between school, industry, university and research centres.
E.4. ACTION SUBSEQUENT TO POLICY REPORTS – EXAMPLES OF INITIATIVES LAUNCHED

There is a great diversity in the actions set up subsequent to the report. It all depends upon the kind of report and the audience the report addresses. Some reports don’t mention any action at all as this depends upon the nature of the report. In some cases reports refer to possible action but they don’t give any information as to the possibilities or the conditions necessary for the practical implementation or operationalisation of the actions concerned. In several cases actions or initiatives are set up by the Ministry of Education (and science) in other cases it may be by other ministries that are in charge of promoting innovation. In this report we have limited ourselves to initiatives set up and implemented by Ministries of Education for practical reasons. Making a larger study would necessitate more time and means.

Most reports would suggest that more information be given to the target group they aim at. This can be the general public, the companies, the universities or research institutions, the teachers, schools, the teacher trainers etc.

This is quite normal as policy makers involved in drafting policies papers and reports know that the stakeholders have to be well informed if they want them to help in the implementation of the policy suggestions made by the policy paper, report or action plan.

In most cases those reports, action plans and policy papers lead to the following kind of actions:

- Publication of official texts or documents on science education as is the case;
- Making available special funds (i.a. through calls for projects) in order to finance the promotion and dissemination of science and technology (Scotland, IT, NL);
- More funding to science education at primary school level. Those schools get an annual grant for science equipment (IRL);
- This si also the case in the 21st Century Science GCSE course (14-16) (UK);
- Extra funding given to develop existing initiatives, programmes and networks to improve and raise interest in science education (England)
- New contents for the science subjects: new syllabus such as the new Junior Certificate science syllabus in (IRL);
- Science re-introduced in the primary school curriculum (IRL)
- New pedagogical approaches for science education which is discovery based and hands on (IRL, FR, Malta);
- Coordinated science courses (Malta);
- Pilot projects for schools (most countries);
- Pilot projects for universities, research centres;
- In-set training activities for science teachers (IT, Bnl, Malta, De, PT, FR);
- Action towards initial teacher education (FR, NL, England);
- Appointment of additional in-service trainers to set up and run in-service training for science teachers;
- Organisation of initiatives, activities or projects e.g. 100 class projects (Agreement USRLAZIO);
- The organisation of a regional database of good practices (Agreement Tuscany);
- Activities for pupils and/or students: science days or weeks, visits to, science museums, work in laboratories, meetings scientists and researchers etc. (most countries);
- Creation of a CD-ROM with information material (La main à la pâte, FR);
- Multimedia support materials for primary schools (FR);
- Partnerships between schools (several countries at national or European level);
- Partnerships between schools and teacher training institutions (e.g. in European projects such as SMEC);
- Partnerships between schools, universities, research centres and/or companies (IT, IRL, Bnl, DE, FR);
- Reorganisation of school systems: How the school is changing - IT);
- Creation of National Network of Science Learning Centres (England)
- Creation of a network of ‘Centres for Excellence in Mathematics Teaching) (England)
- Creation of a partnership between existing science centres/museums to promote science education initiatives and create joint exhibitions and activities (Scotland, Hungary)
- The setting up of a national agency ‘Discover science and engineering’ to coordinate science promotion (IRL);
- TV and radio programmes were set up to promote science (IRL, Bnl, Hungary);
- Actions towards the inspectorate (FR);
- The creation of a permanent WG on the curriculum (FR);
- Improved incentives for graduates wishing to pursue a career as a science teacher (England)
- Implementation of a career structure for science technicians and assistants (England)
- Funding to create a network that will provide coherence to the many initiatives in place to raise interest in science in school (UK)
- Creation of a national career structure for science technicians and assistants (England)
- Impact on the policies for counselling pupils and students (in France: setting up other reflections on scientific culture, the dissemination of scientific culture as in the six main orientations for research policy, publication of official texts in the Official Bulletin)

E.5. PRESENTATION OF SOME PILOT PROJECTS LAUNCHED

1. INTRODUCTION

A very popular and widely used means of promoting innovative approaches in education are the pilot projects. They are used for all sorts of innovation in school education in general and also in science education in particular.

The pilot project may differ in nature according to the country concerned and according to the legislation that allow pilot projects to be set up. Some countries have an important tradition with pilot projects (DK, NO etc.) and have a flexible legislation that facilitates the setting up, the implementation, the evaluation of the pilot projects and the dissemination and valorisation of the outcomes of such pilot projects.

The pilot project mechanism is very often part of an overall strategy within which a top down approach is combined by a bottom up approach. The top down approach focuses on the government asking the stakeholders or actors to participate in an activity defined by the government in a policy paper. The bottom-up approach enables stakeholders and actors (such as schools, universities, companies etc.) to present ideas for projects and activities to the government either on an ad-hoc basis or by participating in calls for proposals. R+D institutions can be mediators of this process like it can be seen in Hungarian pilot projects of Országos Közoktatási Intézet (National Institute for Public Education).

In most cases schools are invited to come forward and present creative ideas as to innovation in education in general or in a specific area such as sciences. The ministry of education just described the general contours within which the projects have to be proposed. The implementation of the pilot projects is the full responsibility of the schools but the ministry will follow-up and assess the outcomes. The ministry of education may also directly or through some support structure give training or other forms of help to the teachers and schools involved in such pilot projects.
In all cases schools involved in pilot projects have to pay attention to disseminating the outcome to other schools. This takes the form of schools becoming gradually so-called aquarium schools where other schools can go and see how innovation is implemented. In some cases like in Germany schools cannot apply on an individual basis with an innovative project but have to give proof that the school has set up together with other schools in a region or area a network. Such a network has to be created to strengthen dissemination and valorisation of the outcomes. Pilot projects have thus to be seen as the first step towards generalisation of innovative initiatives.

The support given to schools of teachers may be a direct financial support or an indirect one be exempting teachers part-time or full-time from their teaching assignment when they are involved in a project. In the case of Austria the teachers involved in the science projects supported though the University of Klagenfurt get financial support when they have written their action research report.

2. NATIONAL PILOT PROJECTS

National (or regional) pilot (demonstration) supported by the Ministry of education are implemented in several countries across Europe. It is important to point out, as mentioned earlier, that in all countries pilot schools commit themselves also to disseminate by becoming ‘aquarium schools’ which are schools that can be visited by other schools so that they can observe how innovation is being implemented in those schools.

Denmark has had for many years a mechanism to support innovation in Vocational and Technical education with the FOU or Forsøgsprogrammet omfatter bl.a. afprøvning af nye undervisningsformer og -forløb (16). These FOU pilot projects are very successful and have contributed to promoting real and through innovation in Denmark. A full database of all the projects supported is available on the Internet but only in Danish!

Norways has worked for many years with ‘Demonstration schools’ which is a similar model as schools are given opportunities to implement creative ideas. They have to show and communicate the results of their innovation to other schools in the area.

The Flemish Community of Belgium is implementing at this moment the ‘Hothouse schools’ (Proeftuinen ) (17) which in a pilot phase of two years were called the ‘Voortrekkersscholen’. One teacher per pilot school is part-time exempted from teaching to coordinate the pilot project. Descriptions are available of the Proeftuinen on the Internet but only in Dutch!

England had its Beacon schools (18) and now has the Leading Edge Partnerships and the Pathfinder schools19. The Leading Edge Partnerships (20) provide capacity for practitioners to work together in order to tackle some of the more intractable challenges facing the education system in the drive to raise standards. The programme offers funding distributed via a lead school for use across their partnership to work on locally determined learning challenges. Partnerships are committed to working collaboratively to inspire, design, test and adapt professional practice to raise standards of teaching and learning where improvement is most urgently needed. There is a particular focus on partnering

16 FOU database of pilot projects: http://www.delod.dk/kompudvikling/
17 For further information on the Proeftuinen in Flanders; see the website of the department of education: http://www.ond.vlaanderen.be/NIEUWS/2005p/0615-proeftuinen.htm
18 For further information on beacon schools, see the website: http://www.standards.dfes.gov.uk/beaconschools/
19 For further information about Pathfinders, see the website: http://www.dfes.gov.uk/14-19/dsp_pathfinders.cfm?sid=9&pid=214&ctype=TEXT&ptype=Single
20 Leading Edge Partnership schools: see website: http://www.standards.dfes.gov.uk/leadingedge/what_is_leading_edge/?version=1
with schools struggling to raise standards and partnering in order to raise pupil achievement by addressing issues of under-achievement among pupils from poorer socio-economic backgrounds and from particular minority ethnic groups.

Germany and Austria have the possibility of Schulversuch (pilot projects or schools that ask to be pilot schools) as a mechanism to create and support pilot projects. This means that schools can submit on a regular basis, projects ideas to the ministry which can be selected and funded.

Germany as it has set up a major initiative up from 2000 to promote math and natural sciences, viz. the SINUS initiative (21). This initiative has resulted in the development of 11 modules that support teachers in their daily work. This is particularly interesting as the modules developed give a strong general and specific basis to improve the teaching and learning of maths and natural sciences. Based on the knowledge and competences teachers acquire through those modules specific innovative projects can be implemented which are chosen by the schools.

The 11 modules are the following ones:
- Module 1: Development of project work in maths and natural sciences education
- Module 2: Work with natural sciences
- Module 3: Learn from one's mistakes
- Module 4: Ensure basic knowledge and comprehensive learning at different levels
- Module 5: Make pupils realise that their competencies increase: cumulative learning
- Module 6: Interdisciplinary work; learning to link different subjects
- Module 7: Promotion of maths and natural sciences with girls and boys
- Module 8: The development of projects to promote cooperation between schools
- Module 9: Strengthen one's responsibility for one's own learning
- Module 10: Evaluation of and feedback on acquired competences
- Module 11: Quality assurance within the school and the development of whole school standards

The SINUS project is now extended into the SINUS TRANSFER project of which the major objective is to disseminate to transfer the outcomes of the SINUS pilot projects to a larger number of schools.

Science colleges in England is another interesting development. They have a very clear mission to promote science. They have to use their specialist status to create a challenging environment which raises standards of achievement and the quality of teaching and learning in science and mathematics for all their students, leading to whole school improvement in performance. A science college has to provide a centre of excellence in scientific, technological, enterprising and vocational education. It has to be an active contributor to local and national developments within science and mathematics and has to encourage young people to pursue science and mathematics beyond 16, providing them with appropriate learning pathways so that they develop the skills needed to be active citizens within an increasingly scientific world and to progress into employment, further training and higher education according to their individual abilities, aptitudes and ambitions. Science colleges have to be active partners in a learning society with their local families of schools and their communities, sharing resources and disseminating good practice (22).

The ‘Arany János Programme’ of the Hungarian MoE supports the progression of talented pupils with social handicaps in the school system. Both schools and pupils get financial aids to improve talent. Specific programmes are developed by schools, often supported also by colleges, to make possible to enter general secondary school and university. Mathematics is one of the main areas of development (see ‘Developing mathematical skills of 14-15 year-old students’, GRID Initiative No 1098 / 1025).

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21 The SINUS programme: see website: http://www.sinus-transfer.de/
22 For further information on ‘Science colleges’ see the following website: http://www.schoolsnetwork.org.uk/main.asp?page=52
Policy papers, reports or action plans may lead to more funding for science and science education in general. Sometimes policy reports focusing on innovation and quality in education lead to more funds for innovative projects of which only a certain number will focus on science education. The schools involved in pilot projects may be funded in different ways. The extra funding may be made available in different ways: staff will be exempted from teaching so as to invest time in the project, in-service training is provided, publications of outcomes are funded etc.

Next to pilot schools, partnerships may be created between schools, universities, research institutes, museums and/or companies. The Lernort Labor (23) initiatives in Germany are good examples of cooperation between schools and companies or research laboratories (possibly within universities). The Edison project of the University of Antwerp, in Flanders is a close cooperation between schools, the university and companies to promote scientific entrepreneurship.

The 100 Classi project (24) of Italy has the specific originality not only to focus on sciences strengthening cooperation between schools, a museum, universities and science institutes but also to promote the European dimension in education within science education. Particularly interesting is this cooperation in Italy between a regional education institution of Lazio and the Deutsches Museum which has resulted in the “100 Classi” project which has now been expanded into cooperation with French schools and classes (25). This project doesn’t only promote science education but also the European dimension in education.

3. European projects

Several European projects or initiatives have also been set up either in the framework of the Socrates programme or in the framework of the R & D framework programme. However, most projects with a direct impact on schools and initial or in-service teacher education and training are to be found in Comenius, the sub programme of the Socrates programme. Many Comenius 1 partnerships between schools (at least three countries involved per partnership) focus on science, maths and/or technology.

Several Comenius 2.1 projects developing initial or in-service training are also focusing on sciences, maths and/or technology. Some of the Comenius 3 thematic networks focus on science directly or focus on science through e.g. environmental education.

The SMEC (26) project involving teacher education institutions and science museums plus schools does not only promote sciences but also promotes the interest for museums as the objective is to promote cooperation between primary school teachers and science museums.

The Comenius 3 Hands on Science Network (27) has enhanced for several years cooperation between all agents involved in science at the level of school education and initial or in-service teacher education.

Other Comenius projects contribute to motivating and raising interest towards science by environmental activities. Comenius 1.1. ‘Our Environment the School and beyond’ programme includes many elements of science and effects on pupils’ environmentally conscious behaviour.

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23 Lernort Labor: http://www.lernort-labor.de/
24 see website: http://www.100classi.net/
25 The 100 Classi Project: see the following websites:
   - http://www.deutsches-museum.de/wir/koop/lazio.htm
   - http://www.100classi.net/
26 SMEC project: see website: http://www.museoscienza.it/smek/project.html
27 Comenius 3 Hands on science Network: see website: http://www.hsci.info/
Many innovative schools contributed to the GRID database are members of the European Schoolnet (www.eun.org). Within the broad goal of e-learning and building an online community, there are specific challenges here for actors of science education like SkyWatch 2007: an International Astronomy Contest. One of the EUN sites is xplora, the European gateway to science education where news and ideas, databases, information on projects and guidance for science teaching are available (www.xplora.org).

Next to Comenius several other European projects in the framework of e.g. Socrates focus on science education. A full list is available in a separate database with 120 Socrates and Leonardo projects made by Educonsult.

4. PILOT PROJECTS COMBINING SCIENCE WITH OTHER DISCIPLINES SUCH AS CULTURE AND ARTS

Some countries tend to promote projects which focus simultaneously on interdisciplinary approaches. This is the case with KunSTof (Bnl). The objective is to bring artists and cultural actors in the classroom to teach one or other discipline such as e.g. mathematics, chemistry languages, history, geography, ICT etc. while linking it to arts and culture. The target groups are pupils from 12 to 18.

This is also the case of the many initiatives focusing on Cultural heritage classes in France, Italy and Spain. The Catalonian Camps d’Apprentissage (Learning camp) are a good example of this. In those camps for children from 5 to 18 years pupils will work on different subjects while combining different disciplines or areas of interest. Thus the Learning camp at the Abbey of Poblet focus on the one hand on medieval art and culture and on the other hand on learning science maths and technology through the medieval Cistercian abbey.

The natural heritage is in the centre of another international student camp and conference, organized by a Hungarian secondary grammar school. National Parks are scenes of the international camps where students, in English language, give their report on their research, done mainly on environment protection problems.

The German KUBIM project (Kulturelle Bildung im Medienzeit-alter) s promoting projects which combines culture and new technologies and thus indirectly also science and technology. Kubim is linked to the larger context of concepts and programmes in Germany to help build the global “Information Society” and to improve arts and media education. Separate information is given later in this report.

E.6. REFERENCE TO THE LISBON STRATEGY

Some documents explicitly refer to the Lisbon strategy of the European Union. This is the case of the Italian Science Degrees PR document which refers to increasing recruitment in the fields of science and technology, reinforcing the links between the working world, research and society in general and improving the training for teachers and teacher trainers.

The Concrete future objectives (3 strategic objectives and their 13 sub objectives) of the education and training systems of the European Union are mentioned here below.

Quality
- improving vocational training for teachers, trainers, cultural actors
- developing the necessary skills today’s knowledge society
- facilitate the acquisition of skills in the field of education
- increasing recruitment in the fields of science and technology
- make better use of (financial) resources

Access
- creating an environment favourable for learning
- making education and vocational training more attractive
- encouraging active citizenship, equal opportunity (women-men) and social cohesion

Opening education up education & training to the wider world
- reinforcing the links between the working world, research and society in general
- developing entrepreneurship
- improving foreign language learning
- increasing mobility and exchanges
- reinforcing cooperation in Europe

First of all it must be stressed that very few reports refer explicitly to the Lisbon 2010 strategy of the European Union. Most of them refer to it indirectly. The reason for this can be that benchmarks developed for science, maths and technology are connected more to higher education than to public education. (This is the case in Hungary, for example).

It is quite normal that all the reports and action plans contribute to increase recruitment in the field of science and technology. Most of the reports also stress or mention that the link must be strengthened between sciences, research centres (within universities or industry), companies, (science) museums and other bodies or organisations involved in science. This is clearly reflected in the (large) number of projects in the GRID database that show cooperation with all the stakeholders just mentioned above. In several countries major initiatives have been launched to develop cooperation between university or company research laboratories; this is e.g. the base for the Lernort Labor in Germany.

Similarly it is normal that all reports and action plans hope that they will contribute to bring about environments which are favourable for learning in general but especially for science in particular. The analysis of the concrete projects, which are to be found in the GRID database, shows that most, if not all, of the projects have as an explicit objective to promote interest and motivation for learning by developing a creative learning environment.

In several reports or action plans there is also large attention to making education and vocational training in general more attractive as mentioned. The efforts done in the field of sciences is usually not an isolated effort but is embedded in a larger strategy at national, regional or local level to enhance interest and motivation for learning in general.

Quite some reports and action plans stress that enhanced science education also helps in developing the necessary skills for today's knowledge society. Those reports are fully aware that sciences contribute greatly to enhance on the one hand general skills and on the other hand specific scientific skills. The generic skills are those such as problem-solving, critical attitude, communication skills, team skills, project management skills and many others. The more specific skills are mainly the scientific and technical or technological skills that in many case a specific focus on research-mindedness. The analysis of the projects in the GRID database will inform this as many projects work explicitly on the acquisition of generic skills and of scientific skills.

As many reports or action plans also seem to be aware that improving science education encourages active citizenship, equal opportunities and social cohesion.

The analysis of the projects in the GRID database shows that especially projects in environmental education (with a focus on science) contribute to enhance active citizenship. Some of the science projects also address youngsters of disadvantaged groups or with less interest for science (such as
girls or women) and thus these initiatives contribute to promoting equal opportunities or social cohesion.

Very few reports or action plans refer to the contribution of ICT through science education. This is quite surprising as in many countries there is a strong link between science education and ICT. ICT being used to process data gathered in certain science projects. Most of the Dutch projects described in the GRID database make a strong link between ICT and science and in many of those projects the primary focus is on ICT and the secondary only on science. Some action plans in the field of ICT refer explicitly to the E-learning action Plan of the EU but not to the Detailed Work programme. This is the case for the national action plan for ICT in Italy.

Few references are made in reports and action plans to the contribution of the promotion of science to entrepreneurship, to improving language skills, to increasing mobility and exchanges and to reinforcing cooperation in education in Europe. This is supported by the fact that the GRID database contains very few projects that combine the promotion of science education and the promotion of entrepreneurial skills. A few do this like the Edison project of the University of Antwerp in Belgium.

Only occasional science projects focus on the acquisition of scientific language or on increasing mobility, exchanges and European cooperation. However all the Comenius projects and other European or international projects clearly focus on those elements.

### E.7. RECOMMENDATIONS AT NATIONAL LEVEL

Some reports do not mention explicit recommendations but include implied recommendations. In other cases reports have clear and explicit references. Some reports, like the Irish report, comes up with a great variety of recommendations of which some are structural, systemic and other more pragmatic or more practical. Some recommendations address certain aspects, elements or level of science education while others enable to create a comprehensive approach to do something about science education. Some recommendations address all stakeholders or more specific stakeholders. Sometimes recommendations are backed up by proposals for actions or initiatives and sometimes not.

When summarising the recommendations made in several reports one can make a difference between general recommendations, structural recommendations, didactical and pedagogical recommendations to improve the teaching of science. Here below we mention most of the recommendations to show the variety of suggestions made towards action to promote science, maths and technology.

#### 1. GENERAL RECOMMENDATIONS

The more frequent, adequate recommendations can be found as follows:

- Put in place a clear policy in science education (FR, NL);
- Put in place a systemic, holistic policy in science and technology education (NL);
- Decision about the curriculum to stress importance of MST (several countries e.g. Sweden);
- Stimulate the implementation of a national science framework possibly with a European perspective (FR, NL);
- Further develop and implement the Plan of renovating science and technology education and for extending to secondary schools pedagogical approached inspired by the Main à La Pâte which is primary school oriented (FR);
- Put in place follow-up of a science policy in education through and agency or a foundation which is also in charge of evaluation (FR);
- Set-up a programme for positive discrimination for girls (grants, research grants, special reserved places) with particular attention of youngsters with potential in difficult upper secondary schools (FR and several countries);
- Promote the teaching of science especially at primary school level (FR and many other countries);
- Build and implement a coherent and comprehensive project to enhance science education from the primary school to H. Ed. (FR);
- Create committees to reflect on the teaching of science to ensure the link between the upper secondary school and the university (FR);
- Fostering and supporting the collaboration between schools, universities and research institutes / laboratories at national or regional level (IT, FR, DE, IRL);
- Improving the quality of the methodology used to teach (and learn) sciences and technology: improve the training of teachers (in initial and in-service teacher education) (IT, FR, HU);
- Disseminating ICT and new technology in schools a.o. to support science education (IT);
- Pay specific attention to science education in whole school reforms leading to higher secondary schools (Liceo) specialised in science and technology;
- All schools should have a science strategy (IT);
- Positive culture of science should be present in all schools (IRL, IT);
- All primary schools should get start up funds for primary science with the introduction of science to the curriculum - (IRL);
- Investment to bring all secondary school laboratories up to first class level (IRL);
- Develop new methods of teaching science mainly focusing on the bringing about of creative learning environments (IRL, FR, IT, B, GR Malta, PT, UK, NL)
- Develop in-service training for secondary school science teachers, possibly in research centres at universities or companies or in bodies promoting science education (IRL, DE, FR, IT, Bnl, GR, Malta, PT, UK);
- Promote science education research (all countries);
- Review Maths education (IRL, UK, AT);
- Teachers should provide basic information regarding the duties and ethics that scientists and technologists have to observe (Malta);
- Pupils have to acquire through sciences and technology a variety of skills and attitudes (Malta);
- National Forum on Science Education to be established (IRL);
- A co-ordinating agency to co-ordinate all science promotion to be established (IRL);
- Links to be established between second level schools and third level institutions (IRL, NL and others);
- Develop new science courses for mature students (IRL, SE);
- The definition of a set standards of performance that are gauged in accordance with international levels (benchmarking) (PT);
- Stimulate the teachers to make them feel responsible for the reform process (PT);
- Reinforce solidarity between all teachers, especially science teachers, from primary school to higher education (FR);
- Strengthen the role of pedagogical counsellors (conseillers d’orientation) to give better information about science studies (FR);
- Concerted approach to make students aware of careers in science (IRL);
- Develop actions to enhance science education in primary and secondary schools (FR, IRL, IT etc.);
- Clarify the responsibility of teachers involved in fieldwork outside the school. Teachers tend to be less involved in activities outside the school as their liability and responsibility are not clearly defined (FR);
- Enhance solidarity and cooperation between teachers in general and science teachers in particular both at the level of the primary and the secondary school (FR);
2. Specific Structural Recommendations

- All secondary schools should have a laboratory technician (IRL);
- Lower teacher student ratios for physical science subjects (IRL);
- New junior Certificate syllabus to be introduced (IRL);
- Develop software infrastructure for secondary schools (IRL);

- Review current Science 14-16 education and create a new national (England) GCSE science course for the 21st Century (UK);
- Pilot innovative ways of teaching and learning of science (IRL, FR, DE, DK, LITH, IT, PT);
- Teacher sabbaticals or in-set to work in industry and with research bodies (IRL, FR, DE, AT);
- Develop internships for teachers (or future teachers in laboratories (FR, DE,);
- Promote regional cooperation between universities, research centres and ODL centres (FR);
- Review pre-service training of primary and secondary teachers (IRL, HU, NL);
- Focus in initial teacher education on scientific knowledge (PT);
- Programme for the minimum investment in teacher training institutions (IUFM) and secondary schools (FR);
- Actions towards initial teacher education and in-set (NL, SE, HU);
- Prepare all future primary school teachers with a solid basis on science education so that they can contribute actively to the promotion of science education in the primary school (FR). A special module is developed to this effect by researchers, educationalists, representatives of companies, philosophers, scientists etc.
- Science and society to be studied in depth in the upper secondary school (IT);
- Create different science 14-16 courses to match the variety of student aspiration. This recommendation has seen the development of the first ‘Scientific Literacy’ programme, this is to be launched as a national qualification throughout England in 2006. (England);
- Have a general science subject for Leaving Certificate (IRL);
- Review all curriculum for leaving Certificate level (IRL);
- Science to be mandatory for Junior Certificate students (IRL);
- Practical assessment to be introduced at Leaving Certificate (IRL);
- Set up a collaborative teaching and learning centre (IRL);
- Science advisor to the government to be appointed (IT, Scotland);
- Exchanges with the community’s cultural, scientific and artistic organisations (IT);
- Better conditions for progress to higher education or to professions in scientific, technological or artistic areas (PT);
- A multimedia support gathering law texts and information (FR);
- Creation of websites and interactive portals (in most countries);
- Setting up of science clubs, Science cafés, junior science cafés, science holiday camps, visits to science museums, science days (FR, DE, ES, HU plus other countries);
- Mobilisation of the Pôles Universitaires Européens linked to French universities and the CCSTI (Centre of scientific, technical and industrial culture) (FR);
- Valorisation of activities of ateliers de science in schools (Fr);
- The creation of a national pilot group concerning science programmes (FR);
- The creation of pilot groups involving the inspectorate (FR);
- Collaboration with town halls and local authorities (FR);
- Implementation of an observatory to evaluate new actions and pilot projects (FR);
- Programme of positive discrimination towards girls (FR);
- Action plan for bright pupils from ‘difficult’ schools (FR);
- Set up pedagogical help to diminish the failure rate during the first two years of studies in the GEUG in higher education (FR);
- Bring together all those who at H.Ed. level are involved in science studies (FR);
- Stimulate research into MST (several countries).
3. **Didactical or Pedagogical Recommendations**

- Encourage the use of observation in science teaching in the primary school so that children, up from a young age, get acquainted with scientific approaches and ways of thinking and reflecting (FR);
- Contextualised application of curricula: new pedagogical approaches (group work, interdisciplinary work (PT), differentiated modes of learning the various contents specific to the different subjects (PT);
- The science and technology curriculum should be based on an evolutionary model and on the idea of conceptual change (Malta);
- A progressive appropriation of science concepts and operative techniques, with the consolidation of written and oral expression (FR);
- Each child keeps an experiment diary with his or her own words (FR);
- The students must continuously deepen their understanding of science and of the way scientific processes take place, their knowledge of the application of the effects of science on everyday life and their understanding of particular concepts in the different branches of science (Malta);
- Teachers must indicate the connections that exist between science, technology and society in the way science is learnt and in the curriculum content, the textbooks, other educational materials and the mode of assessment (Malta);
- Teachers must recognise that different students can experience science differently and bear in mind that information technology plays a key role in the scientific process and the teaching of science (Malta);
- Coordinated science must be taught which has to include themes from different branches of science, technology, nature studies and applied science;
- Examine the possibility to replace at the level of the lower secondary school (Collège) the cutting up of sciences in three special subjects by a more general initiation science course focusing globally on scientific processes (FR). This can be compared with the ANW (Algemene NatuurWetenschappen) approach in the NL.
- The creation of a new integrated beta discipline within which elements of the disciplines maths, physics, chemistry and biology (and possible other natural science subjects) are integrated in a modular structure so as to facilitate flexibility and selection by pupils (NL, HU);
- Promote interdisciplinary science teaching (FR, DE, IRL);
- Students have to think scientifically and technically (Malta);
- Develop science teaching resources (IRL);
- The teachers of the initial T.Ed. institutions (e.g.; in France the IUFM) bring their pedagogical and didactical experience to the teachers in schools;
- Teachers can get modules from the Internet (FR);
- Teachers can participate in cooperative work (learning communities) by talking to colleagues, trainers and scientists (FR);
- Creation of a video support with training actions (FR)

4. **Recommendations concerning Dissemination and Promotion**

- Organise a seminar on the topic of "Be a scientists today: which changes?" (FR);
- Organise a debate on the changes in the status of the expertise (FR);
- Take action so that make visible the part of CSTI in the activity reports of public bodies and organisations (FR);
- Put in place a process to elaborate a project to as to recognise the CSTI activities of the researchers (FR);
- See to it that research institutes are more open to the general public (FR)
- Incite universities and research laboratories to commit certain people to dissemination and to take those activities into account as part of the evolution and the development of their career (FR);
- Setting up an advertising TV campaign showing how science studies lead to attractive and diverse jobs (FR);
- Organising an international conference of science educators was organised to consider innovative approaches at all stages of education (Scotland)
- Training actions for researchers or research professors to cooperate with the media and thus communicate about science with the large public (FR);
- Create an internet portal on scientific culture which is accessible to the large public and involving all the stakeholders involved in scientific culture (FR);
- Study the possibility of creating a series of short video clips focusing on the ‘FUN’ and playful approach of science teaching and learning (FR);
- Train researchers or teachers-researchers (involved in action research) to cooperate with the media: How to write for the large public? How to remain scientific and comprehensible? (FR);
- Incite the television channels to capitalise on successful television programmes or documentaries such as "The Odyssey of the species"; train TV channels to create high quality scientific programmes which should be scheduled early evening so as to attract large audiences (FR);
- Invite television channels to include in their planning and broadcasting schedules more scientific programmes (FR, HU);
- Make use of the new possibilities to use broadband internet to create channels on scientific and technical themes combining the thematic approach with a regional approach (FR);

**E.8. RECOMMENDATIONS FORMULATED BY THE EUROPEAN MST GROUP**

It is interesting to compare what has been mentioned above as recommendations with the key recommendations of the two reports of the EU Working group on MST: the progress reports for 2003 and 2004 (28). It is clear from reading the recommendations to be found in the separate reports, policy papers and action plans of the different countries that they are fully in line with the recommendations of the WG MST at EU level. The recommendations at the level of some of the countries are much more detailed and very often refer to the recommendations needed to bring about the practical implementation of a policy in the field of science education.

**1. INTERIM RECOMMENDATIONS OF THE PROGRESS REPORT OF 2003**

The MST Group has identified 'compulsory education' as the top priority sector for action, since it has the central role in the education systems.

No single campaign or initiative is likely to ensure the long term future success of MST. All promising initiatives should be part of a systemic reform which will focus on the development of interpretation and understanding along with acquiring the requisite knowledge and skills at all levels and in all sectors of primary and secondary schools.

- Mathematics, scientific and technology education should be an entitlement for every child and introduced at an early age. It should be mandatory at all levels of compulsory education.
- More effective and attractive teaching methods should be introduced in mathematics, scientific and technical disciplines at primary and secondary level, in particular by linking learning to real life experiences, working life and society, and by combining classroom-based
teaching with appropriate extra-curricular activities (participation in science fairs, festivals, competitions, excursions, science camps, visits to science museums, encouraging the study of appropriate scientific journals, ‘inquiry’ learning, etc.).

- The professional profile and practice of MST teachers should be further enhanced, not only by providing them with opportunities and incentives for updating their knowledge of content, but also by developing the didactics of MST and improving the teaching resources available. Improvements to the provision of effective initial and in-service training are needed, as well as providing incentives and special measures for sustaining the long-term engagement of teachers. This will require investment of the necessary resources at all appropriate levels.

- The needs of special groups (both high and low achievers and young people from different ethnic backgrounds) should be addressed, and the appropriate measures taken to respond to gender-specific attitudes to mathematics, scientific and technical subjects. Teaching methods, pedagogical tools and assessment procedures should be refined and adapted to take account of these specificities.

- Strong and effective partnerships between schools, universities, research institutions, enterprises, parents and other actors should be strongly encouraged and supported at all levels, both in order to improve the quality and ‘user-friendliness’ of teaching and with a view to preparing young people more effectively for working life and active citizenship. In this collaborative process, the leading role of universities should be recognized and supported.

2. RECOMMENDATIONS OF THE PROGRESS REPORT OF 2004

The 2004 report quotes that “The first results of the ‘mapping’ exercise, along with the work carried out by the Subgroup on partnerships and the preliminary conclusions of the good practices in this field (2004), suggest some areas for action in MST in view of improvements as regards technology in curricula, needs of low-achieving pupils, gender balance, MST connected to real-life context, activity-based teaching, access of teachers to resource centres, but also their reluctance to adopt new didactics, valorisation of practical work in the assessment procedures, and finally the role of parents. Moreover, in its 2004 recommendations, the Working Group MST restates the need for education policies in the area of MST to assign priority to education pedagogies involving meaningful practical applications and ensuring the active participation of learners.”

The 2004 recommendations are the following ones:

- Curricula should clearly take into account the important role of Technology education, which should be addressed as a field in its own right within MST. Technology education should be seen as different but complementary to science education.

- The needs of low-achieving pupils in MST should be addressed specifically by implementing MST curricula that are appropriate to their needs, abilities and interests, by providing more opportunities for practical activities and by introducing initiatives such as special classes, inclusion measures, appropriate textbooks and materials, etc.

- It is essential that policies tackle the problem of gender imbalance in MST, either through general policies designed to address equal opportunities and/or through specific measures (at teacher training level, through revision of didactical materials, special programmes to appeal specifically to girls, etc.).

- Pedagogy is a crucial area for decision-makers to address if MST subjects are to improve in effectiveness and attractiveness. Measures should therefore be taken to connect more systematically MST teaching to real-life contexts and experiences: Teachers should be provided with the means (in time and resources) to do so, especially through extra-curricular activities. As the most effective pedagogies are time-consuming, time devoted to practical activities should be reallocated in order to improve the effectiveness of teaching and learning. One possibility would consist of moving from ‘content’- to ‘activity’-based teaching and foster pupils’ curiosity while avoiding the overcrowded curriculum.
- Policies should address the perceived reluctance of teachers to adopt new didactics in the field of MST and find ways and means, in particular through the dissemination of good practices, to change the situation. Teachers should also have access to resources centres supporting the development of new innovative pedagogical methods.
- Pupils’ assessment procedures should give importance to both theoretical and practical work and promote new teaching methodology.
- Any measure taken (at policy level or through the development of specific initiatives / partnerships) to increase interest and participation of pupils in MST, and in particular girls, should foster the participation of parents in order to help them overcome their prejudice vis-à-vis these fields.
- Partnerships/initiatives aimed at providing "second chance“ opportunities for those who did not opt for MST subjects should be developed.
- Partnerships between schools and universities to increase interest and participation in MST should be made more frequent. Universities, and higher education institutions, should have the adequate means (both human and financial resources) to cope with potentially large demand that might arise from schools.

3. Recommendations of a sub group – cooperation between schools and universities

- The Subgroup recommended that efforts should be made ‘to promote the creation of new positions for MST education in higher education institutions’.
- Governments should encourage schools to liase with universities, parents associations, and industry on MST subject development.
- Second-chance opportunities” were considered as good potential methods for inspiration in establishing partnerships and should therefore be supported.
- Member States should promote and/or update ‘school development plans’ for MST.
- Partnerships should be seen as ‘equal opportunities and reciprocal partnerships’ – universities should be able to learn from school partners and school partners from universities.
- Alliances should be formed between stakeholders so as to ensure equitable access pathways to training programmes and employment in the field of MST.

4. Conclusion

The recommendations made vary according to the situation of MST in the country concerned. However it has to be stressed that the impression prevails that not all countries have developed recommendations based on systemic and/or holistic policies that try to address all the issues related to MST. The countries that seem to have sets of recommendations that want to bring about a systemic or holistic change seem to be countries like the Netherlands, France and Ireland. Some countries clearly have less focus on MST when it is considered not to be a major problem. The interest for MST is still very large in Bulgaria and hence major recommendations are not made to do MST but action is taken nevertheless to create continuity in the interest for MST.

Even if the recommendations are not part of a systemic and holistic approach, they are in several countries embedded in an overall strategy to promote scientific thinking and innovation. However, it has to be added that few recommendations are made (and subsequently actions taken) to promote entrepreneurial skills with youngsters specifically interested in MST. Some countries do this as it is thought to be very important that interest in MST should generate innovation which is to be translated into entrepreneurial activities to contribute to economic development. Many countries have acute problems in attracting students in to MST in general and especially when it comes to convincing students to go on studying specific MST studies in higher education. Hence a
A variety of measures and recommendations are suggested at this level. These measures may range from restructuring the curriculum as to the contents of MST up to adding in schools specific personnel to support the development of and the interest in science education. Although the role of teachers and teacher trainers is crucial in promoting the interest in MST not all countries make recommendations in relation with improving science education in initial teacher education and in-service teacher education. Some countries recommend the creation of teacher support centres which can organise in-service training and make resources available to teachers.

Several countries have specific problems in attracting students not only to MST at secondary school level but to technical / technological (vocational) studies. Recommendations in this case tend to try to do something about this.

All countries are aware that efforts have to be made to interest youngsters from their very first age for MST. Hence an important group of recommendations are made as to activities to be set up from the very early age. However, it has to be pointed out that only in a few case explicit recommendations are made when it comes to promoting SMT up from the very early age of the kindergarten.

Several countries recommend to set up kind of science and technology promotion centres which then develop activities for a variety of groups ranging from young people at schools till the large public. Very often the involvement of the different groups (across all ages) and the local community is seen as a key element to promote an overall interest in MST. They can indeed not only be promoted just by enhancing the interest and commitment of the youngsters, efforts have to be made to interest all adults as they will also have an influence on the choice of youngsters.

Cooperation between schools and industry / research centres / science foundations etc. is a recommendation which is to be found in most countries. The linking up with partners in the local community is definitely seen as a major contribution to promoting MST.

It is interesting to point out that most of the recommendations are in line with the Recommendations made by the Working group on MST of the European Union. This proves that there is a clear interaction between the activities of the working group on the one hand and the development and implementation of policies on the other hand.

Several countries make recommendations to see to it that MST should be an entitlement for every child and should be introduced at an early age. Several recommendations support the idea that MST should be mandatory of all levels of compulsory education.

Nearly all countries recommend that the teaching of MST has to be made more attractive and that innovative competence-based learning environment have to be created for young people to learn MST. All those recommendations propose measures to link MST teaching and learning with real life situations and to combine classroom-based teaching and learning with a variety of extra-curricular activities.

Many countries address the issue of initial and in-service teacher training with special attention to giving support to teachers in a variety of ways. However, few recommendations are made as to specific action to be taken with weaker, disadvantaged groups. Most of the countries clearly propose recommendations as to increase the number of girls or women interested in MST. Finally most countries recommend strong partnerships with industry research centres etc. This all proves the clear interaction between national and European strategy and policy.
E.9. IMPACT AND VALORISATION

None of the reports refer to the possible impact that the actions, proposals or recommendations proposed may have on science education. Very little information is given about the use of indicators or descriptors to find out which the impact is.

1. ACTION TO IMPLEMENT THE RECOMMENDATION

Different actions were taken to implement the recommendations made in the different policy papers or reports. The kind of action depends upon the country. It also has to be stressed again that in several countries action was taken subsequent to external reviews or audits such as the PISA studies of OECD. The action taken subsequent to such studies is also included in the present report.

Some countries make available funds to schools and launch to this effect pilot project based on calls for proposals, in order to finance the promotion and diffusion of science and technology through activities and projects to be undertaken within the schools. This is the case in Italy, France, Belgium (nl), Germany and Austria.

Several countries organise in relation with this special initiatives, activities or projects as mentioned earlier under ‘Action subsequent to the policy reports’ and ‘pilot projects’. Examples mentioned under these headings were: the "100 class project" in Italy. The SINUS and SUINUS transfer project in Germany. The ISMT2 in Austria, The pedagogical hothouses in Belgium (nl), the VOORUIT projects in the Netherlands etc.

In some cases the recommendations also lead to a re-organisation of the school system, testing of the new school regulations introduced in selected schools; drawing up of more specific documents related to the different school levels, school curriculum debate, diffusion and promotion of changes introduced among the teachers community and the students' families. This is the case e.g. in Italy.

2. MONITORING AND SUPPORT

The reports, policy papers and action plans do not give many details about the monitoring of the follow-up to the activities which are set up. According to the size of the country and according to the specificities of the education system, the monitoring can be done at national, regional (as in Italy, Flanders) or at local level.

In some countries (like Italy, France) committees are created subsequent to the policy report, paper or action plan, which may have different roles such as the selection of pilot projects, the drafting of the curricula, the coordination of the follow-up activities, the monitoring and/or follow-up of those projects and even their evaluation.

It is interesting to note that in some countries the bodies involved in the selection of the pilot projects are later on also in charge of the monitoring. In the case of the SET pilot projects in Italy, the school selection was done at the local level by the science and technology working groups of the local administrative centres (CSA). Later on, schools have been invited to answer directly to the ministerial call for project proposals. However for The FORTIC ICT activities the Regional offices are in charge of the training courses of teachers and of the coordination of the network of schools involved in the training programme.
In France monitoring or follow-up is the responsibility of the general Inspection. Next to this the "Académie des Sciences" gives on a regular basis some 'health news' about the initiative 'La main à la pâte' comparing to the same activity which is implemented in other countries or continents such as Africa and china. This is an interesting example of benchmarking.

The monitoring of the innovative actions and activities differs according to the country concerned. As most countries work with some system of pilot projects to promote innovation, they usually also foresee some system of monitoring to help and support schools. The monitoring may be organised in different ways: in several cases (such as the German SINUS projects) a university is attached to a set of pilot projects with the responsibility to support the schools through monitoring. This university is also taking care of the evaluation of the activities of the pilot projects and the products and results. In one case (for the Flemish Community) monitoring was attributed by the department of education to an external company (Deloitte) which set up different monitoring and support activities for the schools (voortrekkersscholen) involved in the project during one year; later on it was taken over by a group of advisors nominated with this responsibility.

In some cases the implementation and part of the monitoring is done by committees and working groups, composed of experts and often chaired by ministerial officers (as in Italy). In other cases the monitoring is done by a specific section or department of the ministry of education as in Malta where the Curriculum implementation and Review section is in charge of it.

3. Evaluation

The policy papers, reports and action plan hardly ever refer to the evaluation of the implementation of the recommendations made. The organisation of the evaluation is left to the responsibility of those in charge of implementing the policy report/paper or the action plan.

As most countries have specialised bodies or organisations dealing with evaluation, it is entrusted to those bodies. These bodies may be located within the ministry of education or be outside it. In other cases the ministry may ask an external organisation to respond for a call for tender to do the evaluation.

In Malta e.g. the Curriculum Implementation and Review Section (of the Ministry of Education) is in charge of evaluation.

The Italian FORTIC programme (ICT in education) has foreseen the creation of a web site, managed by the INVALSI (National Institute for the Evaluation of the Education System) for the monitoring and evaluation in real time of the project progress (monitoring of the quality of training courses offered; monitoring of the beneficiaries' degree of satisfaction and self-evaluation of competencies; verification of the training effects one year later). The school reform is evaluated in the framework of activities coordinated by the INVALSI. The evaluation of the initiatives subsequent to the LAW 6/2000 is done in the framework of the official report presented by the Ministry to the parliament every three years.

In some cases the evaluation may be carried out by different bodies or organisations at national, regional and or local level. In Italy it will be the responsibility of INVALSI but possibly in cooperation with the IRRE (the Regional Institutes for the Pedagogical research), the Regional School Offices (USR) and possibly also the INDIRE (National Institute for Documentation of Innovation and Pedagogical Research).
In France, an observatory of evaluation of the actions set up to promote science education has been set up which could be involved in monitoring activities. The evaluation is an, will remain the responsibility of the appropriate inspectorate.

In Belgium (nl) evaluation of innovative action in the field of science education will be organised at the level of the department of education in cooperation with the ‘pedagogical advisors’ in charge of supporting schools in implementing innovation in education in general and in science in particular.

4. DISSEMINATION AND VALORISATION

Different ways of disseminating the reports, policy papers and action plans are used. Possibly the most used one is the Internet that in no way is the most efficient. Other means of dissemination are publications through leaflets, brochures and articles in magazines for teachers and schools, presentations at conferences, seminars and colloquia. In some cases countries organise workshops during which the policy reports are discussed especially towards their implementation. Some countries also strengthen dissemination by putting a major focus on examples of good practice as teachers do not like to be informed about abstract recommendations but like to see examples of good practice showing the way forward. The inspectorate very often plays a key role in the dissemination of the recommendations.

Dissemination and valorisation of the results of actions set up subsequent to the recommendations of policy papers and action plans are done in several countries in a somewhat different way. Result may be disseminated over the Internet or through publications etc. but in some countries like Bnl, workshops are organised during which the results are presented and discussed first within the group of pilot projects and at a later stage towards the whole school community. Fairs exhibiting outcomes and results are also used in several countries to inform teachers and invite them to make use of the outcomes in their own classrooms.

The dissemination and valorisation is in all cases organised by the Ministry which may be assisted by external bodies: In Bnl the Department for education is cooperating closely with the King Boudouin Foundation and the Prince Philippe Foundation to support dissemination and valorisation. In France the ministry of national education, the ‘Inspection Pédagogique Régionale’ and the IEN (Inspection of National education for primary schools) are involved. Eduscola (29) disseminates in France all key information.

The dissemination of results of pilot projects may also be done through structured approaches which are part of the way in which the pilot projects are implemented. Thus most countries, schools which get funding, to set up innovative action in education have the obligation to make the results available to other schools. This can be done in a variety of ways. In some cases teachers interested in starting up innovation can go on a fixed day to the ‘innovating’ school that has the role of an aquarium school. In other cases teachers from the innovating schools go to other schools, are involved in in-service training seminars or in general seminars at local, national or regional level.

29 Eduscola: http://eduscol.education.fr/index.php?./D0109/ASTDISP.htm#valorisationvalorisation
F. PRESENTATION OF REPORT 2 – REPORT OF INITIATIVES

F.1. A MULTIDIMENSIONAL APPROACH

One of the main difficulty encountered lies in the difficulty to define a unique typology of initiatives identified. The first approach which can be made concerns (1) national based initiatives launched at country level which encompass a multitude of actions, projects developed at school level (a specific section is proposed hereafter to present in detail some of the representative national initiatives identified) and (2) more stand alone projects at school level.

Whether the initiatives or projects are stand alone activities or are integrated into a larger mechanisms depends upon the country or upon what has been looked at by the expert involved in the present study. The experts who have been working on individual countries have very often tried to pinpoint structured networks of projects which in one way or another are supported by the Ministry. In several cases many projects are linked to such structured initiatives or networks but this is not always the case.

1. OFFICIAL PILOT PROJECTS (LOCAL, REGIONAL, NATIONAL AUTHORITIES) PART OF LARGE MECHANISMS

Some initiatives can be put in the categories started up and supported by the official authorities, mostly the ministries of education (and science). These may be the authorities at national or regional level depending upon the political structure of the country. Sometimes it may be a project started up by local authorities. The starting point of an official initiative may be an official action report or study or it may just be the findings of external studies such as the PISA studies.

As mentioned above the projects on innovation can be specifically addressing solely sciences, maths and technology or they can focus on any innovation in the school education system. The pilot project may also have another primary focus on MST may only be a secondary or subsidiary focus.

In that category, different possibilities appear:

- Projects within the framework of pilot projects launched by the ministry of education, another ministry or different ministers together; these can be national or regional initiatives according to the political and administrative structure of the country.

Two main types of pilot projects can be identified:

- Pilot projects with a primary focus on Maths, Sciences and Technology
  Such pilot projects can be specifically in the field of science and technology and maths (such as IMST2 and IMST3 in Austria) or they can be integrated into a general approach of innovation in education (e.g. Vooruit NL and AOT proeftuinen Bnl).

- Pilot projects with a primary focus on innovation in education or another specific area
Projects may also have a primary focus which is different from MST but a secondary focus of secondary effect which is to promote science, maths and technology education; this is the case for the German KUBIM initiative.

2. PROJECTS LAUNCHED WITHIN VARIOUS FRAMEWORKS

It concerns projects which have been launched within various frameworks such as:

- Projects launched within the framework of European and international networks or organisations.
- Projects launched within the framework of associations, foundations, universities or companies.
- Projects started by individual schools and/or teachers etc.

3. INDIVIDUAL OR STAND ALONE PROJECTS

When one looks to individual projects developed at school level, they can be subdivided in different ways and categories. Projects can be subdivided in different ways:

- According to the disciplinary, interdisciplinary or cross-curricular approach
- According to the organiser for specific MST projects
- According to the target group: pupils, teachers, both groups, involvement of yet other groups of the educational community;
- According to the disciplinary, interdisciplinary or cross-curricular approach;
- According to the topic addressed: sciences in general, sciences and maths and/or technology; or biology, chemistry, physics each separately;
- According to various disciplines involved sciences combined with other discipline such as ICT, arts & culture;
- According to the combination of scientific disciplines and cross-curricular issues such as: environmental education, citizenship education, cultural education, health education, traffic education etc. according to the organisation in charge of it at local, regional, national, bilateral, European or International level

In the following sections, some attempts have been made in order to propose some possibilities of typology regarding the projects identified.
F.2. PRESENTATION OF NATIONAL OFFICIAL PILOT PROJECTS / PLANS

1. NATIONAL INITIATIVES WITH A PRIMARY FOCUS ON MST

1.1. The IMST2 and IMST3 initiatives of Austria

Most of the initiatives described for Austria in the GRID database are initiatives that are all linked to the IMST2 initiative of the University of Klagenfurt. Dr. Konrad Krainer has set up for the Austrian Ministry of Education this major innovation scheme in the field of Maths, Science and technology called the IMST2 and which focuses on MST in the secondary school.

Subsequently the IMST3 pilot project is put in place which is also a support system put in place by the Ministry of Education in the areas of mathematics, science and technology as well as related subjects taught at Austrian schools. The support system comprises seven core measures, with evaluation, gender sensitivity and gender mainstreaming as systematically integrated principles. These measures are implemented collaboratively by a wide network of persons and institutions.

The advantages of such a centralised system as for Austria are manifold. One is that a support and monitoring or follow-up structure is available to help the teachers involved; A second advantage is that financial means are available to support schools and/or teachers involved. In this case the teachers who draft an action-research report get 1000 EURO. Experience in other countries shows that it is impossible to make teachers draft action-research reports if you do not pay them! Another advantage is the fact that there is a central database with detailed information about all the projects. This database is a key element in the dissemination of the innovation. Unfortunately the very rich and useful AT database is only available in German.

1.2. The SINUS and SINUS TRANSFER project of Germany

The SINUS and SINUS transfer projects are two excellent examples of national (in the case of Germany , federal) projects across the different Länder to promote maths and science. The advantages are gain manifold: a strong support structures through universities in terms of monitoring and evaluation; financial support to schools and universities involved and a detailed database with information on the projects. A website strengthens the dissemination and multiplier effect.

Important is that the first pilot project SINUS was at a later stage transferred into the SINUS TRANSFER project of which the objective is to ‘transfer’ the positive outcome of the first pilot project to many more schools. Pilot project should by nature lead to multiplier projects and be available to all schools.

1.3. The Mains à la pâte initiative in France

The initiative ‘les Mains à la pâte’ (Hands on science) has been launched by the Ministry of education in France at the initiative of a Nobel prize winner for physics, Georges Charpak, in cooperation with the Academy of sciences.

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30 A detailed description of the IMST2 and IMST3 initiatives is to be found in an issue of the Austrian Education News n° 44 of 2005 to be found on the following website: http://www.bmbwk.gv.at/medienpool/13059/oen44.pdf. The article is both in German and in English.
The objective is to promote within the primary school a creative and innovative approach to promote the interest in science and scientific research.

Those interested in joining have to agree with a ten-point charter of which key elements are the creative scientific activities of the children in a real life context to promote the scientific reflective competences. Positive elements are the cooperation with the families, with local scientific partners and with the IUFM (the initial teacher training institutions) that put their pedagogical expertise at the disposal of the schools involved.

1.4. Sciences Colleges in England (31)

The science colleges in England should definitely also be put into the official initiatives to promote science. Science Colleges use their specialist status to create a challenging environment that raises standards of achievement and the quality of teaching and learning in science and mathematics for all their students, leading to whole school improvement in performance. A Science College provides a centre of excellence in scientific, technological, enterprising and vocational education. It is an active contributor to local and national developments within science and mathematics and encourages young people to pursue science and mathematics beyond 16, providing them with appropriate learning pathways so that they develop the skills needed to be active citizens within an increasingly scientific world and to progress into employment, further training and higher education according to their individual abilities, aptitudes and ambitions. Science Colleges are active partners in a learning society with their local families of schools and their communities, sharing resources and disseminating good practice.

It is interesting to point out that are also maths and computing colleges, Technology colleges and Engineering colleges. All those are managed by the Specialist schools Trust on behalf of the DfES.

1.5. Science education 3 – 18 (Scotland)

Promoting science education in schools is one of the key elements of the Scottish Executive’s Science Strategy that sets out a wide range of measures designed to inspire a new generation scientists. In support for the strategy, SEED has funded a variety of innovative projects (32) to fulfil the Executive’s aims.

The executive also made available a large amount of funds to each of the individual education authorities. This has allowed for a vast amount of regional and local projects and initiatives to be developed.

1.6. Science and Technology week in Malta

The Malta Council for Science & Technology (MCST) has also been involved since 1996 in science popularisation events and has since been the promoter and national co-ordinator of the "National Science & Technology Week". In itself this initiative was innovative as it was the first of its kind to be organised on a national scale and proposed an eye-opening view to science i.e. the fact that science affects everybody’s daily life and branches into most fields/disciplines. Throughout the years, the Science Week has taken different formats. Its inception in 1996, it took the form of a fun fair and

31 Science Colleges; see further information on the following websites: The Specialist Schools Trust: http://www.specialistschools.org.uk/ The DfES: http://www.standards.dfes.gov.uk/specialistschools/what_are/science/
32 A list of major projects available here: http://www.scienceeducation3-18.com/projects.htm
was organised as a large scale event at the University of Malta. Subsequently it shifted venue and was located in a popular shopping mall. It included hands-on science exhibits, poster presentations, discussions on topical science issues, a theatre representation on the history of science and visits to scientific laboratories. Scientists from foreign universities were invited to give original presentations such as on science and music and science, sounds and light. Students as well as parents and interested individuals could walk through the stands and attend at leisure the various activities. The National Science Week subsequently evolved to become a decentralised activity. A number of local industries and companies which use scientific and technological processes open their doors to groups of students. The organizations that participated are from the public sector, university faculties and private companies including pharmaceuticals, electronics, IT and tourism set-ups. The Ministry for Education is planning to review the S&T Week and reshape it according to the perceived needs of the students: a fair with greater interactive features and with lessons to take back home and spin-off activities to be taken up by schools. The S&T Week should address the use of S&T to solve current environmental problems that have an effect on the Maltese environment such as waste management, transport and traffic problems etc.

1.7. Natural science classes in Denmark

Young people’s lack of interest in science programmes remains a central topic in the political debate about education. As a result of the questions asked in the Danish Parliament in 1996 and the subsequent debate, the Ministry of Education initiated projects linked with three-year science classes in the Danish Gymnasium (upper secondary school) in order to strengthen the students’ interest in mathematics, physics and chemistry and thus motivate them to continue with further studies within the fields of technology or natural sciences.

The science classes were established in a way that enabled interaction with companies and institutions of higher education (Industry Education Cooperation).

1.8. Physics and Chemistry Applied to Arts in Portugal

An initiative launched by the Portuguese Ministry of Education through its general department of Innovation and Curriculum development. Particularly innovating as it combines in an interdisciplinary way the promotion of interest for science with arts.

At the secondary level (11th, 12th grades) the students in the artistic areas have the discipline of Physics and Chemistry as optional. The project aims to develop an attractive curriculum useful and applied to technical-artistic situations that can be useful for their carriers, in competition with other artistic subjects; thus the project links sciences to arts or aesthetics.

It can be compared to the KunSTof(33) initiative of the Flemish department of education which is not listed in the GRID database but is along the same lines.

33 KunSTof initiative: This is a very good example of combining education with culture because the explicit objective is to bring artists and cultural actors in the classroom to teach one or other discipline such as e.g. mathematics, chemistry, sciences in general, languages, history, geography, ICT etc. while linking it to arts and culture. The origin of this initiative is to be found in the will of the department of education to create more attractive learning environments at school, both at secondary and higher education level: This one of the key concerns of the department of education so as to enhance motivation for and commitment to learning. The target group are pupils from secondary school (from 12 to 18 years of age) and students from institutions of higher education (bachelors level). See website but only in Dutch: http://www.nsdis.be/web/canon/kunstof/index.html
1.9. The LUMA Joint National Action programme in Finland (34)

Even if this programme was finished in 2002 it is important to mention it because it is more than a project as it is an integrated programme to enhance knowledge in maths and natural science. The LUMA programme is a good example of an ‘integrated’ approach in improving natural sciences and maths education involving all the key stakeholders.

In 1996, the Ministry of Education launched an extensive programme to develop knowledge in mathematics and the natural sciences (LUMA Joint National Action) for 1996–2002. Results are evident. The enrolment in science and technology in H. ED. has increased beyond objectives, but the numbers of upper secondary school students studying advanced courses in mathematics and extensive syllabuses in the natural sciences have not risen enough to satisfy needs of H.ED. Girls/women are still a minority among physics and technology students in H. ED. , even though their share is rising. On the other hand, university studies in biology and geography and the training of class and kindergarten teachers do need more men.

In basic education, the quality of learning results looks good in the light of international studies. In addition, equality of education appears to be implemented well both regionally and between schools and genders.

During the LUMA JNA teaching in VET has been developed to take better account of students with defects in their basic knowledge and skills. The extra hour of mathematics in the upper forms in the new division of lessons in basic education and the clarification of the position of physics and chemistry in the lower forms supports improvement in knowledge and skills in these subjects in future. Different players were involved in JNA: the education administration, the municipalities, schools, educational establishments and H.ED as well as industry and other organisations. The most important work has been carried out at schools and educational establishments, where teachers have undertaken additional studies and developed teaching across subject boundaries. Teachers’ IN-SET was the most visible of the projects in the LUMA JNA: 11,000 teachers took part in IN-SET.

Subject teacher organisations, other organisations and industry have supported the teachers’ development work in a variety of ways. Schools, educational establishments and H. Ed. engaged in significant co-operation that transcends the boundaries between the various levels. H. ED. have provided schools with their equipment and expertise, given teachers supplementary training and carried out research and researcher training projects relating to the learning and teaching of mathematics and the natural sciences.

1.10. The SCI-TECH Basic Year in Sweden

One measure that has increased the recruitment of students into MST higher education is the establishment of the Sci Tech Basic year. The objective of the project is that youngsters who have completed their gymnasium studies in other fields than Sci Tech can study a supplementary year with that particular focus. The students study during this year the courses in which they lack qualification for continued studies in the Sci Tech field to go to university. The choice of courses to be taken by a student is adapted to the previous knowledge. This leads to the fact that for many students not a full year is necessary to upgrade their knowledge in the areas of Sci Tech. The initiative started in 1992 and has existed and expanded ever since. The Sci Tech year at a specific university is generally attached to a place in a programme in that university afterwards. The student is entitled to financial support during the basic Sci tech year but this doesn’t mean that he will get support later on in the university studies. The basic years doesn’t give any academic points or credits and can thus not be combined with a first year at university.

34 Full information about the LUMA Joint national Initiative and the evaluation report of 2002 is to be found on this webpage: http://www.minedu.fi/minedu/education/luma/finn_knowhow.html
The SCI Tech year is a way to broaden the base of recruitment to MST education at the university. Thus students who have NOT followed an MST programme at the gymnasium (secondary school) level get the possibility to change their direction of studies to enter the Sci Tech field. Above all pupils who have attended the Social science Programme or more theoretical professional programmes as the electricity programme are recruited.

The Sci Tech Basic Year is regularly followed up, evaluated and reported upon; Special external evaluation of the initiative has also been set up. Every year around 7000 students from the social science programme or from different vocational programmes in upper secondary school have studied at the Sci Tech basic year. Most of them are entering higher MST education. About 50 per cent of those are female students. At the teacher training programmes in MST fields for lower secondary schools, about one third of the students have been recruited who came from the Sci tech Basic year.

Other important project to promote the interest in MST in Sweden are: the SCI-Tech Project "NOT projektet' 35 and the creation of five National Resource Centres.

The SCI-TECH project wants to develop teaching methods within MST so that young people and adults get the possibility to approach SCI-TECH in a stimulating and thought-provoking manner. Linking up MST with the reality of the learner is a key element. The project also want to raise the general interest and motivation for MST.

The work in the project has been organised in a number of activities: in-service training activities of teachers and teacher trainers, series of seminars for teacher trainers at the university institutes of education, evaluation of science education, in-set in science teachers for class teachers at lower and middle level, regional conferences concerning science education in cooperation with the National Resource Centres.

National resource Centres have been developed for Chemistry, Physics, Technology, Mathematics and for Biology and Biotech. Each of these centres is attached to a large university, thus ensuring a professional scientific expertise. All the centres focus on some form of support and cooperation with teachers to enhance MST but they each have their specific points of interest and attention. The help of the centres is greatly appreciated by teachers.

1.11. The Space for technology and science initiative in Belgium

In Belgium there is serious concern about the small number of pupils that choose studies in the field of sciences and technologies. Hence it is thought to be important to start to raise the interest of children at a young age. A special committee suggested it would be good to raise the interest for children through the theme of space and all the elements related to astronauts. Hence the initiative launched by the Prins Filipfonds (The Prince Filip Fund) which invite schools from the three linguistic communities to cooperate on a topic of space, research in relation with space or travelling in space. Schools across at least two of the linguistic communities have to develop and implement together a one-year project to promote sciences and technology linked to space. Creativity and innovation are key elements focused upon in the projects. This project thus combines raising the interest for science and technology with increasing intercultural understanding across the communities in Belgium. See website: http://www.kbs-frb.be/code/page.cfm?id_page=125&ID=971

35 NOT projektet: website: http with information:
http://www.ucr.umu.se/PDF/Utv%20E4rderingsrapporter/Evaluationreport14.pdf#search=%22NOT-projektet%20Sweden%22
See also presentation: http://www.ntva.no/rapporter/Gago-2002/13-backlund.shtml
1.12. The Platform Bèta Techniek, Netherlands

The is an excellent example of the implementation of a policy outlined in the Policy plan Delta Plan Bèta Techniek, described in the GRID database. It is a holistic systemic approach to work systematically at the promotion of MST and technical studies in the Netherlands.

The Platform Bèta Techniek has been commissioned by the government, education and business sectors to ensure sufficient availability of people who have a background in scientific or technical education. This approach has been formulated in the Deltaplan Bèta Techniek, a memorandum on preventing shortages. The aim: to achieve a structural increase of 15 per cent more pupils and students in scientific and technical education and to use existing talent more effectively in businesses and research institutes. The aim is not just to make careers in science more appealing, but also to introduce educational innovations that inspire and challenge young people.

The Platform therefore targets schools, universities, businesses, ministries, municipalities, regions and sectors. The objective is to ensure that the future supply of knowledge workers will meet the future demand. It is not simply about 15% more beta technicians. It is about working to create talent for the future: more beta technicians who have broader competencies, and increased affinity with science and technology in the entire population. It is also about more effective deployment of the talented professionals already in the job market. Particular attention is paid to women and ethnic minorities. A broad approach is needed.

The approach is divided into programme lines that correspond to the stages of education and employment that young people encounter: primary and secondary education, secondary and higher education, vocational education, job market and innovation.

**Primary and Secondary Education**

- Broaden Technology in Primary Education. Structurally embed technology in the educational programme of 2500 schools by 2010
- Set up experiments with continuous educational directions for science and technology. Stimulate networks in primary and secondary education. Join forces with task group for innovation in primary education
- Stimulate innovation in primary education curriculum theme of Man and Nature. Connect to ‘Secondary Education Direction’
- More room for developing teachers, stimulating innovation and improving teacher training courses

**Secondary and Higher Education**

- Stimulate chain networks between secondary and higher education
- Launch guide projects, professional innovation committees and educational profile committees and stimulate internal coherence of innovations
- Improve numbers of new students, selection of degree programmes, feasibility of study and rate of graduation from university. Expand and revamp bachelor phase
- Individual incentives: experiment in science fairs, science bridge, SmartCard study

**Vocational Education**

- Redesign seven new pilot projects. Fundamental innovation emphasising continuous education. New project locations, alliances in VMBO, MBO and HBO
- HBO Sprint to achieve 15% more science graduates
- Ambition programme for VMBO science and technology

**Job Market and Innovation**

- Conduct 2010 exploratory studies with sectors, technology fields and regions
- Improve R&D careers by means of employee exchange (Casimir)
- Public/private mobility for innovation and employability
AKTIE network for improving career prospects in market sector
Bèta Techniek regional action plans

1.13. Education reform in Hungary

Content reform in public education in Hungary in the late 90-s was based basically on school-level developments. The implementation of the new National Core Curriculum by MoE was based on setting databases and information network. After modification of NCC state regulation become stronger. State decided to work out models of frame curricula for different school types. The stress on development later was taken on systemic development, where complex pedagogical programmes (curricula, methodology, textbooks, evaluation and teacher in-service programmes) were to serve active learning. One of the pilot projects were organized to produce these complex programmes, National Institute of Public Education - an institution of MoE for R+D in public education - accomplished new integrated models of science teaching-learning. Development was organized in a close collaboration between the institute and innovative schools and school teachers. Following the same approach, different models were reached (see QE2-86, QE1-476).

From 2004, further pedagogical development became a central issue, connected to the first National Development Plan (the basic document of EU Structural Funds. For this, a new institution was established (Sulinova Kht.). These developments are in the first phase but rely on previous workshops and professionals. The structure of the development is that after the central, competency-based programme-developments regional school centres will try out and adopt the programmes, and in a 3rd phase they will be centres for dissemination in regions.

1.14. Raising standards in Mathematics and Science, Norway

The action plan focuses on FOUR primary goals

1) Improve the teaching of M & S in day care centres and primary and secondary school

The work done in day care centres linked to the subject areas of “Nature, the environment and technology” and “Number, space and form” will be increased.

The Norwegian University of Science and Technology implements a project up (similar to the Swedish “Head Start”) within which university students will act as good examples and mentors for the pupils. (especially disadvantaged ones and girls).

Thematic evenings with speakers from business, universities and regional colleges, are set up to encourage pupils to believe in a future linked to M & S. Students will also be connected to business to enhance collaboration education, business & industry and later career opportunities.

To meet the challenge of deficient knowledge in pupils of M & S, the Government seeks to increase the number of M & S hours at primary level. A charting test for numerical comprehension shall be introduced in the second or third grade. The aim is to find out what skills pupils actually acquire, so that teaching can be better adjusted to the needs.

2) To improve the competence of teachers and teacher training.

To increase recruitment of students in teacher training who choose M & S, to reinforce the proportion of M & S in their training and to increase the competence of teachers in M & S goal-oriented continuing and further education of teachers will be organised.

To strengthen partnerships and collaboration between businesses and education, opportunities will be given for personnel with an M & S educational background in enterprises and organizations to be given secondary senior teacher positions in schools.
In order to increase the proportion of teachers with M & S in their portfolio of subjects, the Ministry will evaluate financial instruments for recruiting teachers/trainee teachers to take master's courses in M & S, and to recruit M & S students to the teaching profession.

3) To develop M & S subjects in higher education and research.

Recruitment of students to courses in M & S and engineering at universities and university colleges must be increased, as well as improvement of the quality of M & S teaching in higher education. The number of women choosing M & S in H. Ed. and research must be increased.

4) To reinforce expertise in M & S in the labour sector.

A national meeting-place between the Government, business / industry and education will be established to monitor developments in M & S, reinforce collaboration and propose schemes.

5) To improve communication with the general public

The aim is to increase awareness of the importance of M & S among decision-makers and in the media, and we wish to increase the opportunities for parents to motivate their children to study M & S. To achieve this it is important to develop M & S arenas outside schools with a view to creating interest in these subjects and the desire to study them.

2. NATIONAL INITIATIVES WITH A PRIMARY FOCUS ON INNOVATION IN EDUCATION OR ANOTHER AREA

Official pilot projects may have another primary focus than science, maths and technology. The pilot project may focus on innovation in education in general such as the VOORRUIT projects in the Netherlands or the PROEFTUINEN in the Flemish Community of Belgium. The primary focus may also be a different topic such as the KUBIM pilot initiatives of which the primary focus is on new technologies / ICT.

2.1. The KUBIM pilot project in Germany

Although not specifically in the field of science it is worth while mentioning the KUBIM project (Kulturelle Bildung im Medienzeit Alter) which is promoting projects which combines culture and new technologies and thus indirectly also science and technology. KUBIM is linked to the larger context of concepts and programmes in Germany to help build the global "Information Society" and to improve arts and media education.

This project has also been launched by the Bund Länder Kommission across the different German Länder. The 5-year programme is made up of 23 large scale projects and has a budget of ca. 11,6 million EURO (2000-2005); it is financed equally by the Federal Ministry for Education and Research (BMBF) and by the Länder Ministries for Education or Science and Culture.

It has been mentioned before in the present study that projects which combine different elements such as culture and science appeal very much to a variety of groups of youngsters. Also for KUBIM there are financial means, there is a monitoring and support structure enabling follow-up and evaluation towards possible dissemination and multiplying the outcomes.

Several concrete projects combine arts with elements of science and technology or ICT and new media. See: [http://www.kubim.de](http://www.kubim.de)
2.2. The VOORUIT pilot projects in the Netherlands (36)

The policy measure ‘Vooruit’ (Forward!) of the Dutch ministry of education and Science of January 2005 intends to stimulate innovative projects which focus on the promotion of the learning of young people, on the motivation for learning, on the improvement of learning results and on the development of the talents of youngsters in secondary schools. The objective is not primarily to promote science education but several of the projects funded have to do with science education. The Amstel institute (37) (specialised in science education) has helped several schools in drafting their application for the VOORUIT initiative. Several of those projects are described in the GRID database.

2.3. The PROEFTUINEN or Pedagogical hothouses of Belgium (Flanders) (38)

Subsequent to a major report on innovation in education the Flemish department of education launched in 2003-2004 a series of 16 pilot projects called ‘Voortrekkerscholen’ or pathway schools to promote all sorts of innovation in education. In 2004-2005 this first pilot project was turned into the larger pilot project ‘Proeftuinen’ (pedagogical hothouses) with the primary objective to promote innovation in education in general and in vocational and technical education in particular. Within those Proeftuinen some projects also focus on science education, on maths and on technology.

The Proeftuinen projects are to last three years, from 2004-2005 to 2006-2007; at this date a full evaluation will have been carried out before generalising its results.

2.4. The ATTRAKTIVE SKOLA project in Sweden (39)

The aim of the Attraktiv Skola Project (2001 – 2006) is to draw attention to the school sector as an attractive workplace by increasing the appeal of the teaching profession. Tangible work got started in March 2001, and is in 2005 in its last working year. The project is ending in June 2006. In 2005 there are 23 municipalities participating in the joint network of the Attraktiv Skola Project. The final phase of the project is the networking of organisations of the Attraktiv Skola Project which is greatly appreciated. The main focus of this Swedish project is not on science education but some of the partnerships and networking focuses on science and technology.

Five key elements have to be implemented in every partnership:

- Networks of local authorities, schools and universities;
- Document the activities of the partnership and networks;
- Exchange teachers between participating schools and universities (o.a. to stimulate transfer of research findings into school education);
- Give the opportunity to teachers to be involved in a variety of educational activities;
- To set up an exchange programme between schools and companies.

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37 Amstel institute: see website: [http://www.science.uva.nl/amstelinstituut/english.cfm](http://www.science.uva.nl/amstelinstituut/english.cfm)
39 Attraktiv Skola: for information in English see the following website: [http://www.skola.se/](http://www.skola.se/) Click on ‘in English’ and the intermediate report of 2004 is available.
2.5. The Danish "Better education"

The Danish report "Better education"(June 2002) mentions 7 key policy lines towards the future: a clear focus on qualifications, competences and skills; flexibility of educational programmes; pupils and students compose their individual learning programme to acquire clearly defined competences and skills; coherence between the disciplines and contest which respond to the needs on industry and the public sector; innovation and entrepreneurship; the increase of motivation of the learners; a larger autonomy of the educational institutions. The report also mentions 6 transversal policy elements for which actions have to be taken at all levels: professional advice and career counselling of pupils, interest more youngsters in natural sciences and technology, internationalisation of education, ICT in education, accreditation of experiential learning and Danish for adult migrants.

The Danish Ministry of Education has developed DEL with the Danish Innovation and Development (FoU) programme and Project Database with pilot projects.

FoU is an action programme for the innovation and development of vocational education and training in Denmark managed by the Department for Vocational Education and Training Programmes of the Ministry.

The FoU-programme has a key objective of supporting the innovation and development of vocational education and training in Denmark by promoting projects at vocational schools and other institutions within the system. Furthermore, the programme is concerned with enabling the vocational education and training system to prepare for future demands from the labour market, to anticipate new skills needs generated by societal change, and to experiment with new educational methods. FoU is a central mechanism for facilitating continuous adjustment and adaptation of the schools’ practice to changing demands. Projects on innovations in science and technology could be funded through FoU.

2.6. A Curriculum for excellence, Scotland

As a result of a national debate on education in 2002 the Curriculum for Excellence was decided in Scotland. Its aspiration is to enable all children to develop their capacities as successful learners, confident individuals, responsible citizens and effective contributors to society. A Curriculum for Excellence challenges establishes clear values, purposes and principles for education from 3 to 18 in Scotland. The document has profound implications for what is learned, how it is taught and what is assessed. It enables to anticipate changes and challenges which young people will face in the future, to take account of advances in education and to tackle the aspects of the current curriculum which must be improved. It focuses on all aspects of education and has a specific focus also on science education. In this area a series of pilot projects have been set up.

It is stressed that the curriculum should:

- make learning active, challenging and enjoyable
- not be too fragmented or over-crowded with content
- connect the various stages of learning from 3 to 18

40 The full Better education report of Denmark is to be found on the following website: http://pub.uvm.dk/2002/better1/
41 Further information about FOU and DEL are to be found on the following website: http://www.delud.dk/fou/internationalising/english.htm. The database with good practice is to be found on the following website: http://www.foul.emu.dk/ but is only available in Danish.
42 For full information about the Curriculum for Excellence in Scotland; see the publication on the following webpage: http://www.scotland.gov.uk/library5/education/cerv.pdf. For Full information on science education 3 - 18, see the following webpage: http://www.scienceeducation3-18.com/
- encourage the development of high levels of accomplishment and intellectual skill
- include a wide range of experiences and achieve a suitable blend of what has traditionally been seen as 'academic' and 'vocational'
- give opportunities for children to make appropriate choices to meet their individual interests and needs, while ensuring that these choices lead to successful outcomes
- ensure that assessment supports learning
F.3. PRESENTATION OF PROJECTS LAUNCHED WITHIN VARIOUS FRAMEWORKS

1. PROJECTS LAUNCHED WITHIN THE FRAMEWORK OF EUROPEAN AND INTERNATIONAL NETWORKS OR ORGANISATIONS

Several projects in the fields of Sciences (and sometimes maths and technology) in schools and teacher education or training have been developed in the framework of European or international organisations.

The following subdivision can be made so far:

- Projects funded through the European Union either within the framework of the large education and training programmes – Socrates and Leonardo or within the framework of the large framework project for Research and Development. Within Socrates the projects will mainly be funded through the Comenius chapter and will Comenius 1 school partnerships focusing on science, Comenius 2 partnerships between teacher training institutions or a few Comenius 3 networks.

- Projects funded within the framework of international organisations such as UNESCO, the Worldbank, OECD etc.

- Projects funded within the framework of international associations or foundations.

- Projects funded within the framework of bilateral or multilateral cooperation between several countries.

1.1. European Union funded projects

A selection of projects is selected. A full database with EU funded projects especially within the Socrates and Leonardo da Vinci projects is available through GRID.

The WESPA project - a 6th Framework for R & D project, Italy (coordinator)

The European project WESPA - A Web portal for Energy and Semiconductors Public Awareness - aims at providing pupils with a deeper understanding of the nature of energy (its transformations, exploitations, nowadays problems and future scenario) and of semiconductors (and the related technology) and their impact on modern society. This is achieved through the development of a web portal where one can find information about scientific and technological issues in the form of multimedia contents. Main Objectives: to explain the impact of scientific and technological developments and their applications, benefits and limits to the general public and to young students. The portal will allow to enter the multilingual versions of the multimedia and to ask for more deepening to experts of the network established among partners.

ePhys - Towards an effective use of ICT for Open Learning in the Teaching of Physics in Europe: A Socrates MINERVA project, Greece (coordinator)

The "ePhys" project seeks to promote European cooperation among teachers, learners, and researchers on an effective use of ICT in the teaching of Physics. "ePhys" will combine successful implementations of ICT in teaching Physics (computer based experiments, data-acquisition and processing, simulations, modelling, video measurements, remote labs) with the flexibility of web-based
modules (open java-like simulations) in a unified learning environment for open and collaborative learning in Physics. The project focuses on: q designing, developing and testing new educational resources q identifying and establishing supportive conditions for enhancing the local (in-school) infrastructure, the successful adaptation and transfer of innovative pedagogical approaches (e.g. open and collaborative learning using ICT) q developing new learning activities based on ICT, that foster higher cognitive skills and aim at the well-known difficulties of conceptual understanding q evaluating and documenting efficiency gains and added value for teaching and learning in secondary education q disseminating the improved methods and educational resources at regional, national and European level. The target groups for the "ePhys" project are teachers at Secondary Schools, Pre- and In-service Teacher Training Institutions and National Physical Societies, and also students, who in classes or at home will use more tools to investigate, communicate, and understand Physics and its applications in modern society. The Sint-Gabriëlcollege in Boechout (BEnl) participated as a secondary school in this project. Her task was to test the educational materials (hardware, software and teaching strategies). In what follows this point of view will be taken.

The SMEC project (\(^{43}\)): a Socrates Comenius 2.1 project , Italy (coordinator)

The main aim of the project is to encourage the use of the museum as educational resource for the teaching and learning of science in primary schools, and to contribute to the training of teachers for the development of competence and expertise in using museums. In particular, the project aims to:

a. encourage collaboration between educational institutions and museums for improving training practice and raising the quality of school teaching and learning;

b. develop pedagogical methodologies and resources for producing, acquiring and applying knowledge in science, to be used individually or jointly by schools, training institutions and museums;

c. offer support to the teacher in terms of his/her professional development and delivery of the subject in a competent and confident way that can also encourage the creative development of the pupils;

d. improve museum provisions in order to make museums more effective training and teaching resources;

e. develop a European dimension through sustained, long-term collaboration between trainers, teachers and museum educators across countries;

f. contribute to raising teachers' and pupils' awareness of the shared European scientific heritage;

g. through various activities and dissemination of educational material encourage communication and collaboration, as well as reflection and debate in the fields of science education, teacher training and museum education.

The EduRobot project: a MINERVA Socrates project, Greece (coordinator)

The EduRobot project has been financed by the European Commission in the framework of the Socrates Programme - Minerva Action. The project’s partnership involves ten partners in seven European countries. The aim of the EduRobot project is to spread the knowledge of the robotic science throughout European secondary schools. The reason for this is that robotics is a science that incorporates several other sciences (e.g. mechanics, electronics, etc.). The project activities include the creation of training packages deliverable on-line, on topics related to robotics, a glossary for robotic terms, the delivery of training to all teachers and students involved carried out with the use

\(^{43}\) For further information, see the website: http://www.museoscienza.it/smeg/project.html
of an e-learning platform, the development of a virtual "lab" and the creation of robots by the transnational working groups of schools involved in the project. The aim of the activity is for the students to experiment with the concept and methodology of transnational research and development projects. This is achieved through a "learning by doing" approach.

WITEC

WiTEC – the European Association for Women in Science, Engineering and Technology (SET). WiTEC was formed as a network in 1988 and after more than ten years of networking and project activities related to women and SET, established itself as a non-profit European association in May 2001. The WiTEC Network has developed and managed a wide variety of projects relating to women and SET (Science, Engineering and Technology) with partners from across Europe over the many years it has been in existence. WiTEC National Co-ordinators have successfully received funding for projects from European Commission departments in Education and Culture, Research, Equal Opportunities between men and women and several national funding agencies.

WiTEC has the following aims at European level:

- To increase the number of girls and women studying SET subjects and to help them progress to related careers
- To develop women’s technical and entrepreneurial skills through training initiatives and projects
- To create information exchanges and networking opportunities for women in SET
- To promote and support research into areas relating to women in SET
- To support initiatives to promote the Gender Mainstreaming Policy
- To promote regional, national and international awareness and interest in this field.

1.2. Projects funded within the framework of international organisations

Baltic Sea Project (BSP) (**) Poland (coordinator)

It is the first regional Project within UNESCO Associated Schools Project to combine environmental education on a specific environmental issue, the Baltic Sea, intercultural learning and the promotion for science education.

The purpose of the Baltic Sea Project is to awaken young people’s interest in environmental issues and environmental protection, to develop their sense of responsibility for the environment. Schools from Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden take part in the project. Indirectly the project also promotes the interest for sciences linked to environmental education.

1.3. Projects of international associations or foundations

ECO-schools projects (Cyprus, Hungary)

The Eco-Schools Programme aims to raise students’ awareness of environmental and related sustainable development issues through classroom study together with school and community action, and provides an integrated system for environmental management of schools based on an ISO14001/EMAS approach. During the classroom activities specific focus is given to sciences and their role in relation with environmental education. In this way sciences are linked up with a concrete real life issue which appeals to children. The ECO schools programme thus raises interest and motivation for science learning and teaching.

For further information, see the website: [http://www.bspnews.kiss.pl/](http://www.bspnews.kiss.pl/)
Eight countries among the 10 new EU-members are members of the eco-schools network and Bulgaria and Romania - two candidate countries are, too. (see: www.eco-schools.org)

There are eco-schools in other countries joined to another network, ENSI (Environment and School Initiatives), an international government based network established under the auspices of OECD - CERI (Centre for Education, Research and Innovation) in 1986. This is the case in Hungary where there are approximately 150 eco-schools and their activity in environmental studies is very intensive. Some of them contribute to the GRID project, as well.

**GLOBE (Germany)**

Global Learning and Observations to Benefit the Environment or GLOBE is a worldwide hands-on, primary and secondary school-based education and science program. Pupils, teachers as well as scientist work together to achieve, through long-term observation of environmentally relevant parameters, a deeper understanding concerning cooperation between individual environmental elements such as climate, waters, soil and biology. The environmental data gathered are stored, treated and evaluated in a central computer of NASA. The results are downloadable as diagrams and can be compared with satellite photographs and afterwards discussed. The website contains suggestions on how to work with the GLOBE in education. GLOBE Germany is promoted by BMBF and the KMK.

2. **PROJECTS LAUNCHED WITHIN THE FRAMEWORK OF ASSOCIATIONS, FOUNDATIONS, UNIVERSITIES OR COMPANIES**

Several associations, foundations and /or companies (involving their research centre) promote a variety of rich projects which are quite similar across Europe. They very often want to link up schools, children and teachers with real life situations to promote science and technology. They offer a framework that may include didactical and pedagogical materials and sometimes even monitoring and support. Several of those projects focus on cooperation with museums so that the richness of museums can be put at use in the school environment.

**The EST project in Italy**

The EST project or Education in Science and Technology involves teachers and students of more than 1000 schools in the region of Lombardy with the aim to promote scientific and technological culture by means of a 'hands' on methodology. It is a joint initiative of a Foundation, the Fondazione Cariplo and the national Museum of Science and Technology Leonardo da Vinci of Milan with many other institutional partners.

**The LLC project or Life Learning Centre in Italy**

It is run by the Marino Golinelli Foundation. Life Learning Center is the first center in Italy to be devoted to a permanent research and training on Life Sciences, addressed mainly to upper secondary school students and teachers (vocational and technical secondary schools) but also to primary and general secondary schools. Its main goal is to provide teachers and students with a practical and interesting instrument for approaching Life Sciences (Biotechnology, Molecular Biology, Genetics, Biochemistry, Microbiology), giving them a chance to live a lab experience in a university structure. The Center has very technologically advanced labs, which become classrooms out of the usual school context, and where teachers and students, with the support and supervision of university tutors, can live in person a "hands-on" experience of Life Sciences.
**SEA: Science and engineering Ambassadors (GRID database UK)**

Science Year became a launch pad for other initiatives and programmes. One major example is the 'Science and Engineering Ambassadors' (SEA) programme that is still in progress today. Managed nationally by SETNET (45), and locally through the network of 53 SETPOINTS, the SAE programme aims to promote STEM (Science, Technology, Engineering and Maths) by providing enthusiastic, vetted volunteers to work with young people and teachers in schools.

SEA’s are volunteers from business and the community who are willing to offer their time and expertise in order to communicate their enthusiasm for STEM and encourage young people to discover what these subjects and careers have to offer. The SEA programme has been running since January 2002 and has grown steadily over these years. In May 2004, there were over 6000 volunteers fully registered as SEA’s and at least another 1500 currently going through the induction process. The most recent figures suggest that currently over 10000 ambassadors are registered with the programme and are actively involved in schools throughout the UK. The scheme has succeeded in recruiting volunteers and companies with a wide variety of different backgrounds truly enabling schools to access an invaluable wide-range of expertise.

**3. PROJECTS STARTED BY INDIVIDUAL SCHOOLS AND/OR TEACHERS**

Many projects in the GRID database are examples of stand alone projects. It means that they are not part of a larger network or mechanism at local, regional, national, European or international level. Very often these projects are born from an initiative by one or two teachers who decide to set up innovative approaches in their classroom or school.

**3.1. Individual projects of one schools or small groups of schools**

The ‘In the wood’ project (Italy)

Observation and exploration path of the earth and the wood environment realised with the children of the pre-primary school to activate and develop scientific abilities, by means of experiences, research and observation. There is given particular attention to the construction of contexts and environments able to stimulate learning and the choice of a multiplicity of languages so that different cognitive styles can be identified and the privileged way of each child to enter in contact with reality. The project foresees activities of direct contact, observation, manipulation, practical experimentation, individual and emotive approach and in a second step guided work of synthesis which facilitates the passage from concrete aspects to symbolic and graphic ones.

The SOFIA project (Portugal)

The project up to now is part of a network of 8 private schools in Portugal. The initiative wants to establish a new project pedagogy for teachers and students. Young people shall learn and learn to learn by means of projects elaborated by themselves. Teachers have the task of serving as models and of orientating pupils and projects. The projects of teachers have a duration of one school year. The projects of pupils have first a duration of one day, then a duration of one week and after that a duration of two weeks. Pupils learn how to take decisions right now and to be concrete about now and tomorrow. They work together in small groups and help each other. It is a project about active and united citizenship which can be transferred to every discipline, also to science subjects, and which helps pupils to learn with active engagement.

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45 For further information on SETNET, see the following website: [http://www.setnet.org.uk](http://www.setnet.org.uk)
**Website of physics experiments (Ireland)**

This project was initiated by a science teacher. The numbers studying physics are in decline, and this website provided simulations of physics experiments for pupils and teachers.

**KTapir (Hungary)**

The individual initiative of a chemistry teacher in a small settlement school of the North-Hungarian region is an alternative of motivating pupils and enhancing individual and small group activity. The programme is aimed at teaching Chemistry, supported by ICT and applying project methods (GRID Initiative No. 1104 / 1134).

**Teaching Environmental protection as a separate subject (ISED 3a, before final exam) (Hungary)**

The 8-grade secondary school is a so called elite educational institution; the majority of students goes to universities. Teaching sciences ends one year before the final examination. The school developed an own curricula as a synthesis of sciences in this subject. The subject stresses the importance of sociological, human ethological and psychological background of environmental protection (GRID Initiative No. 1105 / 1135).

### 3.2. Individual projects leading to a broader network

However, in a few cases such local stand alone projects may develop from an isolated initiative into a wider mechanism adopted by several schools within one country or even beyond. The Italian Béziers is a good example of this.

The BEZIERS CURVES initiative, undertaken in a higher secondary school, has foreseen the study of the Bézier curves and their application in the programmes used by University and Industry. The initiative has been first realised in 2003/2004 by an idea of a teacher who got in touch with two professors of the Maths Department of the University of Torino (Mathematics, Physics and Natural Sciences Faculty) as well as with the responsible of a company and proposed them to cooperate in the activities related to applied maths.

In the school year 2005/2006, the initiative has been included in the national "Science Degrees project", as one of the didactic laboratories to stimulate students towards careers in the field of mathematics. The "Scientific Degrees Project" is promoted at national level by the Italian Ministry of Education (MIUR) and by the Science Dean’s National Board (Con.scienze) in cooperation with the Association of Italian Industry (Confindustria), in the frame of the triennial planning (2004/06) for the University System. It has been launched in order to increase recruitment in science universities (mathematics; physics and chemistry) and to create a link between school, university and industry.

### 3.3. Projects disseminating outcomes of science projects of pupils

A special category of projects, of which there seem to be very few, is the projects that disseminate the outcomes of science projects conducted by pupils.

**SU 18 or Science Under 18 project (Italy)**

Conceived in 1997/98, Science Under 18 can be considered in the Italian panorama the first structured dissemination space of science projects carried out by pupils. The initiative has the objective to present in an exhibition the science products made by pupils. It consists in a structured space at the National Science and Technology Museum L. Da Vinci in Milan, where, during an entire week (in general the second or third week of May), the pupils of all ages of the Lombard schools, from
pre-primary to upper secondary schools, present to other pupils the science projects they have prepared during the year. In 2005 there have been involved 5 exposition places, 297 projects and about 13,000 visitors.

F.4. A FIRST ATTEMPT OF TYPOLOGY FOR INDIVIDUAL PROJECTS

All the projects analysed can be put classified into the following typology:

1. Women and science
2. Innovation in teaching and learning sciences at school
3. Cooperation with the (local and regional) communities
4. Cooperation with research laboratories of the universities, with schools of engineering, with companies
5. Scientific culture
6. Students counselling and career counselling
7. School failure and drop out: primary school - secondary - university
8. Education and training of teachers and/or heads

1. WOMEN AND SCIENCE

Several projects described in the Grid database either in the QE1 forms or QE2 forms concern projects focusing on the promotion of the participation of women in scientific studies in secondary and in higher education. Some projects also focus on the fact that women are not willing or are not given opportunities to take key responsibilities in research laboratories in universities or companies.

If one carries out an analysis of the situation of the women in sciences, one notes several disparities. This is clearly pointed out in the report "She Figures 2003 - Women and Science"(46). Engineering professions are particularly badly affected with an important unbalance between men and women in engineering professions and occupations. The study also points out that women are still strongly present in areas such as literature, health, arts and social sciences. The study also points to a decline in the number of graduates in certain areas: the areas most affected are engineering, sciences in general, mathematics and informatics (data processing). This is worsened by the fact that in those areas the majority of the graduates are also men. The research sector is also affected by this trend; in particular research in engineering and technologies where the proportion of women hardly reaches 25% in the majority of the countries of Europe. Even the more feminine disciplines such as medical and human sciences have a majority of male researchers except for countries such as Finland and Sweden. Research in industry is also subject to this problem with only 15% of female researchers.

Although the percentage of women researchers seems to be more important in the civil services, it is still well below 50% of the researchers.

The initiatives set up in several countries concern the following actions:

- Information and counselling of young girls at the level of the secondary school. This is mostly done at the end of the secondary school, in the final two years so as to influence the choice of the young girls. In one case the project to increase the number of female researchers works with young researchers who become the mentors of girls in their final years of secondary school.

- Developing and organise in-service training of teachers and career counsellors to make them more aware of the potential there is for girls in scientific and in research jobs

- General information days for girls at all ages such as the German Girls' day. During such days girls can visit companies and other organisations that employ researchers and scientists and can talk with female scientists and researchers about a potential career as a women scientist or searcher.

- Better inform the parents of the pupils a.o. with the support of the parents’ associations.

- Some initiatives are set up at the level of European associations such as SEFI (La Société Européenne des Ingénieurs or European Society for Engineering Education) that as a separate working group on women in engineering. Lecturers from engineering departments go to school to give information about engineering studies and the prospects for women in engineering.

- Peer education models are also used within which older girls at secondary school level and who have already decided to study sciences help younger girls in the study of their science subjects. In this way they may contribute in a certain way to counselling their younger fellow students and may strengthen their interest in a scientific career.

The following initiatives are to be found in the GRID database:

- Femmes et sciences (FR)
- Set Women Resource Centre (UK)
- The Ada Lovelace initiative (DE)
- Girls’ day (DE)
- Girls teach girls (AT)
- PALLAS project (Ambassadors for women and science) (DE)
- The DIAM  project (DE)
- Women in Technology and science -WITS (IRL)
- WITEC initiatives (not in the database)47
- VHTO initiatives in the NL (not in the database)48

2. Innovation in Teaching / Learning Sciences; General School Level (2-14 yrs) ISCED 0,1 and 2

This theme includes all projects that aim at making the teaching and learning of sciences and technology more effective and efficient at primary school level. In some cases these projects already exist at the level of the kindergarten or pre-primary school. The projects may have an approach focusing directly on elements of science or they may focus on linking up science with other disciplines or areas such as arts and culture or creativity.

Innovation can focus on teaching-learning methodology, which can modify attitudes and motivation towards science and maths. Methodological innovations can relate to tools for more efficient learning (e.g. ICT) or to dealing with different groups of pupils, e.g. those of special needs or those who are talented, having social backwards.

This is done by trying to give to science education a more experimental dimension and by developing the capacity of argumentation and reasoning of the pupils. The objectives can be broad, but they try to integrate also all fundamental learning activities and focus on the acquisition of generic skills that can be useful in lifelong learning. Under the supervision of the teacher, the children observe a phenomenon of the real world and afterwards are invited to formulate questions, to carry out some research activities, to suggest and implement experiments and to be involved in analysis of documents.

47 For further information see the website: http://www.witec-eu.net/index.html
48 For further information see the website: http://www.witec-eu.net/index.html
The main objective is to develop the concrete intelligence of children and to raise their interest and motivation for sciences. Sometimes the main tool for this is ICT.

Some of the initiatives are focusing on the training of primary school teachers as it is vital that these teachers are better trained to help raise the interest for sciences with the pupils.

Innovation of science education on lower levels of public education sometimes appears in periodic activities out of contact teaching time or connected to specific school-events. Theme-days or -weeks, seasonal project-activities in some Hungarian general schools for example often deal with broad scientific problems (e.g. water as the source of life). Besides pupils’ initiatives and activity, enhancing motivation and effectiveness via active learning, synergy can be achieved by that the same theme is dealt with in another subjects.

The following examples are to be found in the GRID database:

- L’école des sciences, centre de ressources (France)
- La main à la pâte, classe (France)
- Chip, Chip, Chip Hoera (Bnl)
- Tous chercheurs (Bfr)
- Van rooksignaal naar aapenstaart (From smoke signal to monkey’s tale) (NL)
- Kidsbits (DE)
- Science in Kindergarten (DE)
- Hands on Science (Comenius 3 network) (PT)
- In the Wood (pre-primary school - IT)
- The territory of Valdarno Superiore yesterday and today - a historical-geographical path (primary school - IT)
- Physics on show (peer education - primary and secondary school - IT)
- Round and sharp-cornered objects - Geometry experiences in 3D (primary school - IT)
- Big Numbers (maths project - primary school - IT)
- Arithmetic tales at "Numberland" (primary school - IT)
- Play with constructions: Maths that exists (primary school - IT)
- The little graphics designers are growing (technology - primary school - IT)
- Környezetünk tevékeny megismerése (Active recognition of our environment) (primary school, special needs - HU)
- A Vertán telepről Európa élvonalába (From Vertan settlement to forefront of Europe) (primary school - HU)
- A Víz világnapjától a Föld napjáig (From the Water Day to the Earth Day) (primary school - HU)
- A víz az élet forrása (Water is the Source of Life) (primary school - HU)
- "Danish programme" - waste and recycling (Dán program – hulladék újrahasznosítás) (general school - HU)

3. Cooperation with the (Local and Regional) Communities

The organization of the educational administration differs according to the countries. First of all one has to make a difference between the centralised countries and the federal ones. In federal countries such as Germany and Belgium the components of the Federal country, the Länder for Germany and the Regions for Belgium, have a total autonomy in terms of education and hence they will develop initiatives in the field of science on their own. Italy is stressing more and more its regions while Spain has given a lot of power to the 17 Autonomias or autonomous regions.

In the case of Germany, however, joint initiatives between all the Länder have been agreed upon, designed and implemented to promote science education as the quality of science education is a
concern for all the Länder. The SINUS initiatives and subsequently the SINUS TRANSFER initiative are good examples of such federal initiatives in Germany. Such initiatives across all Länder do not exclude individual activities for some of the Länder.

In Belgium the regions do not cooperate in science education and each has different initiatives. The French community of Belgium has strong structures organised around the universities which cooperate together with their own initiatives gathered through their own key network: RéseauScité. The Flemish community has no centralised activity to promote science education but supports several initiatives through universities, institutions of higher education and other bodies such as associations (a.o. of teachers) and foundations. In some cases, universities across Flanders cooperate together in initiatives such as the Chip, chip, Chip Hoera of IMEC (Inter University Micro electronics Centre) created by all the Flemish universities together.

Italy is attributing a stronger role gradually to the regions which is also reflected in initiatives which may be launched in science education by some of the regions or by bodies in charge of education within the regions such as the IRRE which are dealing a.o. with in-service training of teachers in general and sometimes with specific activities for science teachers in particular.

Spain has an interesting decentralised approach with the 17 Autonomias which are in charge of education. Several if not all of those autonomies are developing initiatives to promote science education using regional funds next to the fact that science is still a key area at the level of the ministry of education in Madrid. An example of what the Autonomias do is to be found in Catalonia with its Camps d’Apprentissage (learning camps) within which science education maybe combined with other disciplines or even interdisciplinary approaches such as environmental education.

In France, initiatives may be possible at different levels as different levels are in charge of education. The village or town can play an active role as the primary schools fall under the responsibility of the local (commune) authorities as to the construction, the maintenance, the extension, the repairs, the equipment and the functioning of the buildings. The French ‘Département’ is in charge of the ‘collèges’ or lower secondary schools in all matters concerning equipment and the functioning of the buildings. The Département is responsible for recruitment and management and in particular of the remuneration of the non teaching personnel. It has the responsibility for the central libraries, for the management and the maintenance of the archives and the departmental museums. As to the environment, the law entrusts the Conseil Général (the political structure at the level of the Département) with the protection of natural spaces considered to be sensitive (ENS). To promote the respect of the environment, the Conseil Général sets up educational programs to raise the awareness for the environment and thus indirectly also focuses on the promotion of sciences. For example, the departmental house of the environment of the Conseil général of the Département of Meurthe&Moselle, runs a series of campaigns towards the general public and towards the schools which has an impact on science education. Finally the Région in France has a.o. the responsibility of the ‘lycées’ or upper secondary schools as to the functioning and the equipment. The region is in charge of the recruitment, the management and remuneration of the non teaching staff. The region may also be involved in a variety of educational activities directly or indirectly promoting science education.

In some East-Central-European countries like Hungary there was a large-scale decentralisation, which had resulted that schools had a wide range of autonomy. Under the umbrella of a state frame-regulation schools define their pedagogical programmes which are accepted by local authorities or by their other maintainers. Central development in these circumstances relies also on school-based innovations. Innovative teachers and schools can become developers and/or nets of piloting, adapting and disseminating new, centrally developed programmes. School teachers and schools are also targeted to take part in applications of a state-established public foundation (Közoktatási Modernizációs Közalapítvány, KOMA, from 2005: Oktatásért Közalapítvány) that aim at bottom-up innovation (see ‘The pedagogy of teaching physics in practice’ (A fizikatanítás pedagógiája a gyakorlatban), GRID Initiative No. 1127 / 1100)
The following examples are to be found in the GRID database:

- La maison de l'environnement, l'écologie pratique avec Un exemple de classe : Etude sur les insectes
- Camps d'apprentissage of Catalonia (ES)
- Chip, Chip, Chip Hoera (Bnl)
- Réseau Scité (Bfr)
- High school at sea (DE)
- Applied mathematics competition (promoted by the IRRE Lombardia - IT)
- LLC Life Learning Centre (agreements with the Regional School Office of Emilia Romagna - IT)
- Statistically (promoted by the IRRE Emilia Romagna - IT)
- Science Under 18 (originally promoted in cooperation with different local bodies, among them the Regional School Office Lombardia - IT)
- Zooeducation (Zoopedagógiai foglalkozások) - HU
- Zooeducation program of Animal Park, Nyíregyháza (Nyíregyházi Állatpark Zoopedagógiai programja) - HU
- Environmental education R+D programme in the Jászberény Zoo (Környezetpedagógiai K+F program a Jászberényi Állat- és Növénykertben - HU

Within this type of projects, it is interesting to analyse the nature of the cooperations developed with the members of the local communities.

Which members of the local community? In many projects there is cooperation with a variety of members of the local communities such as:

- universities and institutions of higher education
- engineering schools or colleges
- teacher training colleges
- in-service training organisations
- research laboratories
- industry, companies
- foundations
- associations of teachers
- engineering associations
- museums
- social actors
- cultural actors
- all sorts of NGOs
- trade unions
- public works or utilities (water / electricity companies)
- zoos
- etc.

Which cooperation with the industry? This cooperation may be directly with companies or through professional organisations and may have different objectives:

- Inform about certain professions, careers and diplomas and their development
- The joint building and construction of partnerships
- The promotion of high quality and creative learning environments
- Exchange and reflection on the role of each agent involved in training and education: the teachers, the trainers, the tutors etc.
- The promotion of interest and motivation for science in general and scientific jobs or careers in particular
- The promotion of entrepreneurial skills.
- High tech industry giving support science education not by a collaborative way but by but incentives. The results of this can have an effect on education: awards and competitions.

The cooperation with companies or professional organisations may take different forms:

- Placements of pupils
- Placements of teachers as training in companies
- The creation of pedagogical tools
- The development of in-service training courses
- Visits of companies
- Interventions at certain moments as elements of educational activities
- Making equipment available to schools
- Enable schools to use company equipment
- Peer support by people from industry.
- Etc.

The following examples of cooperation with industry are to be found in the GRID database and are herewith added as annexes:

- Examples The Edison project of the University of Antwerp (B)
- Junior Ingenieur Akademie , Deutsche Telekom (AT)
- Deutsche Telekom Stiftung and Promotion of science (DE)
- Chip, Chip , Chip Hoera : IMEC (BE)
- Award for the best science teachers, offered by Ericsson Hungary Ltd., Graphisoft Corp., Richter Gedeon Corp. yearly in Hungary since 2000 (4000 EUR/person).
- ISEF (INTEL International Science and Engineering Fair) world competition for the young.
- SMEC (IT)
- The JET-Net project (NL) 49

Cooperation with NGOs

There is a branch of innovation in science education where not educational actors are the engine of the process but the civilian sphere. NGOs are involved in significantly cross- or multidisciplinary activities like programmes of sustainable development, environmental studies, 'green' movements. In Hungary for example, more NGOs gave an impetus in development science education. Complex approaches, applying pupil-activating methods, achieving much more motivation and understanding scientific problems in a real lively context is significant in activities of NGOs, that is why these activities are very popular in schools. These activities generally part-time, extracurricular and outdoor ones (forest schools, camps, green schools). (see MagyarKörnyezeti Nevelési Egyesület - Cserkúti kölökpajta; E-Misszió - Természeti és Környezetvédelmi Egyesület - környezeti nevelési program).

Ngos often offer teacher-in-service training, therefore approaches and methods used here, can be applied in school environment, too.

The following cooperation with NGOs can be found in GRID database:

- Kid’s Stable in Cserkút (Cserkúti kölökpajta) - HU
- In the Forest of Mecsek (Mecseki erdők mélyén) - HU
- In communion with nature (Közösségben a természettel - HU
- Forest school programme in Hortobágy (Erdei iskola program a Hortobágyon - HU

49 The JET-Net project: In 2005, the Platform Bèta Techniek supports the successful Youth and Technology Network. Over 15 major companies and some 100 schools now cooperate in Jet-Net. Science graduates employed in companies teach classes in schools, schools take field trips to visit companies, and partners work together to develop teaching materials. In the coming year, Jet-Net works to achieve national coverage of businesses and schools that will cooperate in a regional setting.
The environmental Education Programme of E-misszió Nature and Environmental Protection Association (Az E-misszió Természet- és Környezetvédelmi Egyesület Környezeti nevelési programja - HU)

Teachers for the future generation (Pedagógusokkal a jövő generációért) - HU

4. COOPERATION WITH RESEARCH LABORATORIES, UNIVERSITIES AND ENGINEERING SCHOOLS

These initiatives have numerous objectives:

- Enable pupils or students to exchange and cooperate with real scientists and researchers;
- Motivate the pupils and the teacher for different (creative) pedagogical approaches; the intervention of external people in the classroom has an impact on the typical and traditional classical model;
- Children get interested in a real scientific approach;
- A link is made between science and real life situations which enhances understanding of and interest for science;
- External input from the scientists improves the quality of the teaching of the learning;
- The support of scientists and researchers makes the teachers feel more safe as some of them have doubts about their scientific level;
- Moreover the help of scientists and researchers can be seen as a form of in-service training.

Universities and their research centres or laboratories play a key role in the promotion of science, maths and technology. Universities and their research centres may have a variety of roles in science promotion:

- They are running official pilot projects for the ministries of education: see to this effect the ISMT2 (and IMST3) AT project, the many projects run by the INP Leibniz Institute in Germany, projects run by Waterford Institute of Technology (IRL) etc. This running involves starting up, implementing, monitoring following up of the activities, evaluation of outcomes and dissemination of official pilot projects.
- Run local or regional projects in direct cooperation with schools or teacher training institutions to promote science education;
- Open their laboratories for secondary school pupils as in many of the projects focusing on cooperation between university laboratories and schools;
- Have some of their junior staff or research students involved in mentoring pupils (women!) to raise their interest fro sciences
- Have some of their research staff involved in mentoring science teachers in schools;
- Help the ministry of education organise large scale awareness raising events in the field of science and technology such as the science week in Malta.
- This may also involve initial and in-service training of teachers at different levels in the primary or secondary school.
- Develop materials and tools that can be used in the classroom or in in-service teacher training;
- Be active in managing European or international networks such as the hand-on Comenius 2 network funded by the Socrates programmes, 6th Framework project on R & D etc.

The cooperation with research laboratories, universities and engineering schools may take different forms:

- Welcoming pupils from mainly secondary schools (final years) during a period which can last one day to a full week. During their tray in the laboratory at the university the pupils are engaged in research activities together with young researchers or student researchers. In some cases they attend lessons at their level.
- In some cases university research people or linked up with women students to motivate them to choose a scientific career (Ada Lovelace project).

- University students or students from engineering colleges work in primary schools and set up pedagogical sessions focusing on scientific approaches.

The following examples of cooperation with research labs / universities and engineering schools are to be found in the GRID database:

- The MATHS MACHINES (IT)
- Cooperation between the Ecole des Mines de Nancy (Engineering school) and primary schools (F);
- Lernort labor (DE)
- X Lab or Experimental Laboratory (DE)
- Phys@theLab (BE)
- Gläsernes Labor (DE)
- Collaborative Laboratories for Europe - Co-Lab (NL / DE)
- HISPARC (NL)
- JULAB (DE)
- Schülerlabore (DE)
- DLR Schoollabs (DE)
- Ruhr-Universität Schulerlabor DE)
- Secondary teacher assistant researcher (IRL)
- DRAGO (IT)
- LLC (IT)
- Science Under 18 (IT)
- Radon (cooperation with university and local authorities - IT)
- Wespa (cooperation with university and research labs - IT)
- Classe de 3e avec laboratoire de recherche ITER (FR)
- The Comenius 3 Hands On Science Network
- Neumann János Tehetséggondozó Program or Janos Neumann Programme for talent development (HU).
- Study-group work for secondary pupils, organized by John von Neumann Computer Society and Eötvös Loránd University, Budapest (HU)
- The Jet Net project NL (see footnote 50)
- etc.

5. **Scientific culture**

As mentioned in one of the key reports on science education in France, the Jantzen report:

"Initial education or training contributes to scientific and technical culture because it transfers to the children scientific and technical knowledge whether this happens in general education of in vocational, technical or technological education. Initial education has a key role to play as the first interest and motivation for science and technique will be transmitted at that stage...."

- How then to educate and train youngsters who have to face a growing flow of information and as a multitude of questions do not find an answer only in the disciplinary fields which tend to break up knowledge in little pieces which are not adapted and which do not, by nature, facilitate a synthesis (teaching and learning being mainly analytical)?

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50 For further information on the hands on Science Comenius 3 Network, see the following website: [http://www.hsci.info/](http://www.hsci.info/)
How can the school and how can education, confronted with those changes, increase the level of scientific culture and not only just the level of knowledge?

Which approaches have to be developed and implemented enable to respond to all those requirements?

To reach those objectives, one has to distinguish:

- practical advice as to the vulgarisation, the dissemination and as to scientific communication
- structures and sites of which the objective is to promote scientific and technical culture: a particular role is given in this field to museums, associations, scientific parks or cities of sciences etc.
- productions and events: exhibitions, performances, sciences festivals and celebrations, scientific clubs, films, TV and radio programmes, press articles, magazine contribution etc.

The following examples are to be found in the GRID database:

- Physics on stage (CH)
- Girls’ day (DE)
- The Helmholtz Foundation (DE)
- Junior science café (NL)
- Hiking across Estonia (EE)
- The summer of science (DE)
- The astronomical night in Pissouri (CY)
- Technopolis (Bn)
- La Cité des sciences (FR)
- Science Under 18 - (in cooperation with the Leonardo da Vinci Museum - IT)
- WESPA - A web portal for Energy and Semiconductor Public Awareness (IT)
- A Web Portal for Chemistry and Science Education (IT)
- Quand les sciences font leur cinéma (Bfr)
- Palace of Miracles (Csodák Palotája), (HU)
- Meet the scientist (Ízelítő a múzeum műhelytitkaiból) (HU)
- University of ‘Omni-knowledge’ (A mindentudás egyeteme) – State Television programme (HU)

The website: [http://www.latitudessciences.ird.fr/sites_utiles/cst.htm](http://www.latitudessciences.ird.fr/sites_utiles/cst.htm) proposes numerous examples to this effect.

### 6. STUDENTS COUNSELLING AND CAREER COUNSELLING

Several national policy reports refer to the need strengthen the interest and motivation for the learning of sciences up from a young age. Several reports also stress the need that awareness raising and motivation for science should not just be a one-off activity at a certain age but they stress that constant efforts have to be made up from the primary (or even the pre-primary) school to raise interest in science (and technology).

In general the following elements are stressed in those reports:

- Strengthen the actions to raise the awareness for scientific professions and careers and raise the interested for the learning pathways in schools which can raise the interest for sciences (and technology) towards all target groups at school. These actions include any action of the type of the ’Hands on project’ or ’Main à la pâte experience’ such as in France or many other countries.
• Strengthen the actions within which schools (at all levels) cooperate with research institutes, with universities or research laboratories of companies.

• Enhance the cooperation with scientific and technical museums and the many initiatives set up by local, regional, national or European associations.

• Include in the training programmes of future teachers of the primary and or secondary school issues related to how to raise the awareness of schoolchildren for scientific professions and careers. At this level the LUMA initiative and all the activities focusing on the promotion of science need particular attention. This country gives a special place to science in initial and in-service teacher education and training both for primary and for secondary education.

• Make the scientific professions and careers accessible to young people from disadvantaged families and social background. Certain countries like Germany, Finland, Hungary and Ireland focus very strongly on the role of the mechanisms of professional counselling to enhance professional opportunities in certain scientific and technical / technological areas for young disadvantaged people.

The following examples are to be found in the GRID database:

• Raise awareness for scientific and technical pathways in schools:
  o Accent op Talent (BnL)
  o Main à la pâte (FR)
  o Hands on science, Comenius 3 Network (PT)
  o The LUMA JNA programme (SF)
  o Bézier Curves (IT)
  o Developing mathematical skills of 14-15 year-old students (14-15 éves tanulók tehetségfejlesztése (Arany János program) (HU)
  o Etc.

• Cooperation with museums, foundations, associations, companies
  o The SMEC, Comenius 2.1 project (IT)
  o The EUDIST Comenius 2.1 project (DE)
  o The Helmholtz Stiftung (DE)
  o Junior Ingenieur Akademie (DE)
  o School science Museum (PT): a museum in a school!
  o Developing mathematical skills of 14-15 year-old students (14-15 éves tanulók tehetségfejlesztése (Arany János program) (HU)
  o Etc.

• Raising awareness for science in initial teacher education
  o The SMEC project (IT)
  o The IMST2 initiative of the University of Klagenfurt (AT)
  o LUV: Lernen aus Unterrichtsvideos fur Physik-Lehrkräfte
  o QuiSS-ProSa: Professionalisation of primary school teacher activity in general science education (DE)
  o SINUS (DE) Enhancing of pupils interests and motivation for natural sciences through integrated projects (LITH))
  o SINUS TRANSFER (DE)
  o Teachers’ certification in science (DK)
  o Secondary teacher assistant researcher (IRL)
7. School Failure and Drop Out: Primary School – Secondary – University

Transition from the primary school to the secondary school

The transition from the primary school to the secondary school or from basic school into upper secondary school (this depends according to the education system in country concerned!) is a problem in many countries. Several initiatives are launched across Europe to do something about this transition as it is at this particular moment that problems may occur and which result in drop out or in downslide effect for an important number of pupils.

Special initiatives are taken at different levels such as stronger cooperation between primary schools and secondary schools which take the form of teachers in the final years of the primary school cooperating with teachers in the first years of secondary schools or teachers from the secondary school who teach in the final years of primary school. Secondary schools use special introduction or welcome days for the 'new' primary school children, organise special information sessions for parents and pupils and set up extensive support and tutoring mechanisms for the 'new' pupils. No needs to stress those children from disadvantaged backgrounds need particular attention also at this stage.

Many of the actions taken in several countries may have the direct or indirect promotion to enhance or to continue to enhance or strengthen the interest and motivation in sciences. Many of those initiatives prefer not have a sole focus on sciences but combine it with a focus on different disciplines and have transdisciplinary, crossdisciplinary or interdisciplinary approaches.

Some examples to clarify this matter:

- France has 'Les Classes à Projet Culturel et Artistique' (Classes PAC) of which the objective is to facilitate the integration of the pupils in the lower secondary schools or colleges. Such classes will be mainly organised in sensitive areas in so-called zones of priority education with pupils with specific disadvantages.

- The Flemish Community of Belgium has the Dynamo 2 project within which culture and sciences has to be combined; a ceramic artist will cooperate with a chemist to explain about the chemical processes involved in creation arts ceramics. This is not limited to lower secondary schools but can be all through secondary schools.

- The Cultural heritage classes or camps that exist in many European countries may take different forms and are organised at different stages. In most cases they combine interdisciplinary and cross-disciplinary approaches linking sciences, maths, culture, economics etc. to make them more attractive.

- In Some Austrian schools window displays are made of the products and projects children develop within their science lessons so that other pupils can be interested by what pupils do in science lessons; how creative they can be of what practical and real life situations they link up with.
Pedagogical linkage mechanisms between the primary and secondary school exist in many European countries so that there is continuity between the pedagogical approaches in the primary and the secondary school.

Transition from secondary to higher education.

It is generally accepted in most EU education systems that the transition from the secondary school to higher education is a difficult period. Students make different kind of choices: either they choose shorter higher education studies for security reason or they choose more social and human studies in stead of scientific studies as the latter are perceived to be too difficult. Several studies show that pupils who studied sciences at the upper secondary school level do not necessarily go on studying sciences at higher education level. Many future university or higher education students have no clear learning pathway as to their future profession of career at the end of the secondary school. Hence it is normal that in several countries efforts are made to better inform those youngsters about the potential of scientific studies and the professions or careers they lead to. One of the tool for this is the two-level final examination. Choosing the advanced level of exam goes with having more contact hours in the last or last two school years. Within this period teaching materials can be re-organized in a more integrated way than they were taught in a subject-based structure.

It should also be added that several countries have already made efforts to create flexible learning pathways for gifted pupils at the end of the secondary school. Thus examples exist of secondary school pupils who during their final years at secondary school can already take some courses at university or higher education level. This is the case e.g. in Sweden.

Several initiatives are taken to cope with this situation:

- Persons are put in charge of these issues at local or regional level.
- University students and teachers go into secondary schools to give information about scientific studies at university or in higher education expanding on the methodologies used and applied;
- At the end of the first term of the final year in the secondary school, schools organise together with universities and/or laboratories and research people, information sessions in the schools, in companies, in universities or laboratories to inform about professional opportunities and careers in sciences;
- In the course of the final year (or two years) upper secondary school pupils may be invited to the university to attend courses, practical work sessions and laboratory exercises. They also are given the opportunity to meet students, young researchers and professors;
- At the end of the school year schools organise open door days focusing on high quality information about scientific studies and subsequent careers or professions;
- Universities and laboratories organise camps or social events for children with particular interest in sciences or gifted children.
- Universities and Institutions of higher education take special steps to support students who have chosen scientific studies to help them overcome difficulties they may have at the beginning of their studies; this is done by organising special tutorials or support measures either by specialist or by senior fellow students;
- Schools involved pupils of upper secondary school classes in helping other pupils in lower classes with their scientific work. In some cases upper secondary pupils go and teach in the primary school in relation with a scientific project they work on.
- Pupils interested in sciences maybe involved in running events for adults; this motivates the youngsters and the adults.

The following examples are to be found in the GRID database:

- Inter-(t)asking: Studierenden lernen von Studierenden (AT)
- Schülerinnen unterrichten Schülerinnen (AT)
- We watch the stars (Science week) (AT)
- Astronomical night in Pisouri (CY)
- Peer teaching in chemistry (NL)
- The work of the mathematician (IT)
- Matematic@ Project (web site for maths university students of the first two years - IT)
- Developing mathematical skills of 14-15 year-olds students (14-15 éves tanulók tehetségfejlesztése (Arany János Program) (HU)
- Etc.

8. EDUCATION AND TRAINING OF TEACHERS AND/OR HEADS OF SCHOOLS

The initial and in-service training of teachers directly or indirectly involved is essential to promote the interest and motivation in science and to enhance the fact that more youngsters will decide to study sciences at upper secondary school level and later on go on with sciences in higher education or universities. Teachers can raise interest and motivation by developing a creative learning environment closely linked to the real life of the children.

The primary school teachers need particular attention as in most European countries the task of teaching science is assigned to 'every' primary school teacher and not to a subject teachers. Science is at the level of the primary school embedded in a general approach of society or world orientation that is an interdisciplinary subject. Thus subject usually has a different name according to the country where it is embedded in the primary school. Raising scientific and technological awareness is usually one of the elements of the key competences to be achieved at primary school level.

Teachers both at primary and at secondary school level involved in science teaching do not only need scientific knowledge but also need specific pedagogical skills and competences to enhance the interest and motivation for science learning. They also need generic skills such as working in teams within the schools and working in cooperation with industry and other members of the local community.

Teachers also need to be motivated to be involved in education as one of the key elements very often referred to in relation with innovation in education is the reluctance or unwillingness to be involved in innovation. Making the (future) teachers aware of the importance of innovation and their involvement in it and openness towards it should be an important element in initial and in in-service training of teachers.

Several initiatives across Europe focus on the initial or in-service teacher training of science teachers of the secondary schools or the primary school teachers.

Important also is that in several countries structured initiatives (which will be referred to in a separate part of this study) are set up to support teachers involved in innovation in science teaching and learning at primary school and secondary school level. The ISMT2 initiative in Austria, The SINUS and SINUS TRANSFER initiatives in Germany, the LUMA programme in Finland, the MAINS A LA PATE initiative in France etc. include special support structures for teachers involved in innovation in science education. The SINUS pilot projects are linked to a university or to universities, which on the one hand may support the schools, and teachers involved and on the other hand may be involved in the evaluation and subsequently the dissemination of the outcomes to create a multiplier effect. Such a support structure is important and vital in the development and implementation of a true action-research approach.

Special attention is also given in some initial or in-service teacher training institutions to enhance the cooperation between primary or secondary schools and organisations in the local, regional, national or European community able to support the teaching and learning of science (and technology).
In-service training of science teachers should not be limited to updating skills and knowledge as to science or their skills to cooperate with members of the local community etc. Teachers also have to be able to cooperate and interact with key education players such as the inspectorate, pedagogical advisors or career counsellors, teacher-training institutions etc.

Not only teachers are concerned by in-service training courses but also heads of schools and members of the administrative and technical staff need to update their skills and competencies as to how they can contribute to help in bringing about creative environments at school (through improved infrastructure, flexible timetables and learning pathways, cooperation with external organisations etc.) to promote interest and motivation for science learning and teaching.

As science and technology may require heavy investments in terms of equipment close cooperation with industry, universities, research labs and regional technology centres (a development in most European countries) has to be enhanced and requires from the heads of schools and the managers of the board of directors plus the administrative and technical staff specific skills and competencies. Even issues related to (new) school buildings or adapting existing buildings have to be taken into consideration when developing creative learning environments.

The examples described in the GRID database show that next to initial and in-service training institutions, other groups such as associations, foundations, universities, research centres and companies organise in-service training course for science teachers to help to upgrade the quality of science teaching. In some cases, companies appeal to teachers to organise in-service training for their staff in the framework of school-industry cooperation.

As a summary the following elements can be put forward:

- The scientific cognitive skills have to be upgraded with a particular focus on linking scientific knowledge to the usefulness of science (plus maths) in real life contexts.
- Teachers have to acquire active pedagogical skills to teach science and technology in an interactive way making use of ICT and other tools.
- Teachers have to acquire transversal and generic competences or skills enabling them to work with projects, and to work with collaborative and differentiated learning approaches.
- Teachers have to acquire communication and teamwork skills to work not only with pupils but with their colleagues (within their school and across Europe or the world) and with all the stakeholders in the local community such as universities, companies, research laboratories etc.
- Teachers have to acquire skills to promote the learning of science and technology with disadvantaged groups of pupils.
- Teachers need a regular update through in-service training of recent development in sciences (and technology) such as issues related to cloning and biotechnology.
- Teachers also need better preparation to discuss possible ethical issues related to developments in sciences and technology.

Examples of projects focusing on initial or in-service teacher education in the GRID database:

- The SMEC project (II)
- The IMST2 initiative of the University of Klagenfurt (AT)
- LUV: Lernen aus Unterrichtsvideos fur Physik-Lehrkräfte
- QuiSS-ProSa: Professionalisation of primary school teacher activity in general science education (DE)
- SINUS (DE) Enhancing of pupils interests and motivation for natural sciences through integrated projects (LITH)
- SINUS TRANSFER (DE)
- Teachers' certification in science (DK)
- National Science Learning Centre Network (quality of science teaching) UK
- Secondary teacher assistant researcher (IRL)
- The LUMA Joint National Action programme (SF)
- Physics on Show (IT)
- Round and Sharp Cornered Objects (IT)
- Life Learning Centre - LLC (IT)

F.5. A SECOND TYPOLOGY - APPROACH ACCORDING TO THE DISCIPLINARY NATURE

The subdivision according to the disciplinary, interdisciplinary or cross-curricular approaches represents an interesting analysis and a possibility to define another typology with regards to the projects identified and analysed.

Some of the projects focus just on one scientific discipline. Other projects focus on several scientific or all scientific disciplines. Yet other projects combine sciences and other disciplines mainly ICT or maths. Finally there are also projects which combine science education and cross-curricular issues such as environmental education, citizenship education, entrepreneurial skills, health education, traffic education, consumer education etc. This is particularly interesting as it shows how science can be made more attractive by linking it up with real life issues that are more easily tackled through such cross-curricular themes and issues.

1. PROJECTS WITH A CLEAR DISCIPLINARY APPROACH

Many projects focus on one scientific discipline as will become apparent when glancing through the GRID database. Herewith just a few examples are given.

Here again one could make a distinction as mentioned above focusing on whether it is an official initiative, a university initiative, an association initiative etc. But this would lead much too far.

*Fysica is Fun / Physics is fun* (Bnl)

The objective of the project Physics is fun is to promote the interest and motivation for physics learning with pupils at secondary school level. The objective is also to combine playful activities with so-called more scientific activities related to the teaching of physics. The teacher organises for the pupils an excursion to a fairground. While at the fairground the pupil combine enjoying fairground attractions and carrying out experiments and exercises for physics. The pupils carry out different kind of measurements related to time, speed and distance of the different attractions they visit. Based on the measurements done by the pupils, later on more theoretical work can be done in the classroom with the pupils. All the measurements are translated into a written report individually or in group.

*Biologie im Kontext* (Germany)

The objective of the project "Biology in the context" is to promote the teaching and learning of biology in selected contexts. To this effect the development of the competencies of the pupils has to be strengthened by improving the professional development of the science teachers. In addition the authority development of pupils and pupils is to become lively by a stabilization of the professional attitude of biology instructors. The conceptual framework of the BIK project is based on the educational standards developed and published by the KMK and aims as far as the method is concerned to make use of different educational contexts in which biology can be used. The specific operational objectives are expanded upon below. A similar initiative of the IPN exists for chemistry: CHIK: Chemie im Kontext.
Employing individual methods in the biology lessons (Lithuania)

The objective of the project is to promote the use of individual methods in biology lessons so as to increase the quality of biology learning and teaching and the interest in and motivation for biology. The teacher uses original questioning methods used at the beginning of a lesson: scientific relay-race, method for controlling of apprehension of notional words, „Bingo!“, creation of a logically correct-fairy tale using at least one notion by a group of pupils. Such methods stimulate the activity of pupils, moreover, when a pupil is interested in the matter, when it is presented to him in a non-traditional way, when his emotions are involved, he memorise much better.

2. Projects with an interdisciplinary approach

Sciences and ICT (Netherlands)

The Merlet college has an integrated approach on ICT in several disciplines. A special place is given to ICT in sciences. The integration of ICT is part of the mission and vision of the school and is thus fully integrated into the pedagogical plan and policy of the school community. To facilitate the use of ICT in certain disciplines rooms have been adapted: thus there is a special room for physics, chemistry and biology. Since 2000 the natural sciences make use of a common preparation room. There is a room for practical work with next to it a room for experiments or demonstrations plus a computer room. The pupils works in sub groups to promote on the one hand team working skills and on the other hand research skills. In natural sciences they use the pedagogical pack Coach 5 of the Amstel Institute mentioned earlier.

Projects based on the Sulinet Digital Knowledge Base (SDT) (Hungary)

Sulinet Digital Knowledge Base, developed by the Sulinet Program Office, in cooperation with the MoE, is a multifunctional tool for knowledge transfer, supporting content and methodology reform. SDT is a digital curriculum database and a content management tool that consists of different reusable elements (pictures, texts, sound- and video-files), technical and content meta information in different subjects and for different age groups. From the schools use SDT in Hungary, in the database see ‘Pedagogical support for the use and development of ICT tools’ (Biology, Chemistry, Maths, Physics, ISCED 3a, b level) (GRID Initiative No. 1102 / 1132), ‘Esther’ project (integrated science, ISCED 1 and 2 level) (GRID database No. 1103 / 1133) and ‘Pedagogical System of Integrated Science’ (GRID Initiative No, 765 / 1129).

When the sciences work with movies: sciences and culture (movies!) (Fr)

The objective is this project "Quand les sciences font leur cinéma" (When sciences work with movies) is to make young secondary pupils aware of the image that is created by film makers of science, of scientists and of scientific achievements. An objective is also to make youngsters reflect critically on the contribution of sciences to the development of our present-day society. The activity is developed by an organisation called "Atout sciences" in the French-speaking community of Belgium. The activity is composed of three sub activities. One step is the projection of a large audience film (in original version for pupils the second step is the subsequent interactive debate between scientific experts and young people. These two steps are preceded by a preparation possibly in the classroom and by an introduction given by an expert just before the projection of the film.

The same organisation runs a project “Les sciences se livrent” (Sciences through novels combining sciences and literature. Within this project the starting point to create interest for science is a novel of Bernard Tirtiaux “Le puisateur des abîmes” plus the involvement of a geologist.

**Physics and Chemistry Applied to Arts (Portugal)**

At the secondary level (11th, 12th grades) the students in the artistic areas have the discipline of Physics and Chemistry as optional. The project aims to develop an attractive curriculum useful and applied to technical-artistic situations that can be useful for their carriers, in competition with other artistic subjects; thus the project links sciences to arts or aesthetics.

**Can cross-disciplinary education support basic education for natural sciences? (AT)**

The objective of the project is to strengthen the teaching and learning of natural sciences by promoting cross-disciplinary approaches. This project action-research report - one of the concrete outcomes of the project - describes the experiences of a team of teachers on interdisciplinary work. The themes chosen to build the cross-disciplinary work on were: "colours - light - seeing" in a 7th form or with children of 12 to 13 years of age.

The project developed and tried out pupil-centred methods of teaching and learning to find an answer to the question in what respect and how far interdisciplinary work can support basic education for natural sciences. The process of the project, which should give an answer to the title question mentioned above, is fully described in all its phases from the planning to the evaluation in the action-research report. Apart from the results and realizations within the project both the development processes within the team of teachers and the experiences of the pupils are clearly described in the report. The process and the implementation of the project is fully documented with posters and publications on the school homepage.

**Pluri-disciplinary approach to geography (GR)**

Geography is taught in Greece only during the first two years of secondary school (age of pupils: 12-14 years), with two hours a week. In the frame of this project, it is tried to innovate the didactical approach of this subject 1) by adopting country-specific workshops (synthetic presentations of a country with the collaboration of the relevant embassies, search for information in Internet, cooking, music and plastic arts workshops concerning the country in question and the synthetic analysis of the specific conditions of each country starting by graphical representations, 2) by trying to introduce experimentation when teaching geographical concepts, 3) concerning Greek geography by doing study visits to cultural heritage museums.

3. **PROJECTS COMBINING SCIENCE EDUCATION AND CROSS CURRICULAR ISSUES**

Several projects combine science education and cross-curricular issues such as environmental education, citizenship education, entrepreneurial skills, health education, traffic education, consumer education etc.

**Sharing Science Across Ireland : science and citizenship education**

This is a joint initiative between the association for science in Northern Ireland and the Irish Science Teachers Association in the Republic of Ireland. It involves pupils in the 10-14 age range in the border counties working on science and technology topics related to their respective curricula. The project was launched in 2004. Currently 52 primary and 29 post primary schools are engaged in the project, arranged in 22 clusters having cross community and cross border representation. The aim of the
project is to for the children to interact with children from either side of the border and from different sectarian groups within Northern Ireland.

**Freshwater network Project: science and environmental education, Hull, UK**

There are several objectives for the involvement in the Freshwater network and in other projects. One of the objectives is to promote active European citizenship with youngsters. Another objective is to promote science education in a cross curricular way by linking up science with environmental issues and issues related to sustainable development; To reach those objective the school is also involved in European and environmental projects. The overall objective of these activities is to stimulate interest and motivation for learning by promoting a creative learning environment through project work.

The involvement in the freshwater network enables the primary school, Hauptschule 3 or HS3, to strengthen the interest for science and environment by linking up with the real life and the environment (the river Drau) which is close to the children. The pupils are involved in project work with work in biotopes and through other infrastructure measures within the school in close cooperation with the local community. In this way science is incorporated into concrete life and environment. The school is at present also recognised as a result of all those activities as an ECO-school.

**Chemie im Supermarkt: functional food! Science and consumer education, Austria**

The objective of the present project is to create a more attractive learning environment for the teaching and learning of chemistry by linking chemistry to real life situations. Most chemical processes of our direct everyday life are to be assigned to organic chemistry. Food, cooking processes, textile fibres, plastics, wash and purification processes represent only a small cut-out of our chemical everyday life world. These topics offer a multi-layered entrance to acquire important technical basic knowledge in the field of (organic) chemistry. It was thought this project could improve the interest and the motivation for chemistry of the pupils. The foundations of chemistry can be built and acquired gradually by learning through experimenting, by observing and by interpreting. In this way pupils learn to make interconnections and they also develop a completely new kind of learning which has a lasting effect on them and their lifelong learning motivation. It also has an impact on consumer education.

**The Edison project: science and entrepreneurial skills (52), Belgium**

The objectives of the project EDISON of the department of Physics of the University of Antwerp are the following: - raise the awareness for science and research with youngsters at the end of secondary education; - promote the interest for scientific entrepreneurship with youngsters - promote the creative and innovative skills of youngsters Through those objectives the project wants to contribute to the implementation of the action plan for science and technology of the Flemish Government and which is implemented through a.o. the initiative ‘Wetenschap is knap’ (Science is Smart).

**European Traffic and Mobility as an Educational Leitmotiv: science education, traffic education and environmental education plus EU citizenship; Austria**

The objective of this project is to promote interest in sciences by linking sciences with real life situations in the immediate environment of the children. The project also wanted to enhance the

52 Entrepreneurial skills is one of the priorities of the Commission as highlighted in the Plan to promote business spirit in schools and universities of 13 / 02 / 2006. A full brochure with examples form across the EU can be found on the following webpage of DG Enterprise:
motivation for education in general and for science education in particular. As a pertinent part of the school development process of the school, the teachers intend to implement major topics that will give guidelines for the entire education process throughout a school year. The effects of traffic were chosen as a first theme due to its importance for society and nature and because of the fact that a cooperation of all grades and subjects can be based on this topic. The project contributes to EU citizenship, to environmental education and to traffic education.

The RADON Project (IT)

Radon is the most dangerous physical pollutant; in fact, after cigarette smoke, the inhalation of radon represents the second cause of pulmonary cancer. Besides the education aspect, regarding the risks related to the exposure to the main physical pollutants of the environment, the central theme of this experience is represented by the relation between scientific research and educational orientation. The realisation of a scientific research activity, with well defined and limited objectives, allows the students to know better the activity of a researcher, by means of an in-depth study, and contextually allows them to evaluate their own capacities in relation to their interests, increasing by that the awareness of the student concerning the choice of a university course.

Appropriate use of energy - The bet (IT)

The initiative foresees the following parts: a) critical study of the laws of thermodynamics with the aim to use energy in a rational way b) analysis of a complex, global and controversial question, as is energy c) contribution of young people to the reduction of emission of carbon dioxide in the atmosphere.

F.6. OTHER POTENTIAL TYPOLOGIES

It would have been possible to make other typologies focusing on other target groups but it was decided not to do it in this report. The GRID database is built in such a way that every teacher or interested person can easily access projects according to a target group.

Projects for pupils

The majority of the projects focus on primary and secondary school children. Very few projects focus on pre-primary schoolchildren although some do.

Projects for teachers

Many projects directly or indirectly focus or have an impact on the teachers. Some just address the teachers and their initial or in-service training.

Projects for disabled

Nearly NO projects address specific groups of disabled. Only one project has been found which focuses on interactive science materials for the blind. This is the case for the Estonian project called ‘Interactive science teaching materials for the blind’. Another exception is the Hungarian school level project called ‘Active recognition of our environment’ that deals with mentally handicapped pupils with special education need.

Projects for disadvantaged groups
Nearly NO projects focus on disadvantaged groups except girls. No projects seem to have been found to facilitate the access of sciences for children of migrants or other cultural or ethnic minorities.

**In-service training initiatives for teachers**

LLC Life Learning Centres (IT)
Science course for primary school teachers (IRL)
Primary science curriculum support (IRL)
SOFIA project (PT)
Etc.

**Placements for pupils or teachers in laboratories or research centres of universities or companies**

Xlab (DE)
Schullabore (De)
STARS programme (for teachers) (IRL)
Etc.

**Cooperation with and visit to museums or technology centres**

SU 18 (IT)
Edison project (+ la Cité des sciences, Paris) (Bnl)
School science museum (PT)
Etc.

**Databases or portals, mapping review**

See all the websites described under a separate heading
SU 18 (IT)
Website of Physics experiments (IRL)
Statistically (IT)
A web portal for Chemistry and Science Education
Etc.

**Games**

Homicide (DK)
Ludomathematics (PT)
Realmat (PT)
Etc.

**Exhibitions / Exploration path**

Window displays in the school (Schaukasten) (AT)
Construction: a travelling exhibition (IT)
Maths machines (IT)
SU 18: Science under 18 (IT)
Physics on Show (IT)
Hiking across Estonia (EE)

**Events / Clubs**
We watch the stars (AT) pupils as guides in watching stars
Science & technology week (Malta)
Science girls’ day (DE)
Astronomical night in Pissouri (CY)
A school symposium (CY)
Science market / wetenschapsmarkt (Bnl)
Junior Science cafés
Zarco science Clubs – Eco schools (PT)
Environmental Education Clubs (PT)
Clubs of science and environment (PT)
Etc.

Pedagogical boxes and tools
Box it (Malta)
Experimenteerkoffers / Kit with experiments(Bnl)
Physics survival kits
Etc.

Competitions
Bolyai Application for the Young (Ifjúsági Bolyai Pályázat) (HU)
National Competition in Science and Innovation for the Young (Országos Ifjúsági Tudományos és Innovációs verseny) (HU)
Electronic mailing competition in Maths (ISCED 3) (www.e-suli.hu) (HU)
National Secondary Schools Competition (organized for secondary grammar and vocational secondary school pupils in several subjects) (HU)
International Student Olympic Games
National Science and Innovation Competition for the Young (Országos Ifjúsági Tudományos és Innovációs Verseny)This competition is organized by the Hungarian Alliance of Innovation and Moe for secondary school pupils and university students (HU)
‘Izsák Imre Gyula’ Mathematics-Physics-Informatics competition. It is a yearly competition, organized by a secondary school (Zrínyi Miklós Gimnázium, Zalaegerszeg). The three subjects are evaluated equally in the competition (HU)
‘Ilona Zrínyi’ mathematics Competition. A regional competition, organized by Kecskemét and Bács-Kiskun county; since 1995 international (Romanian, Ukrainen and Serbian schools are participating) (HU)

Maths competitions (Italy)
ESA competition (CH)

Peer teaching activities
Inter(t)asking (AT)
Pupils teach fellow pupils (AT)
Peer teaching in chemistry (NL)
SU 18 (IT)
Physics On Show (IT)
A Web Portal for Chemistry and Science Education (IT)

53 More on Hungarian Research Student Movement (Kutató Diákok Mozgalma), organizer of the competition see: http://kutdiak.hu/uj/56-4746.php
54 More on these activities see: www.okm.hu/doc/upload/200511/jo_gyakorlatok_matek_2004.pdf
Etc

Newspapers and magazines

Science for fun (IRL)
Mathematical and Physical Pages for Secondary (Középiskolai Matematikai és Fizikai Lapok (KÖMAL)) (HU)
Chemical Pages for Secondary (Középiskolai Kémiai Lapok) (HU)
ABACUS (monthly periodical, Maths). Edited and published by János Bolyai mathematics Society and Foundation for Talented Pupils in Mathematics (HU)
Life and Science (Élet és Tudomány). Periodical of the Scientific and Educational Association (Tudományos Ismeretterjesztő Társulat, TIT) (HU)
Etc.

TV and radio programmes

Jongens en wetenschap : Youngsters and Science (Bnl)
University of ‘Omni-knowledge’ (A mindentudás egyeteme) - TV programme (HU)
Choose the knowledge (Válaszd a tudást!) - TV programme) (HU)
Etc.

F.7. ANALYSIS OF SOME TRANSVERSAL ISSUES

The analysis of the various projects identified reveals some interesting transversal issues presented hereafter.

1. LINK WITH SCHOOL DEVELOPMENT PLAN AND SCHOOL STRATEGY IN INNOVATION

The school development plan has different names according to the country but in all countries schools are invited to develop on an annual or pluri-annual basis a school development plan or a pedagogical plan. Such a plan includes the key elements of the mission and the vision of the school and insists upon the actions to be taken to implement that mission and vision taking into account the school population and the area in which the school is located.

Thus a school development plan will focus on the activities for the pupils, the activities towards the teachers (such as in-service training activities), activities towards parents and other members of the local community. It will focus on curricular and extra-curricular activities. It will pay attention on all means to be used to bring about a creative learning environment for all pupils so that ‘all’ pupils can use their talents and potential as much as possible. Recent reports drafted by many ministries of education show that focusing on all the talents of the pupils is very high on the agenda. Most of those documents also refer to the need to promote science, maths and technology.55

55 Some documents in relation with improving school education to use all talents of the pupils:
- Le rapport Thélot, France, October 2004
- Accent op Talent, Belgium Flemish Community, 2004
- Le contrat pour l’école, Belgium (French Community), 2005
- Better education, Denmark, 2002
- Attraaktiv Skola, Sweden, 2001-2005
- The 14-19 Reform: opportunity and excellence
- Klasse Zukunft, Austria, 2004
- The LUMA programme, 2002 report
In many science projects a clear link is made with the school development plan although this is not always the case. The link is very clear and explicit when the school is involved in an overall science, technology or maths projects set up and implemented by the Ministry of education. In this case schools have to clearly express their interest to be involved in the official pilot project and have to commit themselves to a minimum of rules in such a pilot project. The rules usually concern the monitoring, follow-up and evaluation of the project within the school and through external links with universities or other institutes in charge of these activities. Schools also have to commit themselves to dissemination of the outcomes within the school, the local community and even broader. The organisation of the involvement in an official project thus requires a clear organisational discussion that is to be reflected in the school development plan or the pedagogical plan.

In Italy each school devises on an annual basis its Piano dell'Offerta Formativa or POF or School Training offer which outlines the school organisation, the training offers and other choices made in the framework of the school policy. Innovative actions in Science, maths and technology will be included in this POF.

In French primary schools the innovative actions for science would be included in the PRESTE (Plan de renouvellement de l'Enseignement des Sciences et de la Technologie à l'Ecole or Plan for renovating the teaching and learning of sciences and technology in the primary school) which has to be implemented in all primary schools across the country.

The involvement in an official project which covers several years is often the result of discussions with different stakeholders: parents, teachers, heads, pupils, local community etc. It requires strategic management decisions within the school (infrastructure, use of resources, timetables, structure of classes, purchase of equipment, priorities for in-set etc.) which have an impact on all the stakeholders.

In some cases schools will sign a charter or a contract expressing their interest to be involved in the project and their determination to fulfil the activities laid down in the project. The schools to be involved in France in "Les Mains à la pâte" initiatives sign a charter of cooperation saying they will respect the key rules laid down in this initiative. Schools involved in the ECO schools initiative (see examples in the GRID database in Cyprus, Hungary and Portugal) draft an eco-code, establish a committee and make an environmental review before embarking upon the ECO school project. Flemish schools involved in the ‘Proeftuinen’ of the Accent op Talent innovation initiative sign a contract with the department of education.

In a few cases, like in the Flemish community of Belgium, preliminary discussions are held between schools that will be involved in the pilot project (in this case the Proeftuinen) so see whether the activities can be implemented within the boundaries of the existing ministerial regulations. Experience shows that sometimes-official regulations have to be temporarily relaxed or loosened (applied less strictly over an agreed period of time) to enable the implementation of certain innovations. This proves to be useful as it may reveal that existing rules and regulations (regulating the task of teachers or organising school time etc.) may hamper the innovation in school education in general and in science, maths and technology in particular.

Finally schools which are involved in Comenius 1 projects within the framework of the Socrates programme of the EU have to submit with their project application a Comenius Plan showing that the integration of the European and international dimension in the school curriculum and activities is a deliberate choice integrated in the school development plan and in the vision and mission of the school. Schools which fail to submit a Comenius plan are excluded from funding for their Comenius 1 school partnership.

A lot of innovation is taking place at local, regional, national and European or international level. At European level it may take place through the large European programmes in education and training such
as Socrates and Leonardo da Vinci (soon to become the Integrated Lifelong Learning Programme. International cooperation with policy goals can happen 'out of Brussels'. CIDREE (56), a European consortium of educational research and development institutes, organized more projects with this goal. One of them analysed possibilities of building up and structuring of innovative developments in science education (with contribution mainly of Scandinavian institutes), another tried to modelling involvement of NGO-sphere (resources to be added). The main goal of both of them was to suggest future development policy for European R+D institutes.

2. INTRODUCTION OF A PROJECT TO THE SCHOOL COMMUNITY

The introduction of a science project or initiative to the whole school community is usually linked to the development and the implementation of the school development plan or pedagogical plan. As most countries recognize that a good and efficient school policy should be based on a clear mission and vision of the school embedded in a participatory school culture, efforts are made in most schools to inform and involve teachers, parents and other members of the educational community in the project up from the beginning. Projects initiated by teachers have to be given, furthermore, up from the beginning the backing of the head or the management of the school. Research shows very clearly that educational project (in whichever area) that do not have the backing of the management (and of teachers) and other members of the educational community) have limited (or no) chances of success.

The involvement of schools into official pilot projects seems nearly always to be based on a discussion concerning the involvement of the school in the project. Key questions addressed in such debates are:

- What does it contribute to quality in education for the children and the teachers?
- Which is the workload related to it?
- Which support structures are put in place?
- Which recognition does the teacher get for the time invested?

Experiences shows that teachers are very doubtful about the introduction of innovation as, in many cases, they have already been confronted with many innovation waves which have not necessarily had a positive impact. Teachers are also sensitive to the fact that their local initiative is embedded in a larger project that will enable them to link up with other colleagues at regional, national or European level. The creation of web for a may be useful but should not be overestimated as teachers are already stressed in many countries so that little time is available to communicate with colleagues on the topic of the project. A key issue is also the pedagogical and infrastructure (equipment) support teachers get to implement a project. Basing a project on the voluntarily commitment of teachers for several years turns out to be a non productive strategy.

3. INFORMATION (GUIDELINES), IN SET, MONITORING AND FOLLOW UP

The information about innovative projects, the in-service training, the monitoring and follow-up given to support the implementation of innovative projects differs according to the nature of the project. If the project is part of an official and structured innovation project, special activities may be set up in the field of information, in-set, monitoring and follow-up.

56 For further information on CIDREE: see the website: http://www.cidree.org
3.1. Information and guidelines

The decision taken to implement pilot projects to promote innovation in education in general and in science (maths and technology) in particular is usually taken subsequent to the publication of an internal or an external report (e.g. PISA or TIMMS studies). Information to schools can be in the form of a call for projects or an outline of what is intended. How can a school be selected, to what criteria does it have to respond, what monitoring or support is scheduled etc. The impression prevails that ministries of education do no longer tend to be very prescriptive in what they intend to achieve as they want to set up mixtures of bottom-up and top-down approaches so as to come to real win-win situations.

The starting up of concrete pilot schools usually takes place through some sort of call for projects which is launched by the appropriate ministry or department of education. To this effect a paper is drafted outlining the main ideas of the pilot projects and inviting schools to put forwards their ideas. In some cases (Austria, Bnl) individual schools are invited to submit an innovative proposal in other cases (like in Germany) clusters of schools at local or regional level or invited to send in applications. Thus the concrete pilot projects can be individual schools or small networks of schools. The two possibilities have each their advantages and/or disadvantages. One of the advantages of the networks being that up from the application there is already a clear dissemination strategy embedded in the project at local or regional level. In fact a separate study should be made at European level to analyse the different mechanisms put in place to promote innovation in schools through pilot schools or demonstration schools (e.g. in Norway), whatever they are called.

Some countries work on a regular basis with pilot projects and others do only work with them on an occasional basis. Denmark is one of those have invitations to respond to call for tenders for VET every year whereas as many other countries only have it at certain moments when it is thought necessary to promote innovation in a special way.

3.2. In-service training

For most of the official pilot projects, specifically focusing on innovation in maths, science and technology or focusing in general on innovation in education, important in-service training activities are organised. This is normal as ministries want to see to it that official pilot projects initiated and supported by the ministry yield a maximum profit. In-service training is also a key element in continuity and sustainability of the innovation efforts. Maximum results can be expected if the in-service training activities are backed up and supported by action in initial teacher education.

This in-service training may either be to help teachers / heads and other staff to acquire specific skills to implement innovation through managing projects better or the in-service training may be focusing on specific disciplinary issues. Experience shows, however, that the best innovation focus on all those different aspects. Improving education has to do with disciplinary, interdisciplinary and cross-curricular approaches on the one hand and on the other hand it also has to do with improving management capacity, human resource management, infrastructure, cooperation with the local community etc.

In particular projects such as the IMST2 or IMST3 time will also be invested in training teachers in drafting action-research reports, as this is a key element of the project.

Some projects have invested heavily in teacher training. The Finnish LUMA programme has trained 11,000 science teachers to teach in interdisciplinary and cross-disciplinary approaches. This was one of the most prominent features of the LUMA programme on the one hand but on the other hand, this was heavily criticised as teachers were supposed to invest time voluntarily with no (financial) reward!
The Italian project FORTIC, aiming at the training of ICT for teachers possibly to be used in science education, has trained 180,000 teachers. The Proeftuimen (Bnl) project has mainly organised in-service training to enable teachers to better implement and run their innovative projects.

3.3. Monitoring and follow-up

Monitoring and follow-up of science projects is usually only done if the science project is part of a larger pilot project set up by the Ministry. In the case of small individual projects, there is little or no monitoring or follow-up although it may happen that a school involved in an isolated project invited a teacher training institution or a university to support its activities.

Within the framework of the Mains à la Pâte in France, IUFM (Instituts Universitaires de la Formation des Maîtres) that train primary school teachers are invited to support the science projects set up in the primary schools in its local or regional community. They can support the primary schools with pedagogical and methodological support in general or specifically related to the teaching of science in the primary school.

The SINFUS (180 schools) and SINFUS Transfer projects (800 schools) are in sets of six schools combined as a local network, one of the six assuming a "pilot function". These networks work together with regional universities and teachers seminars (Studienseminar) which in Germany are in charge of the initial training of teachers. Those seminars help in the monitoring, the follow-up and also in evaluation of the projects.

The server of the SINFUS TRANSFER project is used for publishing results and for retrieving information within the regional networks as well as nationwide. It informs about interesting materials and provides a platform for professional cooperation and scientific dialogue, which can also be seen as elements of monitoring and follow-up.

Larger programmes such as the LUMA programme in Finland and the Swedish initiatives concerning Sci-Tech, The Natural resources Centres and the Sci-Tech basic year have been thoroughly assessed. The monitoring and follow-up structure involved universities and teacher training institutions.

Projects with a more general focus on innovation in education within which also science projects are possible such as VOORUIT (NL) and Proeftuimen (Bnl) also have monitoring and support mechanisms. The Amstel Institute of the University of Amsterdam supports science projects up from their conception stage, to their implementation stage, their dissemination stage and their evaluation stage. As to the Proeftuimen (Bnl) pilot project, a team of five experienced seconded teachers are in charge of the monitoring and the follow-up of the schools involved. These teachers are not involved in the evaluation of the activities.

Projects focusing on similar activities and actions are given the opportunity within some of the pilot projects (such as IMST2 and IMST3, SINFUS TRANSFER (DE), Attraktive Skola (SE), Proeftuimen (Bnl)) to meet at regular occasions to exchange information and experiences and to promote networking and building on each others expertise. In some cases this meeting can also be opened to other teachers, not involved in the pilot project activities, so that the outcomes of the innovative projects can be shared with other interested colleagues.

Large European projects funded by the Commission usually have a monitoring or follow-up mechanism either internally or externally. Internally one of the partners may be invited to take on board the role of monitoring and follow-up and in this case he/she also has the role of the internal evaluation.
Externally a university or other institution or organisations may take on board the responsibility of the monitoring end follow-up. In this case the external body can also be in charge of the external evaluation of the project.

Large projects run by European or international organisations such as GLOBE, ECO schools etc. usually have their own monitoring and support structures making use of internet for a and contacts.

For completeness sake it is interesting to mention the efforts made by DG EAC of the Commission of the European Union in organising for the Leonardo da Vinci pilot projects ‘thematic monitoring’ (57) events. During such events projects in a certain thematic area can meet and exchange views and experience. They are also the basis for better quality work, for better dissemination and for the valorisation (58) of the outcomes.

4. BACKING UP SCHOOL PROGRAMMES WITH A UNIVERSITY PROGRAMME

Only one case evidence has been found that a EU member state has developed an interuniversity cooperation programme which is in parallel with another programme of which the major focus is on school education. This is the case in Finland with the Trilateral cooperation programme Finland-Hungary-Sweden "Development of University Education in Mathematics and Exact Sciences via Trilateral Co-operation" (59). This initiative is particularly innovative as it is a trilateral European initiative that holds within itself a clear mechanism for European benchmarking and/or evaluation.

Gifted pupils

The JCU, Junior College of the University of Utrecht

Interesting are also development by which universities offer special programmes for ‘gifted pupils’ to motivate them for science such as the JCU, Junior College of the University of Utrecht. Traditionally, in Dutch senior secondary schools little attention is paid to differences in abilities within a class. In 2004, Utrecht University and schools from the Utrecht region decided to develop a radical initiative to tackle this issue: the Junior College Utrecht JCU. This is a school for the last two years of VWO (pre-university education). JCU started in 2004 with 25 5VWO students that were selected from 13 schools. It is located at the University College Utrecht campus. JCU-students follow all their physics, chemistry, biology and mathematics lessons in the JCU. The other lessons are followed in their own schools. A special two year curriculum has been developed, taught by eight secondary teachers from partner schools and by a number of university teachers.

The initiative was planned as a pilot project for 3 years. In 2005, the 2004 group passed to 6VWO a second group of 50 students (two classes) was selected. In April 2006, the first group took the final examinations. A new group of 50 students was selected and started in August 2006. Many students are interested in participating in the JCU. The ‘JCU open day’ attracted 170 interested students and their parents. About 75 students are selected by their schools to apply for the JCU. They will be invited for an interview and about 50 students are selected to start in the course. The JCU curriculum has two main goals, one aiming at the education of talented students and one at the innovation of science education in upper secondary schools: to offer an interesting and challenging science education program to talented and motivated students (age 16 – 18) and to provide a working place to partner schools for innovation of the science and mathematics curricula.

58 Valorisation: see website mentioned above.
59 Trilateral programme Finland - Hungary - Sweden: for further information with the Report and the programme, see the following website: http://www.minedu.fi/minedu/education/luma/luma_trilateral_co-operation.html
In some cases documents to support the introduction of innovation are made available to schools but in general it can be stated that there are no or few guidelines on how to go about introducing innovations in science education. Probably the ministries of education suppose that general information is readily available to schools or that the universities or teacher training institutions that accompany and monitor the schools will make available to those schools the necessary tools. The impression prevails that in the implementation of innovation the knowledge is gradually being built up while the innovative action takes place. Many of the documents in relation with the innovation are the results of reflection of what is taking place or what has taken place. The websites with examples of good practice and action research reports prove to be very useful for schools starting on the implementation of innovative action.

R+D institutes, maintained by the state, can be actors and supporters of school level innovation. The Országos Közoktatási Intézet (National Institute for Public Education, NIPE) for example has close connections to innovative schools: on the basics of international experiences, analysis made by, and professional support of NIPE, there is a common development. Different models of integrated science curriculum, new teaching-learning programmes, including teaching books, materials, way of evaluation and teacher in-service training are worked out, tried out by innovative pilot schools and then they are offered for other schools.

In some countries like in France the General Pedagogical Inspection (IGP) has produced documents with suggestions how to do something about increasing the interest and motivation for sciences with youngsters. These recommendations are also intended to motivate the teachers to get involved in innovation. Furthermore the Scéren of the CNDP (60) or Centre National de Documentation Pédagogique / National centre for Pedagogical Documentation, has produced documents and working tools that prove to be useful for science teachers in the classroom.

From the website of the Main à la pâte initiative (Hands on Science) in France a very useful publication can be downloaded expanding on how to promote science in pre-primary and primary schools: "La rénovation de l'enseignement des sciences et de la technologie à l'école." (61) (Innovating education of science and technology in the classroom). The website doesn't contain any information on monitoring, follow-up and evaluation of science projects.

There is also a very useful publication on the website for the Science education 3-18 project of Scotland called: IMPROVING ACHIEVEMENT IN SCIENCE IN PRIMARY AND SECONDARY SCHOOLS. This publication of 2005 builds on the evaluation of science between 2000 and 2004. See the website: http://www.hmie.gov.uk/documents/publication/iais.pdf

Action research reports and other documents on the websites of the SINUS, SINUS Transfer and IMST2 and IMST3 project can be considered to be useful monitoring and follow-up tools. For the SINUS projects all publications and reports are found under: http://blk.mat.uni-bayreuth.de/material/material.html
For the SINUS TRANSFER project they are found under: http://www.sinus-transfer.de/ and then click on 'Berichte'.

60 Scéren (Services Culture Editions Ressources pour l'Education Nationale) and CNDP: see the website: http://www.cndp.fr/accueil.htm
61 For the full brochure in French see the website: http://www.lamap.fr/bdd_image/51_renov_sciences techno.pdf
F.9. EVALUATION OF INTRODUCTION OF INNOVATIONS IN SCIENCE EDUCATION

The evaluation of innovative science actions differs according to whether the activity or initiative is an isolated one or whether it is part of larger pilot project. No or little information is available on the evaluation of individual projects or initiatives. However, information made available shows that individual projects even when they are not part of a larger official pilot project have to send in activity reports to the coordinating body. This is the case for the CHEMISTRY programme that does not result from a policy but is linked to the activities of the SET pilot project “Le parole della scienza”. The teachers involved have to send regularly written reports and documents to a ministerial tutor (University of Urbino - Science Didactics). They use these reports concerning the activities related to the SeT pilot project “Le parole della scienza for further study and/or research!”.

The SU18 initiative, being funded at regional and national level, foresees every year a kind of monitoring and internal evaluation. It is also evaluated every year by the Ministry.

When science projects in the framework of Comenius are evaluated one may assume that certain evaluation tools are used which will focus more on the implementation of the partnership than on the quality of the science teaching and learning. Evaluation tools, such as the MICE T tool (62), have proven to be very useful for evaluation of Comenius partnerships.

If it is part of an official pilot project such as SINUS, SINUS Transfer (DE), IMST2 and IMST3 (AT), LUMA Programme (SF) etc. an extensive evaluation is scheduled up from the beginning. This evaluation may be both at the level of the process and at the level of the outcomes. In most cases universities and/or teacher training institutions are involved in the evaluation. In most cases the evaluation is carried out by national universities but in a rare case such as the Finish LUMA project the evaluation report at the end was drafted by an international team of experts of several countries: Sweden, Ireland and UK.

In the case of science projects incorporated in larger innovative pilot projects like the VOORUIT of the Netherlands and the Proeftuinen of the Dutch speaking community of Belgium a general evaluation of the activities is scheduled at a certain moment but there is no specific activities of the science projects. However in the case of the science projects in the VOORUIT pilot project which were initiated, implemented and monitored by the Amstel Institute of the University of Amsterdam some form of evaluation has also taken place. The tools used to carry out the evaluation are not available.

As a conclusion one can state that there is an urgent need to clarify the evaluation carried out in the different science projects. It would also be useful to develop within the framework of a Comenius 2.1 projects sets of tools to evaluate different types of science initiatives and projects set up at regional, national, European or transnational level.

62 MICE T evaluation tool for Comenius: full information is available on the following websites: http://www.mice-t.net/ and the I ProbeNet website: http://www.i-probenet.net/
F.10. PROMOTION AND DISSEMINATION OF THE INITIATIVE

The results of projects and initiatives can be disseminated at different levels. For clarity's sake two levels are distinguished in the present text: within the school and beyond the school community.

As in most cases the science project or initiative is integrated in the school development plan or the pedagogical plan most schools will see to it that all teachers are regularly informed of what has happened in the project. Many schools will also see to it that not only information is given but that other teachers within the school are invited to take on board the positive lessons and experiences resulting from a science project. In some cases schools will see to it that parents are well informed about the projects they are involved in and will in some cases ask for their cooperation thus strengthening the links with the local community. Sometimes the internal dissemination may take specific forms by which 'older' pupils will transfer the achievements of a project in a concrete way to the younger fellow pupils in peer teaching or peer learning projects etc. In other cases pupils involved in a science project will set up within that project an exhibition which can be visited later on by the younger pupils and whereby the older pupils act as guides. Transferring information, knowledge and skills gained within a project thus becomes a supplementary asset of the project that result in more skills and competences.

The internal and external dissemination and promotion happens in different ways but similarities can be distinguished across the different countries.

- Websites with databases;
- Publications on paper;
- Conferences, seminars, workshops etc.

1. WEBSITES AND DATABASES

For several countries a website has been developed with innovative projects in the field of MST this is the case. Most of these websites are linked to a national policy on innovation in general or in science, maths and technology in particular. Herewith a list of websites with, in some cases, some comments.

Austria : a database specific to MST

For Austria: the IMST2 database: http://imst2.uni-klu.ac.at/innovationen/

This website gives full description of an important number of projects; it also gives details of the project coordinators and their schools. It also gives access to the action-research reports drafted by the teachers. This database can be put forward as the example of good practice in database in science education project. One element is the fact that it is only accessible in German.

Germany - a database specific to MST

For the German SINUS and SINUS Transfer projects.

Within the SINUS database: http://blk.mat.uni-bayreuth.de/search/modul.html, one can find all the schools that were involved in the project. They can be found according to the German Land (region!) they are located in according to the Module they were involved in and according to keywords.
The website also contains all sorts of materials and publications in relation with the SINUS project. For the SINUS Transfer project once has to access the website of the SINUS Transfer project and then go to the land one is interested in. Some of the Länder give full lists of all the projects; others not!

For the German BLK project KUBIM

Although the primary objective of KUBIM is not to promote science education but to promote links between ICT and culture, many of its activities have a direct or indirect links with the promotion of maths, science and e-technology. Hence it was thought to be useful to mention this website: http://www.kubim.de/indexie.html
Click on ‘Projekte’!

France: several websites with great use

A website for sciences in the primary school - For France the website of La Main à la Pâte: http://www.lamap.fr

It contains information on the initiative but no database with examples of good practice.

Innovative practices are also to be found on: the PASI website (Pôle Académique de Soutien à L’innovation): http://www.guyane-education.org/innovation/

A network of innovation centres is also available in general for the different Académies and is to be found on the following website: http://innovalo.scola.ac-paris.fr/Innovalos_en_france/innovalo_en_france.htm
It has to be regretted that not all the sub websites of the different academies are no longer available!

Hungary

The main databases of innovative school-projects in the country are available in the website of TEMPUS Public Foundation, which administers EU cooperation programmes and more state-founded applications (www.tka.hu). Here can be found schools, participated/ing in Leonardo, Comenius and other European projects and also in national projects, scholarships (e.g. ‘Road to science’ (Út a tudományhoz). Besides a detailed set of information on usability of these projects is available here, the portal serves as an engine of networking.
Several websites serve electronic networking, e.g. the Hungarian research Student Movement (www.kutdiak.hu); the Neumann János Computer Society (http://www.njszt.hu) and others.

Italy: a general database with parts for MST education

For Italy the GOLD database: http://gold.indire.it/nazionale/
This is a database with good or best practice in Italian schools. There is a subdivision in the database for Maths and sciences and another subdivision for Applied sciences, technology and technique.

Apart from the GOLD database there is also the GOLD TRAIN project (2004-2006) for the dissemination of good practices in schools and more specifically the transferability of good practices to different school contexts: http://gold.bdp.it/goldtrain/
When you click on the fifth icon on top from the left you find the area called: La scienza amica - un amico di scienza which refers to the first edition of the science education project “Physics On Show” - already subject of a GRID case study!
**Netherlands: a variety of websites**

The database of the Platform Bèta Techniek set up in the framework of the Delta Plan Bèta Techniek will be accessible towards the end of 2006. Through this database examples of good practice will be available concerning the promotion of MST in the Netherlands. The database will largely be in Dutch! See the website: [http://www.deltapunt.nl](http://www.deltapunt.nl)

A database with a variety of good practice in schools!

For the Netherlands there is a general database with examples of good practice at school level. It is not a database specifically for maths, science and technology: [http://www.schoolvoorbeelden.nl/](http://www.schoolvoorbeelden.nl/)

On this database called 'Examples of schools' information is to be found for all innovative school projects and not only for the science area. However, the database is only accessible in Dutch.

**Good practice in technology (plus a bit of Maths and science)**

A Dutch database specialised in technology is to be found with the AXIS Foundation: [http://www.platform-axis.nl/](http://www.platform-axis.nl/)

Although most of the projects are focusing on the promotion of technology some may also touch upon sciences. There are many descriptions of good practice in schools (mainly VET schools) in Dutch but there is a selection of examples of good practice in English.

**Projects in Sciences**

The Dutch website of the Amstel institute of the University of Amsterdam mentions many projects in science education according to the level under: [http://www.science.uva.nl/amstelinstituut/vo.cfm](http://www.science.uva.nl/amstelinstituut/vo.cfm)

Click on 'Bestaande projecten'. Unfortunately the projects are only in Dutch. Some information about the Amstel Institute is given in English!

**Projects focusing on the use of ICT in several disciplines; a.o. ICT in MST**

Another Dutch website which mentions many projects in ICT in general and on the use of ICT in science education is to be found under: [http://www.ictopschool.net/kennis](http://www.ictopschool.net/kennis)

Unfortunately everything is also in Dutch!

**Scotland**

A section of the Science Education 3-18 website provides details of the wide range of projects and initiatives which have been funded by the Scottish Executive Education Department (SEED) in line with the school science education commitments of the Science Strategy. See the website: [http://www.scienceducation3-18.com/projects.htm](http://www.scienceducation3-18.com/projects.htm)

2. **SPECIAL EXAMPLES OF DISSEMINATION - SCIENCE SPRING, SCIENCE FESTIVAL, SCIENCE WEEK**

Of the many Italian projects that are indirectly or directly related to a policy, only the SU18 project has the explicit objective of dissemination as it is part of an action called the "PRIMAVERA DELLA SCIENZA" (Spring of Sciences or Italian science week). It has been realised with the contribution of MIUR and the school office of the Lombardy region (together with the Science and Technology Museum L. Da Vinci of Milan), with the explicit objective to communicate and disseminate in the most efficient way as possible the activities in the science and technology field, fostering the comparison and exchange of reflections.
It is important to stress that many dissemination activities in the field of science take the form of festivals or festive events, science spring etc. so as to give such an event a more informal character and so as to attract more people. In several countries and at European level also Science weeks or days are organised. Many examples can be found all over Europe of such science festivals or science feasts or events.

One of the best known European science weeks is possibly the one organised by the EU through DG R & D:
http://www.cordis.lu/scienceweek/home.htm

In the UK the European science week is not generally recognised. This is because there are two other 'weeks', at least one of which has a longer standing. One is the Annual meeting of the BA (British Association for the Advancement of Science), now rebranded as the 'Festival of Science', which occurs each year in September: this event has been running for 175 years and has an illustrious history, including landmark presentations by famous scientists in the past (e.g. Darwin; Clerk Maxwell). However, for the past 50 years or so it has been aimed more at enthusiastic children, teachers and non-specialists.
http://www.the-ba.net/the-ba/Events/FestivalofScience/

The other UK 'week' is the National Science Week that was started by a government initiative in 1994. This occurs in March: it has been rebranded as 'National Science and Engineering Week' from 2007. It is also now strongly supported by the BA.
http://www.the-ba.net/the-ba/Events/NSEW/

A website focusing on a French science festival is the following one:
http://www.recherche.gouv.fr/fête/2005/

The Luxemburg science festival is to found under: http://www.science-festival.lu

The Norwegian science week is to be found under the following website:
http://www.forskningsdagene.no/english/
Similar initiatives can be found all across Europe and the world.

In Hungary the "Day of Water" and the "Day of Earth" are celebrated in most schools. The activities of them are connected to problems of the environment and sustainable development; they include all kinds of school activities, not only science teaching-learning ones (see in the database GRID Initiative No 762 / 1122 and 1107 / 1138).

3. PUBLICATION, CONFERENCES EVENTS, STUDIES, ....

Most of the projects be they individual, pilot projects or European projects have a great richness and variety of publications which it would take too long to list there.

Most of the websites of the projects or their supporting organisations or educational institutions mention a variety of documents and publications. Some have been mentioned under tools or instruments for monitoring or under evaluation when they have produced extensive evaluation reports.

It is important also not to forget the very useful publications of the WG on MST of the Commission of the European Union, DG EAC, under the 2010 strategy for education and training (63).

63 Report of the DG EAC WG on MST; see the webpage:
For most of the official pilot projects conferences or seminars have been held to either within the pilot schools which are involved in the project or involving larger number of schools.

If the conference, seminars and workshops are limited to the pilot project this is mostly the case in the original implementation phase with the objective to strengthen the activities implemented and to support the implementation of the pilot project. Such seminars and conference or workshops strengthen the networking within the pilot project and enhance the quality of the work done during the initial phase.

Conferences, seminars and workshops are also held for larger audience to disseminate the outcomes and results of pilot projects to those schools not yet involved and to create a multiplier effect. Such conferences are taking place at national level or European level. A good example of the European level are the conferences held by the Comenius 3 networks (Such as the hands on science Network (64)) to disseminate what has been achieved between the network partners over one year of activities.

In Hungary two conferences were held in 2004 for policy makers, decision makers, researchers and practising professionals involved in the implementation of the EU work programme ‘Education and Training 2010’. In the experts’ seminar the progress was evaluated and in the conference challenges and tasks were addressed. Both events provided unique opportunities for domestic actors of the implementation process (conference materials in English see: www.okm.gov.hu/doc/upload/200505/oktatas_es_kepzes_kiadvany_angol.pdf).

Petnica Students’ Science Conferences are held for 5 years. The biggest institution of extracurricular science education in South-Eastern Europe, Petnica Science Center organizes these conferences for 15-19 year old secondary school pupils who have to apply for participation with their research papers (www.psc.ac.yu/konferencija).

The IMST project of Prof. Dr. Konrad Krainer in Austria runs yearly Innovation days which last three days. They bring together teachers of MST to discuss several issues in relation with MST, to exchange information and expertise and to look for possible partners to develop and implement new innovative projects.

F.11. IMPACT OF THE INITIATIVE

Most of the initiatives analysed in the framework of the GRID project show that there is a more or less strong impact within the classes or schools directly involved in the experimentation. The impact, however, is always gradual and progressive and it takes time before innovations have an impact on a whole school community with all its teachers.

The impact is guaranteed when the activities carried out within a project, in fact, become part of the teachers' (or the team of teachers’) daily methodology and practice. Furthermore the innovation is often disseminated by the teachers in charge among the school colleagues in an informal and spontaneous way. In some cases the impact is deeper because a network of teachers has been created for sharing didactical approaches and experimentations. This is the case for all the national or regional pilot projects but also for local projects such as the Italian projects BIG NUMB and ROUND. From a quantitative point of view, the impact depends on the dissemination of the initiative as well as on the transferability of the methodology.

Thanks to the national or regional databases (listed earlier in this report) with collection of good practices in and with documents related to the implementation, the follow-up, the monitoring and the

64 See information about the Comenius 3 Hands on science conference and events on this webpage: http://www.hsci-pt.com/hsci/index.php under Events
evaluation of science projects, a local initiative may have, potentially, a national impact. Websites help
to disseminate across the country and even Europe (and beyond) the positive outcomes to the whole
teachers' community.

From a qualitative point of view the impact can be said to be larger if a thorough evaluation of the
initiative has been carried out. Hence the importance of the evaluation reports published by most of
the national or regional pilot projects. The quality of projects is also heightened when teachers have
taken the trouble and time to draft action-research reports. Action research reports are useful to
the teachers who have reflected on the innovation implemented in their school but they also help to
stimulate the reflection of other teachers involved in similar innovative action. The impact is larger if
the evaluation, the monitoring and support has been more thorough and of higher quality.

1. PLACE OF SCIENCE EDUCATION IN THE CURRICULUM AND THE WAY SCIENCES ARE TAUGHT

There is definitely an impact on the curriculum and on the way in which sciences are taught and
learned both in terms of quality and in terms of quantity.

- The reflection on science (maths and technology) in the curriculum is enhanced.
- Ways are sought and implanted to enhance the teaching and learning of science, maths and
technology in a creative way; the main focus is on integrating MST into the real life context of the
group of youngsters concerned.
- Cross-disciplinary or interdisciplinary approaches have developed or are developing as to the
different sciences; in some cases the focus is more on all sciences and the links between the
different sciences.
- Cross-disciplinary or disciplinary approaches have developed by which sciences are linking up with
other disciplines of the curriculum. In fact examples could be given of sciences linking up with
nearly every other discipline of the curriculum (languages, history, arts, physical education etc.).
- New teaching and learning materials and equipment (e.g. dataloggers) are developed (close to real
life) which change the teaching and learning environment. Computers enable to make simulations of
experiments that would have been impossible in the past.
- Sciences are much more embedded in cross-curricular activities such as environmental education,
health education, traffic education, citizenship education as this strengthens the link with real life
situations which have an impact on the interest and motivation for learning. This also has an impact
on the retention of what the youngsters acquire.
- The learning and teaching of sciences and maths is very often linked with the acquisition of ICT
skills. Treating data collected through science in maths courses using ICT equipment to interpret
data is quite common.
- Several projects encourage the use of multimedia in the teaching methodology e.g. y offering
multimedia interactive courses such as those developed by the INFM in the 6th Framework
Programme - Science and Technology - for the WESPA project; it is realized in partnership with
European Institutes, such as LMR - Institute Laboratory for Mixed Realities (DE); European
Physical Society; Sciencewords (UK); Ediciones Laberinto (Spain).
- In some cases there is an impact on the organisation of the curriculum as more focus is given on
fieldwork and extra-curricular activities to support the work in the classroom. This fieldwork very
often takes the form of discoveries, exploration or guided tour, doing field research (alone or
together with specialists) etc.
- Much more focus is given to the fact that science (plus maths and technology) also contributes to
the acquisition of all sorts of generic skills (teamwork, communication skills, social skills etc.) that
have an impact on the general education of youngsters.
- Hands-on experiences (65) in sciences are a key element in helping to bring about real life situations and to make (especially young children) aware of the potential and richness of sciences.
- The use of collaborative Internet tools and the creation of collaborative learning environment, both at the level of the pupils and at the level of the teachers definitely have an impact on the learning and the teaching of sciences.
- Several initiatives try to make the pupils play a more active role in active learning by becoming peer educators. This is based on the results of scientific research that show that acquired cognitive skills can best be internalised and retained by being oneself involved in teaching those elements.
- Some initiatives (see Italian project IN THE WOOD) also try to valorise the individual and different learning styles of the pupils before heaving recourse to the formalisation and abstraction of concepts.
- New methodology initiated by pilot projects become part of the regular didactic activities in schools, networks of schools or even national education systems. This is definitely strengthened by the networking (virtual or real) between teachers.
- etc.

2. **Collaboration or use of laboratories, research centres, museums**

The cooperation with laboratories or research centres has definitely had an impact on the quality of learning and teaching of sciences. The advantages of cooperation between schools and laboratories, research centres, museums etc. have been highlighted before in the introductory typology and do not really need any further argumentation.

This kind of cooperation takes, as mentioned before, different forms: researchers coming into the schools, pupils going into the research labs or centres, teacher being trained by researchers; all this has an effect on the quality of teaching and learning sciences. It contributes to change the image of the researchers and makes young people much more easily understand the contribution of science to society.

This kind of cooperation thus has many beneficial effects and it can only be recommended that this kind of cooperation should be strengthened and deepened.

The cooperation between schools and laboratories is maybe too much limited to the schools in the immediate environment of research centres or laboratories of universities. To create more opportunities for schools to be able to cooperate with research centres or laboratories possibly more initiatives have to be set up along the lines of the LABCAR developed in the framework of the Italian Life Learning Centre (LLC) project: a car equipped as a travelling laboratory for hands-on experiences in the life sciences subjects that goes to the schools offering occasions for practical work to students.

In Hungary Zorka 2004 science laboratory project (ISCED 3 a,b) students are prepared to make meteorological forecasts and other measurements by meteorological stations and Ecolog environmental gauges. They use also data of the National Meteorological Service.

The impression prevails that most of the cooperation with research centres and laboratories is taking place in upper secondary education and that this kind of cooperation is not common in at primary school level. Towards the future possibly more attention should be given to initiatives promoting cooperation between pre-primary and primary schools and research centres or laboratories.

65 An interesting overview of Hands-on experiences in sciences across the world are to be found on the following website: http://www.cs.cmu.edu/afs/cs/usr/mwm/www/sci.html
3. THE DEVELOPMENT OF THE IN-SERVICE TRAINING OF SCIENCE TEACHER

The development and implementation of in-service teacher training of science teachers is at the core of most official pilot project run by ministries or important networks. Teacher training can be seen as an extra benefit derived from the involvement in projects and initiatives. Those activities have an impact on the quality of teaching and learning but it is stressed, by several respondents, that changes for the better in science education happen slowly and progressively. A change within a large cohort of teachers or within a whole school takes time and requires heavy investment of all those involved. This is the normal process in implementing innovation in education at any level. Furthermore it is mentioned that most of the in-service training available still focus on the teacher as an individual who has to acquire new skills and competences. More should be invested in developing in-service training for teams of teachers; in some cases possibly interdisciplinary teams of teachers!

In-service training of teachers is promoted in a variety of ways:

- Teachers acquire new methodological and didactical skills concerning teaching and learning of sciences through projects;
- Teachers are introduced to new pedagogical or didactical tools; especially where it concerns interdisciplinary and cross-curricular approaches.
- Teachers acquire new cognitive elements and insights by being involved in projects and initiatives;
- Teachers learn to cooperate with partners of the local community such as research laboratories or centres in universities or companies;
- They learn how to manage projects at national and European level;
- Teachers are involved in the development of new learning tools;
- Teachers are involved in the development of in-set modules and materials at local, regional, national or European level (ex. Comenius 2.1 course);
- Teachers are involved as trainers at different levels; in Comenius 22C European in-set courses;
- Teachers benefit from the supervision they get from university lecturers or researchers
- Teachers improve their activities through the "intervision" resulting from the (physical or virtual ) learning communities they are involved in together with colleagues from other schools at local, regional, national, European or transnational level.
- Teachers improve their activities and functioning by being involvement within projects in peer teaching or shadowing activities
- More experienced teachers become mentors of younger inexperienced teachers (most countries have periods of induction during which young teachers are helped by senior ones);
- Experienced teachers are involved in the monitoring and follow-up of pilot projects and initiatives and thus become multipliers for innovation in science education.
- Teachers involved in official pilot projects acquire action - research skills by drafting their action research reports
- Teachers become trainers of their subject in companies
- Teachers acquire a variety of generic skills such as teamwork skills, communication skills, negotiation skills etc.
- Teachers job content and assignment is diversified thanks to their involvement in the pilot projects or initiatives. They take on board new responsibilities and new roles which leads to job diversification and to possible promotion within the hierarchy of the school.
- Teachers are promoted from a teaching role to the role of pedagogical advisor for sciences and/or inspector supporting other teachers
- Teachers work on curriculum development centres and in documentation and information centres where new pedagogical materials are developed.
- Teachers inquire their skills and competencies in relation with career counselling.
- Teachers involved in accompanying future teachers during their practice periods in schools are able to pass on new knowledge, skills and competences to future teachers.
- Teachers improve their skills and competences by being involved in conferences, seminars and workshops at different levels.
- Teachers improve their knowledge and skills by being involved as trainers in school-based in-service training. In the new wave of the education reform in Hungary, teacher in-service training programmes are developed together with the curricula- and methodology-development. Therefore, a new approach of the competence-based and practice-oriented teaching-learning process is supported in a common framework.
- etc.
In-service training activities are organised by a variety of bodies or organisations:

- Ministerial bodies such as pedagogical advisors or general inspectorate
- Local or regional authorities
- Independent consultant organisations in education (e.g. KPC in the Netherlands)
- Local, regional or national associations of teachers, heads and other staff
- University or higher education departments and services
- Research centres or laboratories
- Research institutes (e.g. IPN Leibniz (DE), academies of sciences
- Companies
- NGOs in several areas (environmental education, citizenship education, health education, traffic education, consumer education...)
- European networks: Comenius 3 Hands on Science Networks,
- International networks: the GLOBE network, Science across Europe and across the world
- European organisations such as the European Union (through projects funded within DG R & D, Socrates, Leonardo etc., the CERN in Geneva etc.
- Key European and international educational organisations CIDREE, SICI etc.
- etc.

Problems as to in-service training of teachers

- Too many in-set activities are still focusing on the individual and not on team of teachers operating on a school development approach or a learning organisation approach.
- Too many in-service training activities are still organised during the holiday periods of the teachers, which creates problems for teachers with families.
- Not enough places are available for all the teachers interested in taking the in-service training in some countries.
- There is no recognition for the time and efforts invested in the in-service training. Only a few countries (such as Span, Portugal and Romania) have a system of credits that the teachers can acquire and that leads to professional advancement.
- In-service training is not really integrated into a concept of total professional development of the teacher as an element of the development of the school of a learning organisation.
- In some countries the budget is not available to have a large scale involvement in in-service training activities.
- The offer of in-service training activities is not always clear and it is difficult for the head of a school to select the best quality for the money to be paid.
- Too few schools have a structure by which the results of the in-service training activities is made beneficial to other teachers in the same school; there is no multiplier effect after the in-set within the school.
- etc.

No examples have been found of interdisciplinary in-service training activities during which science teachers have joined training activities with teachers of other (non-science) subjects. This could prove to be useful as multidisciplinary teams are more and more implemented in different scientific areas in research centres and companies.

The interest for pupils for science

It is definitely confirmed by the evidence gathered within the GRID project that the development of innovative science projects which bring about a creative learning environment contribute to stimulate the interest and motivation of pupils for science plus maths and technology. The impact is, according to those interviewed, even larger of the pupils are actively involved in the conception, the implementation and the dissemination and evaluation of the science
project. Pupils who have been involved on the one hand together with teachers on an equal footing in a project and/or who have been involved in peer education activities (teaching their younger fellow pupils) seem to benefit most from such science projects! The same applies to pupils who have been involved actively in certain aspects of a project. The pupils who are prepared as guides to lead their fellow pupils in the Italian MATHS MACHINES project is a good example of this.

The freedom of pupils' choice - and together with that, its responsibility - in learning science also can raise interest and motivation. It can be seen in the Lauder Javne School, Hungary, where every secondary school pupil in a semester of the schooling has to prepare an individual or small group project in which both subject area(s), the theme and the way of preparation are based on her/his/their own efforts. Teacher support is available but it is given in accordance with the pupil's need. The achievements of the 'own works' are assessed by commonly agreed procedures and they are included in the final assessment, taken into consideration in the subject that is the closest to the chosen discipline.

Pupils motivation is also strengthened by the fact those external people of the local community are involved in the project and in the educational process. Being in contact with real researchers, scientists, beginners, biologists etc. definitely has an impact on their interest.

The impact is also much larger of the activities of the project have been well prepared in advance by the teacher (possibly through in-service training and are well integrated into the whole science curriculum. It is also stressed that follow-up activities are important in this respect.

All the activities within which pupils have an active role to play in visiting or in working in laboratories have a large impact on pupils. Pupils love to be put in contact with the latest technology, R & D and science! They especially appreciate if links are made with their daily life and their local environment.

Similarly activities which link cognitive science with emotional elements and/or ethical elements seem to appeal to youngsters; for the latter element (the ethical) this is especially true with the older upper secondary school pupils.

However so far most of the opinions expressed concerning the increase of interest and motivation for science with pupils are mainly based subjective elements. No tools or indicators seem to have been developed within projects that enable to gather more tangible and objective data. Some projects check the interest of the pupils by asking them to make presentations after visits made to an exhibition (such as the Italian MATHS MACHINES project) or contributions to certain events (such as in the EDISON project of the Bnl, or in competitions).

It was also repeatedly mentioned that the interest for sciences (and maths and technology) is not raised when the disciplines are easier but when the environment in which they are taught and learned is more creative. The key message to have an impact is create innovative learning environments and to embed the teaching of sciences into real life situations so that youngsters can experience and see the impact of sciences on their life.

3. THE PERCENTAGE OF STUDENTS STUDYING SCIENCE

It is difficult if not impossible to say if the implementation of creative learning environment projects has an impact on the number of pupils deciding to study more sciences or to go on studying sciences in higher education. Only a longitudinal research could shed some light on this. What is clear is that pupils with less interest for sciences feel much more attracted and show more interest for sciences. It thus definitely has an impact on their overall learning and on their school results.
4. **Benefits, Advantages and Obstacles introducing new approaches to Sciences**

Teachers or project coordinators interviewed were always very willing to respond to questions about their projects. They were very open and took a lot of time to respond to the questions. They also show to be very proud of what they have achieved with their colleagues and with their pupils and consider overall that the project has had an impact on their professional development and also to a large extent on the school culture and on the climate within the school community. The teachers interviewed are usually very realistic in describing their projects. Interviews are well prepared and very often supplementary information was sent on to the interviewer to back up what was said during the interview. The teachers interviewed definitely want to be kept informed about the results and outcomes of the GRID project.

4.1. Advantages and benefits

The following benefits or advantages are mentioned while implementing creative learning environments through projects:

- Creative projects give the opportunity to show to students science as a real and living “thing”, which is always “in development”.
- It enhances the interest and motivation for learning in general and for science learning in particular. Not with all pupils but with a large chunk of the pupils anyway! Through the innovative science activities pupils learn to take more responsibility for their learning. They consider certain pedagogical support measures as the ‘carnet de bord’ or ‘pedagogical diaries’ as useful support tools.
- Projects enable to give to teachers a new challenge in their professional life. This is strengthened by the positive response of the pupils (and of some of their colleagues) to those initiatives.
- Several teachers stress that the introduction of an innovative project was an incentive to think about innovation in school education in general and to see how this could be integrated into the pedagogical plan or the school development plan;
- Several teachers had appreciated greatly the support of their head and/or their management of the school. Support of the inspectorate is also greatly appreciated; if the inspectors speaks in favour of the school, the management if ‘forced’ to get involved!
- Teachers involved in projects which had a monitoring and support structure to help them through such a structure was vital in ensuring the continuity and the sustainability of the project and its integration in the school over a along period of time. Teachers also greatly appreciate the in-service training organised to support them.
- Teachers mention that the involvement in the project has strengthened the teamwork within the school and that the teamwork was an essential element of the success of the project. The teamwork is said to be important at a disciplinary, at an interdisciplinary and even at a cross-curricular level.
- It enables to acquire a variety of new competences and skills and new knowledge specific to their scientific discipline. Simultaneously teachers are aware that they acquire generic skills through their involvement in projects.
- By applying the new creative methods and being seeing the positive impact this has on the pupils, it heightens the job satisfaction of the teachers involved in the project. It also has an impact on the appreciation of the parents for the work of the teachers.
- Teachers stress that knowledge and pupils in a more permanent way acquire skills by using creative methodologies. There is less focus on learning by heart and much more focus on acquiring competences, knowledge and skills and on using and applying them in a concrete context.
- Teachers also consider as an advantage the fact that innovative activities very often get the support and the active involvement of the parents and of other members of the local community. These contacts often lead to unexpected forms and expressions of support and sponsoring.
- Reference is made to very concrete benefits such as the use of ICT and multimedia in science education, the involvement of external agents, the acquisition of scientific skills together with generic skills etc.
- Some of the teachers interviewed stress also the fact that science projects can promote several elements of citizenship education. Pupils involved in peer education take responsibility for the learning of others and work on being better citizens. Many science projects contribute to environmental citizenship or to the citizen as a better consumer or a citizens respecting the rights of the others and showing respect for them (behaviour in traffic, no smoking campaign linked to health) etc. European projects are definitely contributing to enhance European citizenship.

4.2. Obstacles

Although during the interviews held in filling in the QE2 generally teachers mentioned the benefits more than the obstacles encountered in carrying out the initiatives, a list of the latter is added here below:

The following obstacles are mentioned:

- The lack of time and space either for meeting and dialogue or for the activities with students. This is sometimes linked to the lack of flexibility in the time table and the organisational structure of the curriculum and the school year.
- The lack of flexibility in the assignment given to teachers; in some cases teachers are still seen solely as people who teach and as people who have to create learning environments within the pupils are active and the teachers become much more coaches of pupils. Thus one can say that an obstacle is the prevailing pedagogical culture that exists in a school. A more teaching approach is very often considered to be safer by some teachers and it further more requires less commitment and less risk-taking! In some cases, the autonomy requested by some teachers has caused difficulties for others. For some teachers more autonomy is a threat to their routine teaching activities.
- A difficulty related to this is the insecurity of the teacher due to lack of competences and skills to manage creative learning environments; This is thus related to the lack of in-service training of teachers.
- Difficulties may arise in involving colleagues and in sharing experiences and results with them.
- Difficulties to make the school deserve the credibility of and the cooperation with the scientific and local community.
- The rigidity of the legislation concerning the involvement of pupils and teachers in fieldwork outside the school.
- The fact that the science action was not really a part of a larger school strategy to promote innovation in school education in general and the difficulty to integrate the science project into the vision and mission statement and the general school development plan.
- A major difficulty is the lack of support of the head or the management of the school. If the teachers involved in the innovative activities do not get real support (not just tolerating what happens!), it is impossible to put in place an innovation with a lasting effect.
- Pupils are very often not used to work in a different and more creative way in which they are supposed to get involved hands on!
- The difficulty to involve in a creative project pupils, who have less interest for sciences or who only have had negative experiences.
- Another difficulty is said to be the development of a cooperative learning environment in which every individual is carrying out an active and participative role. This is linked to the difficulty of developing the school into a learning organisation if the school has no practice or experience in this area. This requires a strategy at school level with a comprehensive in-service training activities at all levels.
The main obstacle is represented by the dissemination of such a didactic practice and by the difficulty to inform schools about the initiative.

Obstacles are also the high cost of certain activities, the cost of acquiring new equipment, the administrative red tape and the important human resources needed to implement some of the project activities.

An obstacle often encountered is that teachers are burdened by the programmes within much has to be compressed in the short time available.

Some teachers are not familiar with or even distrust the use of Internet resources and multimedia tools.

The lack of support structures, able to help set up, monitor, follow-up and evaluate innovative action) at local, regional or national level to help implement innovative action.

Some experienced teachers mention as an obstacle towards the future the fact that young or new teachers have not been enough initiated or informed about creative learning methodologies and the way in which projects and project work can contribute to creative learning environments.

In some countries it is also generally thought that the preparation future primary school teachers get to prepare them to teach science in an integrated way is insufficient.

The traditional structure of subject- (discipline-) based teaching of science can cause deficits of effective and efficient teaching and learning. Though contact teaching time (in total) would be enough for getting to science literacy but it is not so if Biology, Chemistry, Physics, one by one, have their separated requirements. This contradiction cannot be resolved if higher education (and within that, teacher training) is organized by a discipline-based approach, like in many ECE countries.

Authors and publishers of textbook and teaching materials are not interested in innovation.

5. IMPACT ON APPROACH TO SCIENCE EDUCATION

It is difficult to say what the impact on the approach to science education. A few elements can be mentioned which have already been highlighted earlier in the text. These elements confirm what has been stated in the Reports of the WG MST of DG EAC in their reports of 2003 and 2004.

First the general tendencies of the projects are to integrate sciences into a real life context and to link it up with concrete applications or situations in every day life. By making young people realise in a concrete way the effect and impact has on their life and their environment on an everyday basis, the interest and motivation for sciences is definitely heightened. It is also clear that the efforts of making young people aware of the impact of science on their life should happen up from as early an age as possible and should be maintained all throughout their primary and secondary education. It is not enough to raise their interest and motivation at a certain moment. This must be constant effort.

Secondly the tendency prevails to link up science education with a hands on approach so that pupils become active learners and experience through their hands on approach what science can bring about. This hands on experience may take place in a classroom context or in close cooperation with scientists or researchers in laboratories or research centres in companies and/or universities. Again several projects show that such hands on experience should start as young as possible and not be limited to the final stages of the secondary school.

Extracurricular and/or periodical outdoor activities (forest schools, eco-camps, research projects, international cooperation) can also serve the goal of different approach, give way to motivation, makes science attractive and put this field of culture closer to real life.

Thirdly, there is a clear tendency to develop interdisciplinary approaches. On the one hand this means to create links across the different sciences or to create links between sciences and other disciplines so as to raise the interest of the pupils and youngsters. Combine sciences with culture and arts, with languages, with literature, with history, geography, ICT etc are just a few examples. Next to the interdisciplinary approaches sciences are also linked to cross-curricular approaches embedding it in
environmental education, health education, traffic education, consumer education, citizenship education etc. This is in fact a normal development linked to the fact that sciences are more and more embedded in every day life and in the concrete real life context of the pupils.

All of this was already highlighted in the first part of the present text when the subdivision of the GRID projects was discussed according to the disciplinary, interdisciplinary or cross-curricular approach used. All of this shows that teachers are trying to increase the interest and variety of young people for sciences in many different ways.

6. CONTRIBUTION TO INNOVATION IN SCIENCE EDUCATION

The GRID projects described in the database all contribute to innovation in education in one way or another. This is why they have been selected and described in the database. However, describing the key characteristics of an innovative project is difficult as the concept of innovation is complex and is subject to discussion.

To highlight the contribution of the GRID projects to innovation in schools, reference is made to the OECD publication of 1999 Innovating schools and to the OECD study "Innovating networks" of 2003.

According to those documents innovating schools have the following characteristics:

- They are schools that create an innovative learning environment for pupils, for staff and for other members of the school community.
- They are schools that focus strongly on quality assurance by involving themselves actively (and very often voluntarily) in self-evaluation and external evaluation.
- They are schools that take professional development of all its staff members, teachers, head and admin staff and others very seriously and invest in it.
- They are schools that promote active citizenship through concrete civic action within and outside the school.
- They are schools that promote networking local, regional, national, European and international level.
- They are schools that link up and co-operate very closely with the local community in which they are embedded.
- They are schools that are developing a caring and participatory school environment built on trust and belief in the potential of every child and member of the school community.

Innovative learning environments

GRID projects contribute to create innovative learning environments by developing different approaches to learning. Co-operative learning, learning based on experimental problem solving, peer learning (at the level of the pupils or the teachers!), intergenerational learning (involving parents, grandparents), learning through project work, hands-on approaches etc. are ways that promote the acquisition of knowledge, competences and skills in an active way by the pupils themselves.

GRID projects use such disciplinary, interdisciplinary and cross-curricular approaches and thus stimulate the creation of innovative learning environments where pupils become responsible for their learning and for that of their fellow pupils (in peer education projects!). Such environments enhance motivation for learning and for lifelong learning as they are contextual and create real life environments and situations in which knowledge, competencies and skills and attitudes are embedded in real situations that young people can recognise in every day life.

Innovative learning environments are also created by linking the learning and teaching of sciences to a variety of pedagogical forms such as hands-on activities, fieldtrips, activities in museums, activities in
laboratories, visits and work sessions in museums, cultural heritage centres, environmental centres or science centres, the creation or use of games, the visits to or the creation of exhibitions, integrating science into theatre and forms of artistic expressions. All those pedagogical forms heighten the interest and motivation for sciences no doubt.

Many GRID projects explicitly mention that they focus next to the acquisition of scientific and technological skills also on the acquisition of generic skills such as: communication skills (making use a wide variety of ICT tools), problem-solving skills, decision-making skills, organisation skills, presentation skills, entrepreneurship, language skills, intercultural skills, conflict management skills, time management skills, team work and teambuilding skills and pro-active behaviour.

Turning science projects into interdisciplinary or cross-curricular projects creates innovative learning environments. Some of the GRID projects succeed on the one hand in combining scientific elements, with technological elements, with cultural elements, with social sciences etc. On the other hand they succeed in combining cognitive elements, with affective elements and with pragmatic (action-oriented) elements. These combinations create motivating learning environments.

In many GRID projects the pupils are the protagonists of the science project at every level. They are involved in the development and the implementation of the project, in the dissemination of its results and in its evaluation. The individual needs and talents of every child are taken into account in bringing about the innovative learning environment while not forgetting also the benefits of social interaction and of teamwork between pupils (and teachers).

Building on the different learning styles and talents is reflected in differentiated learning approaches and in flexible learning pathways for youngsters.

Many projects stress that involvement in innovating projects stimulates the value of co-operation through team building and team work both at the level of the pupils and the staff. Finally many teachers stress that the science projects promote learning much more than teaching. The pupil becomes an active agent for his/her learning and the teacher becomes a coach or learning facilitator. Taking on board this role as coach is not an easy matter and teachers appreciate official support to do this.

Quality assurance

As was highlighted under the specific section F.10 concerning evaluation, it was pointed out that most of major national initiatives pay a lot of attention to evaluation of their activities and thus to quality assurance of the projects promoted by those initiatives. The fact that several national projects are supported by universities to evaluate and monitor the project activities and to help the teachers proves that a lot of attention is given to quality assurance.

Experience shows that very often schools are involved in innovative science projects that have a whole school strategy as to promote innovation in their school. Part of the innovation is to pay a lot of attention also to quality assurance and to self-evaluation. This is done to see if the projects do indeed contribute to science education.

Professional staff development

Professional staff development is also greatly enhanced through science projects. Either the staff development or the in-service training is part and parcel of the project. This is the case of the official pilot projects as they have as an important element of their activities the training of the teachers involved in the pilot projects. In other cases the development and the implementation of the science projects leads to the teachers taking in-service training to upgrade their skills and competences. It is interesting to note that teachers stress that the fact that they were in charge of the implementation
of a science project has not only given them better knowledge and skills related to teaching their discipline but has also enabled them to acquire project management skills. These are said to be useful in many other contexts.

There is clear evidence that co-operation with colleagues at local, regional, national or European level has a major impact on professional and personal development.

When it comes to European or transnational science projects teachers stress very much the many advantages of mobility and of meeting colleagues from other countries. Transnational mobility and transnational projects (but also local or national projects) are said to be an excellent form of in-service training as during the project activities teachers and staff get in touch with other pedagogical and didactical practices, with other ways or working with pupils of enhancing learning and with other forms of organising school and classroom activities as such.

The teachers stress that European science projects facilitate the integration of the European dimension in the curriculum as very often teachers (and pupils) will develop jointly materials to be used in their respective classrooms, which again has an impact on motivation for learning.

Peer teaching, team teaching, shadowing, which are sometimes used in science projects (especially in European science projects) are also seen by the teachers as a contribution to their professional development and thus contribute to the quality of education and training.

The project activities and the reflections by the teachers involved in the implementation of the project, in its evaluation, in the dissemination etc. is said to contribute to turning the school into a real learning organisation within which organisational learning (instead of individual learning) gets a strong focus.

Teachers regret that that the acquisition of new skills and competences as teachers doesn't get in most countries any official recognition and isn't taken into account in their career progression.

Organisational learning combined with individual learning are leading factor in regional development as shown clearly in the OECD study 2003 “Cities and regions in the new learning economy”.

**Active European citizenship**

Several GRID projects promote active citizenship as they are embedded in cross curricular approaches such as environmental education, traffic education, health education, consumer education etc. The science projects contribute to cognitive, pragmatic and affective citizenship. They get to understand the problems, see the causes and look at the possible solutions. They also may find out about the structures and institutions that are involved in solving a concrete problem such as pollution etc. They learn and discover where science comes in either as part of the problem or as part of the solution. These are said to be all elements of cognitive citizenship.

The active citizenship element is very often linked to a concrete commitment of the youngsters to do something for the concrete environment in which they live and for their local community. This active involvement in the local community through science education linked to cross curricular issues strengthens definitely the interest and motivation for learning science. Science projects thus contribute to pragmatic citizenship by enabling pupils to set up social or political action at the level of the local community within the project. They thus learn 'hands on' what it means to be an active citizenship. One teacher put it like this saying that science linked to citizenship education helps the education of the ecological citizen. It contributes greatly to make young people aware of the sustainability issues which are very high on the agenda of the European Union. It enables also to
discuss with young people issues such as corporate social responsibility or the responsibility of companies for our environment and our world.

Finally projects also contribute to effective citizenship as pupils have the opportunity to feel part of a project, to be respected and valued for the work they put into it. Affective citizenship is a key element to avoid exclusion and promote inclusion which in its turn has an impact on motivation for learning and on the caring school mentioned earlier. Clear participative structures (e.g. pupils’ councils) within the school can only strengthen active citizenship. Cognitive, affective and pragmatic citizenship have been largely described in many Council of Europe and EU publications.

Active European citizenship is especially said to be promoted through Comenius science partnerships as pupils (and staff) get in contact with other European pupils, co-operate and work with them for a common goal within the project. They put in this way also intercultural skills into practice and learn to respect others’ opinions and beliefs. They learn to manage conflicts in a positive way and experience the joy of sharing the responsibility for a European projects and all the activities related to it. Comenius partnerships promote citizenship also by the fact that they make pupils aware of the realities (and the complexity of them) all across Europe and the world. They also contribute to cognitive, affective and pragmatic citizenship.

Promotion of links with the local communities

Many GRID projects have developed links with the local community. They link up with one or even several local partners such as universities, companies, research centres or laboratories, non profit making organisations (NGO’s), foundations, museums, cultural agents (theatres, orchestras etc.), retired people, local or regional authorities (in education and training or other areas such as the environment, tourism, road safety), big utility companies (such as waterworks or electricity works). Some projects cooperate with different groups of citizens such as parents, grandparents and specific groups of professions linking them up with the specific scientific or other disciplines taught (or learned).

Interaction with the local community has an impact on many elements: it embeds education into the local reality, it brings reality and local agents into the classroom and the school, it creates new opportunities for professional development for teachers and new learning opportunities for pupils through fieldtrips, visits or sometimes placements in companies. In several cases representatives of all the local partners mentioned above participate actively in concrete aspects of the project within the school. They may even be involved in the management of the project transferring their project management skills to teachers and schools. Schools get sponsoring in kind or in equipment to strengthen their pedagogical activities etc.

Cooperation with the local community members creates opportunities to enhance active citizenship and may also stimulate entrepreneurship of pupils and staff. It brings reality into the classroom and strengthens motivation for learning by building on the local economic, social and cultural development. The school thus becomes a true partner in local development promoting individual and organisational learning, promoting the development of social capital (values, beliefs and norms shared in social networks) and civic social capital based on social networks and normative structures that support strongly regional development. Especially companies may also heighten the link between science and sustainable development and show what corporate citizenship really means.

Promotion of local, regional, national, European or transnational networking

Many GRID projects are definitely promoting local, regional, national and European or international networking. This largely depends upon the kind of project set up. If it is a project in the framework of
a regional or national official pilot project, there is usually a networking structure which is created to enhance cross-fertilisation within the official network. Even if there is the project is not part of an official initiative networking is set up by GRID schools in their immediate environment. Examples are present in the GRID database of projects which start on an individual basis and gradually become a network of schools. In fact every valuable project of good practice (even outside official programmes) should be given the opportunity to network with others to stimulate cross-fertilisation and the dissemination and valorisation of its ideas and of its successful innovations.

European Networking is definitely promoted through Comenius partnerships as this is the key characteristic of Comenius 1 networks and of innovating schools. The evaluation reports of Comenius 1 under Socrates and the intermediate evaluation report of Comenius under Socrates II in 2004 (66) have clearly shown the many advantages of European networking. European and international networking is also promoted through the involvement of many schools in science projects run by European or international organisations such as GLOBE, ECO-schools, The European Network of Health promoting schools (67), Science across Europe or Science across the World (68), the Young Reporters for the Environment (69), RiverNet with the Youth water Parliaments (70) etc.

Next to local, regional, national and European or international networking one should not forget the many forms of bilateral networking which has been developed, also in science projects, and which is based in bilateral cooperation between two countries. Neither should one forget the international science projects set up in the framework of the ASP (71), Associated Schools project of UNESCO.

The OECD 2003 publication "Networks of innovation" stresses p. 53 the four key functions of networks. Networks have a political function as they enable like-minded people with a common or similar objective. Cooperation leads to greater political force and input than they have individually. Networks are thus lobby groups for innovative ideas. Networks have an information function as they allow for rapid exchange of information relevant for individual and organisational development processes avoiding too much administration and hierarchy. Networks have a psychological function; innovators are often isolated within their schools and networks provide them with opportunities for collaboration and exchange; in this way networks empower strongly innovative individuals. Finally networks have a skills function as innovative work requires a range of skills that are not necessarily offered by traditional training schemes but can be learned from colleagues within networks. Those functions of networking contribute greatly to enhance professional development of staff in Comenius projects as a key element to create innovative schools. Comenius 3 networks, networks by European and international educational associations (EU Schoolnet, AEDE, ATEE, ESHA, EPA, EFIL etc.) are a major contribution to networking.

Caring and participatory school

A caring and participatory school is an important pre-condition to promote and enhance learning and motivation for learning. Research shows that the use of active pedagogical methodologies and of creative learning environments has an impact on the school climate and the school culture. If there is no positive school climate and school culture the quality of learning decreases and sometimes learning becomes impossible. Furthermore, motivation for education and learning is promoted if the talents of every child are tapped into and valued. It leads to increase of self-confidence of especially

66 For the evaluation reports of Comenius 1 partnerships see the following website of DG EAC: http://europa.eu.int/comm/education/programmes/socrates/comenius/evaluation_en.html
67 Health promoting schools: see website: http://www.euro.who.int/ENHPS
68 Science across Europe / Science across the world: http://www.scienceacross.org/index.cfm?fuseaction=content.showhomepage
69 Young reporters of the environment: http://www.youngreporters.org/
70 Youth water parliaments: see the website: http://www.rivernet.org/educ/parlements/parlements_e.htm
71 ASP, Associated Schools Project of UNESCO: see the website: http://portal.unesco.org/education/en/ (click on 'networks and then ASPNet)
disadvantaged children. Many GRID projects contribute to create a caring and participatory environment by their activities and by the way in which the project activities are embedded in the pedagogical community and the school development plan. Pupils and parents are at the centre of the concerns of many schools.

Active involvement of pupils in science (and other) projects changes the relationship between pupils and staff for the better. Such changes in relationship develop more trust and confidence and facilitate guidance and counselling at all levels. They also contribute to tackle more efficiently certain problems such as bullying and violence in every of its forms in schools. Relationships built on trust, confidence and co-operation lead to more inclusion of all pupils (and staff) in the school community and thus avoid exclusion which is the basis of drop out and loss of motivation for learning. The caring school is a school that cares for each member of the school community at whichever level. This belief in the unique value of each member of the school community and the belief that each member has a contribution to make based on his personality is a key in the role of education to enhance personal development and society-building. Many GRID projects contribute thus actively to the bringing about of a caring and participatory school.

Some teachers interviewed stressed that the implementation of project work be it in science, in other disciplines or in interdisciplinary approaches at local, regional, national or European level, definitely has an impact on the school culture and the school climate. It is also repeatedly stressed that the status of teachers involved in projects is heightened as parents show appreciation for the work carried out within innovating projects.

G. CONCLUSIONS and RECOMMENDATIONS

G.1. PREAMBLE

Based on all the information gathered both at the level of the policy papers or action reports and at the levels of the different initiatives and projects described, recommendations are made which can hopefully towards the future be taken into account to enhance MST education across Europe. As conclusions and recommendations are closely linked they are mentioned in the same chapter.

The chapter first makes some conclusions as to the relations between the initiatives and the institutional based reports or policy papers. Then the focus is put on innovative projects and on the importance of management issues in running science projects. Finally the recommendations which can be useful at local, regional, national or European level are added.

G.2. RELATION BETWEEN INITIATIVES AND INSTITUTIONAL BASED REPORTS

Some of the initiatives and projects described in the GRID database are the result of explicit policy at national or regional level. Some are not linked at all to policy developments and are the decision of the schools to be involved in a project to promote MST. Information was already given to this effect in a previous section expanding on the subdivision according to the nature and reflecting upon official pilot projects for science education (very often maths, science and technology) or official pilot projects focusing in general on innovation in education.
The following were said to be interesting examples of national policy based initiative focusing specifically on science, maths and technology:

- The IMST2 and IMST3 initiative in Austria
- The SINUS and SINUS TRANSFER initiatives in Germany
- La Main à la pâte in France
- The Science colleges in England
- Science and technology week in Malta
- Science -Education 3 - 18 in Scotland
- Natural Science Classes in Denmark
- The LUMA programme in Finland
- Physics and Chemistry applied to Arts in Portugal

Next to those it was also stressed that general innovative pilot projects enabled to support projects in the field of science, maths and technology. This was the case for the following ones:

- The VOORUIT initiative in the Netherlands (2004-)
- The KUBIM initiative in Germany (2002-)
- The Proeftuinen in the Flemish Community of Belgium (2003-2007)
- The ATTRAKTIV SKOLA project in Sweden (2001-2006)

It was added by some of the projects contacted that in some cases they linked up with a strategy for the promotion of science which was not coordinated by the national or regional educational authorities but by regional institutes or universities. This is the case for Italy where IRRE or Regional Institutes for Pedagogical Research as well as research centres or University departments or foundations can have a strategy for the promotion of science. This is demonstrated by Italian initiatives such as the MATHS Competition, BIG NUMBERS, MATHS MACHINES and the LLC project described in the GRID database.

Actually, in a strict sense of the word, very few of the initiatives analysed are subsequent to a new policy, but in some projects there are links or connections with institutional programmes or legislations, which deserve to be mentioned.

Although they have not been considered as directly resulting from a new policy or legislation, there are some institutional links for the Italian projects MATHS MACHINES, CHEMISTRY and LLC. The first one, MATHS MACHINES, has been financed by different institutions within different projects: Problems relating to the teaching and learning of mathematics: meanings, models, theories (Prin Cofin Project 2003: [http://www.didmatcofin03.unimo.it/](http://www.didmatcofin03.unimo.it/)); ‘Geometry for you’ within the ‘Matematicainsieme’ Project managed by the School Office of the Emilia Romagna region: [http://www.matematicainsieme.it](http://www.matematicainsieme.it); Thematic Network Maths Alive within the Fifth Framework Programme of the European Commission coordinated by Albrecht Beuthelspacher (Mathematikum, Germany).

CHEMISTRY is indirectly related to the SET pilot project “LE PAROLE DELLA SCIENZA”, in the framework of which the school chemistry teachers'group is playing the role of tutor for the science activities in primary and secondary schools.

Also the LLC project does not directly result from a policy or legislation. Nevertheless, the project can be related to the aims and purposes of the FMG (Marino Golinelli Foundation). At European level the LLC is inspired by the Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions: Life sciences and
biotechnology - a strategy for Europe COMM (2002)27, as well as by the Sixth Framework Programme.

It is interesting to point out that several projects do not originate from official policy or legislation but have been recognised as examples of good practice based on their achievements. So that the Italian DRAGO has been inserted in the SET national programme as a pilot project and the Italian SU18 has been recognised by the protocol of agreement between the MIUR (Ministry of Education) and the Science and Technology Museum L. Da Vinci of Milan and it has been partly financed by the decree 6/2000 (regarding the dissemination of scientific culture). Also the Bézier Curves project has been included in the Science Degrees Project starting from 2006.

This happens in other countries where ‘good practice’ projects are invited to submit an application for funding or are given funding. This was the case for the project "Experimenteer koffers / Kits of experiments" (Bnl) which was given extra money by the Government to develop extra kits as the first kits proved to be useful and successful.

Hungarian processes show a similar picture. School level developments, bottom-up innovations contribute to and/or are converted into state developments, are becoming state-supported pilot projects. Some local initiatives can have more effect on central level than on their close surroundings.

G.3. THE CONCEPT OF INNOVATIVE PROJECTS

Many of the science projects described in the GRID database contribute to bring about innovating schools and innovative learning environments.

Here below a summary is given of what an innovative science project can and should be. This can be useful for project coordinators towards the future.

- It is a project that focuses on the creation of an innovative and creative learning environment.
  It brings real life into the school environment by making links between the curriculum and real life in the local environment of the youngsters but also beyond. An innovative project takes into account the different talents, learning styles and learning needs of the children concerned. This means that the teachers also have a differentiated approach taking into account the different learning styles. ICT and e-learning are very often given a prominent place in the promotion of creative learning environments.

- It is a ‘well-thought of’ project that is integrated into the school development plan as it is part of the mission and the vision of the school agreed upon by all the members of the local educational community concerned. This supposes a participatory school where there is trust and confidence between all partners built on solid participation structures such as students’ councils and parents’ councils. The project is part of the overall pedagogical strategy of the school.- It is thus a project which is built on teamwork and possibly reflects also on the recognition of the time, efforts and commitment of the teachers and other members of staff within the project. The involvement in the project is integrated into the professional development plans of the teachers and other members of staff. In some projects teachers have a teacher portfolio in which their project activities are integrated.

- It is a science project that integrates into its activities in-service training of teachers involved in the project. In-service training at the level of the disciplinary, interdisciplinary or cross-curricular activities but also at the level of the project management and organisational aspects. Next to a clear focus (plus financial means) on in-set, an innovative project will also create links with initial teacher education to guarantee a better workforce towards the future.
- It is a science project that invests in **close cooperation with a variety of members of the local community**. This results in an interaction between the school and the local community that is beneficial to both of them. The local community puts at the disposal of the school talents and means. The school invests itself in community work that has a definite effect on the socialisation at local level.

- It is a project that pays attention, during its implementation, to **monitoring and follow-up** of its activities. This is done by either inviting internal or external people to get involved in these activities. The monitoring and the follow-up is closely linked to the internal and external **evaluation** so as to draw the lessons from the innovation and possibly disseminate them in the whole school and beyond.

- It is a science project that pays attention to and sets up **dissemination and valorisation** activities in the local, regional, national community or even at European level through its involvement a.o. in a variety of networks. Through valorisation it may help to embed its innovative project in another educational reality. Dissemination and valorisation are thus links to a variety of networking activities.

- It is a project that pays attention to its **transferability** by documenting its activities, by making a project’s directory and by embedding itself in an action-research approach. Within an action-research approach projects reflect on what they do and why they do it. The report resulting from the reflections proves to be useful in the transfer towards other schools.

- It is a project that reflects, up from the beginning, also on the **sustainability** and the continuity of the innovative actions which are set up. Cooperation with the local community may strengthen the sustainability of the project.

### 6.4. THE IMPORTANCE OF MANAGEMENT ISSUES IN RUNNING SCIENCES PROJECTS

The following remarks related to management issues can be seen not only as conclusions but also as recommendations for future projects promoters or coordinators.

#### 1. IMPLEMENTATION OF THE PROJECT

The initiative to set up a project is taken in different ways. Either it is the individual proposal of a teacher or a small group of teachers who want to innovate in teaching and learning. Sometimes it is the initiative of a team of science teachers. The individual or group initiative may result from one or several teachers who have attended an in-service training seminar at national or European level where they got in touch with innovative approaches as to science teaching. In some cases the proposal comes from the head or the management of the school. In some cases suggestions are made by inspectors or pedagogical advisors to schools to be involved in such projects. This can happen also at the occasion of in-service organised by those bodies.

When the project is part of an official pilot initiative in a whole country or region, the schools are very often invited to submit innovative proposals to the ministry or to the coordinating body of the pilot project. Based on the proposals a selection is made. Schools are usually involved in such projects

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72 The concept of valorisation has been largely developed and implemented within the framework of the Leonardo da Vinci project of DG EAC of the European Union. Full information on ‘valorisation’ is to be found on the following website: [http://europa.eu.int/comm/education/programmes/leonardo/new/valorisation/index_en.html](http://europa.eu.int/comm/education/programmes/leonardo/new/valorisation/index_en.html)
on an annual basis but the overall support may last several years with intermediate monitoring or evaluation as in Austria and Belgium (nl).

In some cases the project to be set up is discussed with all the (science) teachers and even with the whole staff and the parents. In other cases this doesn’t happen and it is just a few (science) teachers (or teachers of different disciplines!) who decide to go ahead or are given the green light by the head or the management of the school.

Sometimes the start of a project is an initiative that is not integrated in the curriculum but which is outside the curriculum such as a science clubs that pupils can attend outside normal class hours or during holiday periods. In some of those cases the project moves from an extra-curricular activity to become at a later stage a curricular activity which is to be preferred as it is accessible to all pupils.

Whichever the situation is, it can be stated that the decision to set up innovative science projects is very often linked to the outcomes of international or national reports that have shown that there is need to do something about science teaching. The PISA and TIMMS studies are good examples of such reports. Teachers are not necessarily aware that invitations to set up science projects are linked to the results of international studies or may be linked to agreements at European level such as the European benchmarks agreed at EU level by the ministers of education. One of those European benchmarks (73) specifically focuses on science and technology by stating that: The total number of graduates in mathematics, science and technology in the European Union should increase by at least 15% by 2010 while at the same time the level of gender imbalance should decrease.

The implementation of the project and the impact will be enhanced if the staff of the school, the parents and other stakeholders are clearly aware of the way in which the project contributes to quality in education and to bringing about innovative learning environments.

2. TEAM WORK – INVESTMENT OF ADMINISTRATION AND SCHOOL HEAD

The implementation of the science project is usually the result of the work of a team of teachers although there are also projects that are the work of an individual teacher. In the case of official pilot projects or initiatives one of the pre-conditions is that innovative projects are carried by a team of teachers and are embedded into the pedagogical project or the school development plan. In official pilot projects or in other projects the support of and collaboration with external specialist or experts of universities, science institutes, laboratories or centres are part of the project. Those specialists can be involved (as mentioned earlier) in different ways. They can have a role in project monitoring and follow-up, in evaluation and valorisation on the one hand or they can just have a role in the curricular contents of the project.

In the case of official science initiatives or important science projects of foundations specialist will have laid down in advance the guidelines and specifications of the initiative. They will have defined the criteria of the project to be set up and may also have been focusing on monitoring, follow-up, evaluation and dissemination.

73 The five European benchmarks are the following:

- By 2010, an EU average rate of no more than 10% early school leavers should be achieved.
- The total number of graduates in mathematics, science and technology in the European Union should increase by at least 15% by 2010 while at the same time the level of gender imbalance should decrease.
- By 2010, at least 85% of 22 year olds in the European Union should have completed upper secondary education.
- By 2010, the percentage of low-achieving 15 years old in reading literacy in the European Union should have decreased by at least 20% compared to the year 2000.
- By 2010, the European Union average level of participation in Lifelong Learning, should be at least 12.5% of the adult working age population (25-64 age group)

For more information see the EU website: http://europa.eu.int/comm/education/doc/official/keydoc/2003/benchmark.pdf
In a few cases an external organisation such as a foundation may provide the organisational staff of the project (with administrative staff, public relations and project management or development tasks). European or international bodies or organisations may also give support in terms of making available a website and forums on the internet. Those networks also develop common pedagogical tools and materials which can be used by teachers. Even in once case (science across Europe) classroom materials over available in more than 10 languages. This proves to be definitely useful in European or international science projects.

In the case of large projects or pilot initiatives there is an important management structure composed of a scientific committee on the one hand and a more organisational team on the other hand. Within the scientific committee or linked to it there may be a team of tutors or pedagogical advisors to help schools during the implementation of the pilot project. Examples of this are the IMST2 and IMST3 initiatives in Austria, the SINUS and SINUS TRANSFER projects in Germany and the SU 18 initiative in Italy. All the activities concerning the French “Main à la Pâte “ initiative are coordinated in a resource centre Montrouge near Paris.

In very few cases manuals or handbooks (74) are made available to help teachers with the implementation of the project at all phases. As already mentioned before, few or no tools are available to help teachers in the monitoring and follow-up, the evaluation, the dissemination and the valorisation of science projects. The website of organisations, bodies or universities involved in the official or large projects are considered to be very useful especially when they have comprehensive databases as expanded upon earlier in the text.

It is useful to point out that in some cases the team running the project is not only composed of teachers, experts and specialists but is also composed of pupils and sometimes even of parents. Whatever the case is, teachers interviewed agreed that the most successful projects are thus which are supported by a team of teachers and that have the full backing and commitment of the head or the management of the school. This is true for every project be it in science or any other discipline.

The commitment of the team of staff and other stakeholders in a science project is one of the key success factors in the implementation of the project. Other support elements such as direct or indirect support and monitoring are also key success factors.

3. INVESTMENT IN OFFICES AND HUMAN RESOURCES

The investment in offices and human resources at the level of the individual schools varies according to the nature and the scope of the project. Official project may foresee some extra funds to pay for extra staff time but this is not the rule. In fact it is important to stress that most of the innovating science projects are implemented by teachers who do this on a voluntary basis and who are not necessarily paid extra to do so. In some cases the coordinator of a project in a school may be exempted from teaching for a few hours. Extra pay for the extra work invested is practically non existent.

Most of the initiatives do not foresee particular investments in material resources. Generally the school provides spaces and materials needed, but it is better to say that the initiatives take advantage of the resources already available in the schools. The impression received from the people interviewed is that they have thought or designed and implemented the initiative starting from the available resources.

74 In the case of Comenius I partnerships a handbook is available on the website of the Commission DG EAC and on the websites of all the Socrates National Agencies. In Hungarian educational reform stress is put on commonly developed curricula, methods, teaching-learning materials and in-set programme.
In the case of individual or isolated initiatives undertaken within the schools they are mostly not based on a formal collaborative work or these projects do not have special implementation procedures and thus there are no special human or financial resources mobilized. However schools may use bits and pieces of their budget but this is not always possible especially at the level of the primary schools where funds are very limited and where the leeway the head of a primary school has is also very restricted.

The main resources granted by the schools are the teachers' working hours, as well as laboratories and rooms. In some cases schools will make some funds available for the in-service training to be followed by a few teachers in the framework of the project.

Many initiatives are carried out within the teachers' and students' school hours, others require extra working hours in the afternoon both from students and teachers. Generally, the extra hours are voluntary with some minor exceptions. In the case of the Austrian teachers involved in the IMST2 initiative and who drafted an action-research report, they were paid 1000 EURO to draft this report.

In many cases the lack of time and spaces and the crowded timetable and curriculum are the main problems encountered by teachers. All the obstacles were expanded upon earlier under the separate heading of 'obstacles'. Even at university level involvement can be problematic due to financial restrictions that exist in most European countries.

However, in the case of official pilot projects set up subsequent to government policy the financial means are made available to the university or universities (or other institutions) that play a key role in implementing, monitoring and evaluating the whole initiative.

In the case of some of the projects in which students are involved in laboratories in universities for short term placements and experiments, the school may pay a small contribution per pupil to the university.

In some cases the additional equipment needed for the initiative is provided by the project partners sometimes through the links with companies or other partners in the local community. The Italian CHEMISTRY case is exemplary for the resources granted in terms of time and equipment. In fact the school provides rooms, laboratory, working hours (paid at a 50 per cent rate) and tools (wireless PC). The team meets twice a week in the afternoons in a formal way, and many times at week informally. The technical activities of research and development regarding the cooperative working tools of the web of the Institute have been financed by the CRT Foundation and the Piemonte Region thanks to the eSchola network (75). Sometimes there are private sponsors that make possible certain projects or initiatives.

The voluntary work plays an important role and some teachers do not mind investing extra time without being paid. However, other teachers do mind if the voluntary work is the corner stone of innovation in science education (or in any other curricular area). If time is invested voluntarily teachers would appreciate to get some sort of official recognition to that their investment in innovating work is recognised in their professional career or in their professional portfolio. This is the case in France where inspectors may add a special reference in their evaluation report when teachers are involved in innovative projects. Similarly in England HMI (Her majesty's Inspectorate) can make a special mention in their reports for schools that are involved in innovative projects to promote sciences or other curriculum areas.

75 For further information: see website of European schoolnet:
http://www.eun.org/portal/index.htm
If future innovations are to be as successful as present ones, the recognition of work and investment of teachers and other members of staff has to be looked into carefully and some sort of recognition has to be provided.

Another success factor is the investment in human resources to run a project. Sufficient human resources have to be foreseen with administrative or material support to make a project successful.

4. THE NECESSITY TO UPDATE ANY DATABASE OF INITIATIVES

Databases prove to be very useful at different levels in promoting science education. They are especially interesting if they give extensive information about the project and are sometimes even supplemented by action-research reports which is the case for the Austrian ISMT 2 database. Databases can be used in in-service training activities to show examples of good practice. Experience show that they contribute greatly to enhance motivation for and interest in innovative projects. Especially when teachers can get in touch by e-mail with fellow experienced teachers, commitment and motivation is greatly promoted.

However if databases are important and can be a great support in improving MST education, the key issues to be addressed are threefold. On the one hand there is the updating of the databases on a regular basis which supposes enough and regular funding. The sustainability of databases is always a critical point. Second databases should be available in at least the national language and possibly in English. Thirdly ways have to be found to inter-connect the different databases across Europe. Finally it would also be useful if towards the future major MST databases across Europe would be built along the same lines.

Hence it is proposed that the Commission of the European Union would support the creation of one single portal. This website should have some key features:
- link up all major regional or national databases in MST,
- similar project identification sheets to be used across the different databases so as to present projects in the same recognizable way
- recommendations for teachers and other interested stakeholders on how to work with a database.

The web site should be organised in such a way that all potential users can look for information using multiple criteria: information to be found per country, per thematic area, per target group etc. Such a database should be similar as to the databases developed in the framework of the Leonardo da Vinci programme. The database should be fed and updated by the project coordinators themselves.

The web portal should also give access to policy documents, actions reports, research studies, evaluation studies etc. in the field of MST. The web site should also provide an overview of interesting seminars and conference at national and/or European level. Finally the website should also give an overview of community funding to promote European projects in MST education.
6.5. RECOMMENDATIONS

RECOMMENDATIONS AT NATIONAL LEVEL

All countries should be invited to develop a Database with the innovation projects which are promoted in MST. The database developed by the University of Klagenfurt in the framework of the IMST2 initiative could be taken as an example of good practice. However, attention should be paid that the database is accessible in at least two of the major languages of the European Union (FR / EN / DE).

Monitoring and support structures should be set up in all countries involved in developing and implementing science projects. Use should be made of expertise and experience gathered by those official pilot projects which have worked with supportive structures in terms of monitoring, follow-up and evaluation.

Evaluation (and monitoring) of innovative actions should be foreseen up from the very beginning of the project and should be implemented both in terms of processes and in terms of outcomes. It is also recommended that evaluation teams are composed of experts from several EU countries which on the one hand is good for the country concerned and which is also beneficial for the experts from the other countries as they can feed back the expertise to the colleagues in the ministry and in the education community in their country. This kind of evaluation is a win-win situation for both parties involved in the evaluation team.

Initiatives should be taken to develop and implement multidisciplinary in-service training activities whereby teachers of different disciplines (especially scientific and non scientific skills) are trained in project development, management and implementation. Such multidisciplinary training activities could also be set up at European level within Comenius 2.1 projects.

RECOMMENDATIONS AT EUROPEAN LEVEL

The Commission is invited to set up a website or web portal inking up all regional or national databases with examples of good practice. This website should have the characteristics mentioned just above. The comprehensive database should also be linked to access to the outcomes of all the sciences (and maths or technology projects) funded under different EU programmes can be accessed. Thus it should be possible to access R & D projects Leonardo projects, Socrates projects, TEMPUS projects focusing on science and schools or teacher education. Possibly also science projects in the field of the EQUAL programme of the ESF. Etc.

The Commission should study which support it can give to the sustainability of national MST databases. The support to the continuity and the sustainability of databases should be decided after a thorough analysis of what has been achieved and the way in which the national database also contributes to promote the European dimension and European cooperation in SMT education.

The EU (DG EAC) is invited to make a comparative study within the framework of Socrates action 6 - Observation and Innovation - to describe the different pilot project mechanisms that have been developed and implemented in different European countries to promote innovation in education in general or in science education in particular. A qualitative analysis could point out which mechanisms or which elements of which mechanisms can be transferred to other education systems.
A European seminar should be organised involving all those involved in helping to monitor, follow-up and evaluate innovative regional or national pilot projects in the field of science education. The objective would be to compare and improve the methodologies used so as to disseminate them to countries which do not use such pilot mechanisms.

**Evaluation tools should be developed and/or shared at European level.** It would be useful to develop within the framework of a Comenius 2.1 projects sets of tools to evaluate different types of science initiatives and projects set up at regional, national, European or transnational level. These evaluation tools should focus on the key elements such as relevance, efficiency, effectiveness, impact, and sustainability. Expertise could be put together and turned into an in-service training course in the framework of a Comenius 2 project developing in-service training activities for teachers involved in innovative science education activities.

**The mobility grants made available under Comenius 2.2.C** should also be made available to teachers or teacher trainers involved in the transnational evaluation teams in charge of evaluating national or regional pilot projects in the field of science (plus maths and technology) education. This should enable them to be involved in peer evaluation or peer shadowing activities linked to the promotion of MST.

The Commission should promote initiatives in the field of SMT for specific disadvantaged groups that are very not really addressed in SMT projects. Such groups are children of migrants, children of certain minority groups such as Roma children, disabled children. Initiatives could also be promoted to involve much more parents of pupils as very few focus on this aspect.

The Commission is suggested to set up projects specifically focusing on the promotion of participation of girls and women in MST as this still a problematic area. A European project could compare the strategies put in place by different countries to highlight the critical success factors which lead to more women / girls in MST.

The Commission could promote Comenius 2.1 and other projects promoting cooperation between universities and schools to promote MST. Especially the faculties of schools of education should be addressed to which action they take to prepare primary school teachers and kindergarten teachers to promote science education. This is especially important as in most countries those teachers teach all or most of the subjects in the primary school and/or kindergarten. European cooperation initiatives could also be proposed involving faculties or departments of engineering and sciences in cooperation with schools and other partners such as companies.

The commission should envisage the creation of an MST observatory in relation with the promotion of MST education at European level. An observatory is important of the exchanges of experience and expertise is to be clearly structure and if real exchanges leading to change have to be implemented. The partners within this project should / could be groups or universities that have already large experience at national level in promoting, implementing, monitoring and evaluating MST education.

**Possible mission, objectives and main functions of such an observatory?**

**Mission and objectives**

The mission of such an initiative is to contribute to the development and the structuring of strategies and policies that promote effectively and efficiently maths, sciences and technology:

- To strengthen better knowledge about what is happening and what is offered by enhancing transfer of expertise and experiences;
- To facilitate dissemination of the pedagogical / didactical mechanisms and strategies put in place and implemented in the different countries to promote MST;
To promote the implementation of new strategies and approaches by making them user-friendly;
To facilitate the transfer of successful activities at school, teacher education level in other regional or national contexts building on previous lessons;
To organise in-service training for teachers and other stakeholders.

The observatory could have four major functions:

- **Inform the stakeholders (teachers, parents, universities) and the large public**
  - Inform schools, universities, teacher training institutions, parents associations what has been achieved and implemented in the field of MST. In this way more people would be aware of the efforts made so far and would understand the nature of those efforts plus their effects. This would facilitate transfer of successful initiatives. This is also linked to putting in place an efficient information policy so that every school, university, institution or stakeholders can be informed about what has taken place (not only products but also practice and international know-how...). This will avoid unnecessary duplication of efforts. It will also create a multiplier effect and enlarge the field of application involving new potential users of innovative strategies and tools.
  - Put in place multiplier links - relays - across the European Union to promote MST efforts and to disseminate outcomes adequately. The object is to create credible and officially recognized multipliers that have knowledge of the real needs of schools, universities and institutions and that are capable to set up concrete action at grassroots level while promoting dissemination and valorisation.

- **Support projects and the transfer of their activities and outcomes**
  The observatory could support the starting up of large scale projects and initiatives giving particular attention to recognition and quality standards of certain approaches implemented. Certain initiatives could get specific support because they are specifically innovative or creative so that they could move more easily from the prototype phase to the industrial or full implementation phase. This decision would involve assessing first the transferability into and the adaptability of the project to other contexts.

- **Disseminate the products (materials, tools, practice, strategies etc.)**
  - To create a demonstration centre at European level; it would be very useful if results could be visualised and if project coordinators could benefit from adequate and appropriate advice during their activities.
  - To develop the concept of virtual media library so that interested people can access materials and documents through the internet.

- **Support activities concerning analysis, research and study**
  - To develop a counselling and help service to facilitate the introduction of innovative practices. The observatory could give support in project development (management of partnerships, management of projects, technological choices as to ICT etc....).
  - To develop counselling and advice during the implementations of projects or initiatives. The work of the observatory should not just be limited to dissemination of results and products.
  - To observe and communicate developments; this concerns anticipatory actions as to technological and pedagogical developments which are taking place.
H. OVERALL CONCLUSIONS

The conclusions of the GRID comparative analysis are based on and compared with the General Conclusions of the 2003 report of the WG D on Maths, Science and Technology. To facilitate the comparison the present GRID conclusions have taken as a basis the conclusions of the WG D 2003 report and quote, in italics, parts of those conclusions to point out similarities or differences.

Themes of projects

The GRID analysis confirms that “a number of common themes arise which are regarded as important aspects of increasing interest and attainment at all levels of the education system which include:

- Increasing interest and attainment from an early age
- The early development of scientific thinking and fundamental science competencies
- Increasing teacher confidence
- A focus on learning through the adoption of social constructivist pedagogy,
- The use of pedagogy to assist in the development of learning goals, and the use of Meta-cognitive strategies to promote autonomous, lifelong learning
- Increasing interest through a focus on practical work and more authentic learning environments which are of relevance to society in the 21st Century
- Sufficient time to enable practical work to be meaningfully carried out.
- Opportunities to make the links between theory and practice
- The development of competencies and higher order thinking skills
- The use of technologies (ICT) to provide support and to foster collaboration
- The development of teachers as researchers
- Attention to learning styles and how these can affect the interest and attainment of individual pupils

The analysis of GRID has, however, not found much evidence of “Financial incentives at tertiary level”.

Learning

In analyzing the many GRID projects one can conclude, as mentioned in the Reports of the EU WG on MST “that there is a growing recognition that for children to learn, they have to be actively involved in the learning process. They construct meaning through the process of interaction and enquiry. (see Vygotsky and Engestrom).” The GRID partners agree with the fact that: “It is clear that science education must be “more concerned with interpretation and understanding, than in the achievement of factual knowledge or skilled performance.” (Olson and Bruner. 1996: 19) The GRID analysis also shows and confirms that “there is a strong emphasis on an experimental, hands-on approach involving the use of scientific laboratory work in the examples of good practice analysed. There is a concern with making links between theory and practice in order that understanding, rather than simple acquisition of knowledge may occur. An important feature of successful practice is a focus on the development of higher order thinking skills. Pupils are

76 For the full report, see the following website:
encouraged to engage in such processes as problem solving, hypothesis generation and testing, analysis and synthesis". This is a feature of most of the initiatives described in the GRID database.

**Real life contexts**

Integrating science in real life contexts is definitely proved by the GRID analysis. The importance of setting learning within an authentic, real life context is also a feature of successful initiatives described in GRID. "This is reflected within classroom practice in science where the issues of relevance to the world of the twenty-first century are being addressed through the introduction of new subjects and topics."

The impact of science on society in the modern world is also an important area addressed in several GRID initiatives. There is clear evidence in many GRID projects "that specific skills and generic skills are best acquired within authentic practice contexts. Relating science, maths and technology to the world and making connections between the subjects and contemporary society helps to make the subject areas more accessible."

**Cooperation in the local community**

Well-developed and effective collaboration between schools, higher education institutions, universities, companies, museums is definitely a feature of several GRID projects. The important links between education and the outside world are reflected in the strong emphasis on partnership with a variety of external agencies. Many GRID initiatives have links to some extent with higher education, industries and other relevant institutions. The involvement and active participation of those external agents takes different forms from support, to help and advice through in-service training, placements for pupils and teachers etc. The fact that this leads to mutually beneficial collaboration involving both schools, higher education and industry is not always clear in the GRID projects analysed.

**Motivation**

It is clear from the many GRID projects that motivation for science can be increased by means of the type of social constructivist pedagogy and contextualised real-world learning outlined above. It can also be addressed through the use of new and exciting technologies. New and recent technologies impact on all aspects of modern curricula is definitely relevant in the area of MST. Next to providing interest and motivation, these resources are used in successful initiatives to develop pupil autonomy on the one hand and teamwork on the other hand, two vital aspects in the development of lifelong learners.

**Teacher education**

The WG report mentions that the success of initiatives at school level is largely dependent upon the quality of initial teacher education. All initiatives analysed in the Report of the WG D on MST recognised this as an area of concern.

The ability to form links between theory and practice is an important factor in only explicitly mentioned in a minority of GRID projects. Some GRID projects confirm that "The development of reflective practitioners who are well supported by partnerships between universities and schools is a crucial factor in the success of initiatives in this area."

The in-service training support, the monitoring and follow-up or mentoring provided through web-based networks and research based on cooperation with universities, is greatly appreciated by teachers involved in science projects who benefit from these forms of support (see the IMST2 and IMST3 and the SINUS and SINUS TRANSFER initiatives). There is clear evidence that teachers have found this type of support of value in developing confidence and expertise.
GRID confirms, as stated in the Report of WG D of MST that "The long-term success of any initiative in education is ultimately dependent upon the support of the individual teacher in the classroom. Top-down policies, which are forced upon reluctant teachers, are not successful in the longer term. The most successful initiatives (with a potential long-lasting effect, high transferability potential and sustainability) have started at school or local level with support and funding from central government. GRID confirms that "this model of combining a "bottom-up" with a "top-down" proves to be the most effective and efficient one in ensuring a sense of ownership and commitment on the part of teachers that is crucial to long term success of initiatives.

The question of recognition of the commitment, of the efforts and time invested by the teachers is, according to the GRID analysis, an important element in promoting long-lasting commitment and ownership in innovative projects.

**Time and rigidity of curricula**

Time and the rigidity of some curricula emerge also as a key issue in many GRID initiatives. The GRID projects confirm that "the type of learning, which involves a practical approach and the development of higher order skills requires more time in the curriculum than a traditional approach in which knowledge is transferred from expert teacher to novice learners. Account will need to be taken of this in order for initiatives to achieve full success."

**Resources**

The analysis of the GRID projects does not allow any important conclusions as to the resources needed to implement innovative projects. Hence GRID cannot confirm what is mentioned in the report of the WG MST that: "Although many projects demonstrate initiative in the preparation of materials and resources, maintaining interest in science and technology through a practical approach requires the use of up to date, and often-expensive materials and technologies. The development of closer links with industry may be an important means of addressing this."

**Gender**

Neither can GRID confirm or contradict what is mentioned in the WG report on MST concerning Gender. However GRID partners agree with the statement in the report that: "Cultural shifts in attitude will not occur without positive intervention. Policies must be implemented which encourage the recruitment of females. These must include collaborative networks of support between schools, universities, industries, employer organisations, career advisors, politicians, trade unions and very importantly, the media. To be most effective, these cultural shifts need to take place from an early age. The media has a particularly important role to play in the breaking down of gender stereotypes in this area. Taking into account potential gender difference in learning styles and preferences may be another important factor in this respect. The influence of different learning styles in learning and their impact on success may, therefore be an important area for further exploration in the area of MST. Consideration of the attractiveness of topics and subject matter and their relevance to life in the 21st Century may be of particular importance in relation to gender."

**Integration**

As to integration GRID projects also show that “In some initiatives, the problem of uptake in MST has been addressed through the introduction of the subjects as discrete components from an early age. Some initiatives moved towards a more integrated approach.”

The analysis of those projects does not allow any further comments or conclusions at the level of the GRID project.
Systemic reform

Finally the GRID analysis also points to the fact that systemic reform is only possibly by drawing together the strengths of the different types of initiatives and by making the results available through websites, networks, initial and in-service training activities. The GRID partners think that ways have to be found to promote much more interaction between official pilot projects and other initiatives set up by occasional networks and even by isolated projects. Cross-fertilization between existing initiatives is the basis for a major multiplier effect.
F. ANNEXES

ANNEX 1: Methodology used
ANNEX 2: Reports identified and analysed
ANNEX 3: Questionnaires used (QR1 and QR2)
ANNEX 1: METHODOLOGY USED

The methodology used has combined the techniques of investigation and observation (questionnaires, semi-directive interviews, participating observation and filmed observation allowing the analysis of the practices), and the techniques of experimentation making it possible to make a comparative study of the mechanisms put in place to promote science education and making it possible to develop a typology of the initiatives and the mechanisms to enhance innovation in science education.

The GRID project intends to produce two major reports:

- **Report 1**: This report will present the analysis of national reports, institutional policies at whichever is the level (Ministry, academy, schools...) which aims are to improve the learning and teaching of maths, sciences and technology in schools. It has been decided to tackle this issue as broadly as possible and to take as the key criterion the fact whether a document sheds a particular and innovative light on the issue of learning and teaching science. Hence the elements of this report will analyse the recommendations which are integrated in national reports, comments, national communication campaigns etc as well as any action plan which may refer to special measures to promote science education or which allocate supplementary funding or means such as pilot projects etc.

- **Report 2**: This report will focus on the description of initiatives and projects at grassroots or classroom level. Within those reference is made to actions or initiatives which are made possible by the reports, actions plans or recommendations mentioned in report 1.

For the report 1, it is initially a question of identifying a significant number "of institutional reports/action plans", that are either directly resulting from the various internal structures of ministries of education, or that are resulting from associations or foundations that are influencing the official institutions (ministries) directly. These instructions can take various forms: laws of orientation, national reports, academic investigations, comments of programs implemented, putting in place of follow-up or support and of logistical or financial help, reports of major associations (Academy of Science, etc...). To enable the identification of theses reports, it has been necessary to:

- ask support of the European Commission, in particular of the Math-Sciences-Technology group to help identify as many documents as possible in as many European countries as possible ; this making use of the list of members of the WG.
- make a list a listing of the target structures likely to be instigators of recommendations: the Ministry, academies, general inspection services, regional and local education authorities, associations, etc. for each of the partner countries.
- contact first by e-mail, making use of the document giving a general presentation of GRID, the persons in charge within the ministries and other structures and later on to contact them by telephone
- search via the Internet.

For the report 2, the objective is to identify a large number of initiatives and mechanisms put in place to increase the interest and motivation of youngsters for the world of science and to do sometimes about the loss of interest for science. To facilitate the identification of those initiatives, it has been necessary to:

- Prepare a short explanatory document nicely presented which facilitates the comprehensive understanding of the project and of the request to teachers and other potential users to fill in the QE1 form on the website.
• Draft by each of the partners for the countries they are in charge of, of a list of structures or organisations which are possibly supporting and/or initiating initiatives or mechanisms: ministries, academies, general inspection services, regional and/or local education authorities, associations, museums etc.

• Email to all the persons on the lists mentioned above:
  o Directly to those in charge of the structures or organisations in charge of setting up initiatives or mechanisms with the request to fill in the QE1 form;
  o to the project coordinators to ask them to contact their members and to invite them to fill in the QE1 form.

The two comparative reports will, amongst others, highlight the grassroots or field initiatives or projects impelled by instructions from official institutions (such as the Ministry of education).

The implementation of the methodology is described in the diagram below.

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**Collection and use of information collected**

- **Report 1: report on institutional reports and action plans**
  - To gather the information necessary for this report, two questionnaires (QR1 & QR2) were developed which had to be filled in by the partners of the project. Those partners tried to find which major policy papers, reports and action plans in the field of science, science education and even on innovation in education as a whole, had been produced mainly over the last 4 to 5 years. In several cases the members of the MST, (Maths, Science and Technology) Working group of the EU 77 were contacted to ask for their support. Documents, papers, action plans and reports were found by the partners of the project through different channels: contacts with ministries, associations, search on the internet etc. The partners analysed the reports using the two questionnaires mentioned just above. In some cases the ministry or organization in charge of drafting the report was contacted for further information. Each of the partners had to analyse several documents in each of the countries concerned. In the end a synthesis was made per country and the present synthesis is the overall synthesis developed from what had already been drafted at country level.

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77 MST Working group: composition of the group is to be found in the progress reports of this WG; one being the report of 2004 to be found on the following web page:

It was also important to make a form of analysis that allows the creation of a typological classification of the documents identified. The form is composed of some closed questions, **QR1** (one A4 page), describing in a precise way the initiators, the target public, etc... Another part of the form is more open, the **QR2**, and it makes it possible to have a deeper look into the strategies put in place, to have an idea of the dissemination and the real impact of these documents on the target public. It has been also essential that a question is dedicated to the possible identification of concrete experiments directly initiated as a result of the recommendations made in some reports or action plans.

Each partner, for his or her country, made available a file with all the QR1 and QR2 forms of the documents, reports and action plans they have analysed. They also made available a synthesis of all the QR2. All these documents were in English language.

- **Report 2: report on initiatives**

For Study 2, the implementation is organised in the following way:

- Uploading the questionnaire **QE1** on the website of GRID as that it is accessible for everybody. It primarily consists of closed questions. An open question at the end of the questionnaire makes it possible to describe the project and its objectives. It is possible also to annex downloadable documents. The paragraph on methodology explains how a maximum of teachers concerned can fill in the QE1. Questionnaire QE1 is used for the identification of the initiatives and the devices. This questionnaire is short but sufficiently comprehensive to understand clearly the objectives of the initiative or the innovative mechanism put in place. The potential users can choose one of the languages of the partners and answer in one of these languages as far as the open questions is concerned. Each partner is in charge of the follow-up of the collection of the QE1 forms and takes action to incite people to fill them in.

- For each country, based on the analyses of the QE1s, a sample of initiatives and mechanisms is selected which seem to be interesting and which represent a rather broad typology which is representative of the main themes. Semi-directive interviews of the initiators of actions and initiatives at grassroots level or in the field (school) are organised in making use of the **QE2** form. This interview is focused the way in which the models and the practices are implemented and used in concrete settings. Particular attention is given to the questions which enable to identify the factors facilitating the transferability of good practice. The partner is also in charge of inputting the contents of the QE2 forms and is also in charge of making a synthesis document on all the QE2 forms drafted. As far as the dissemination of the QE1 form is concerned and as far as the interviews are concerned this is left to the responsibility of each of the partners. Each of the partners can make use of local experts who manage the local native language if he or she thinks the funds are available to do so. The external person can be involved in identifying the QE2 and in filling in the form and download it in the database.

- Out of all the QE2 a sample has been selected which can be used for the case studies to be carried out in the second year of the project.

- This activity will make it possible to fine tune the report 2 through a more qualitative investigation based on case studies. The final objective being to select the "good practices" which correspond to the objectives of the project, to place them at the disposal of potential users on the website and to classify them according to sufficiently relevant selection criteria.
Presentation of the tools used

The following tools have been used for collecting all the necessary information:

- **Questionnaires**: are seen as "a succession of proposals having a certain form and a certain order requesting the opinion, the judgement or the evaluation of a person who is questioned or interviewed". They aim at the standardized collection of data: they are addressed at a broad population (all stakeholders linked to the mechanisms, the initiative or the project); they have to lend themselves to a statistical analysis. Several types of questionnaires were available according to the information to be gathered. They are primarily intended, on the one hand to give a broad vision of the problem (quantitative analysis) and on the other hand to select the case studies that will allow making the qualitative analysis.

- **Individual or collective interviews**: these are considered as dialogues whose objective is to collect information on a given topic. These tools make it possible to produce rich (not superficial) data. Structured, semi-structured or even free interviews will each give additional information. They will punctuate the various stages of the analysis and have as an objective to identify the representations of the stakeholders (teachers, students, institutional representatives, associations, representatives of companies etc...). These talks will be the object of a textual analysis and an contents and thematic analysis.

- **The participating observations and the filmed observations.** The objective is not to make professional films, but only to make filmed documents whose objective is to make it possible to understand the context and to highlight the key factors of success or the obstacles to the initiative, project or mechanism set up for the revalorization of learning and teaching of science at school. One can distinguish several types of observations with different objectives:
  - Filming of concrete classroom situations: the filming of pedagogical sequences. These recordings will make it possible to have a memory of the work which has been carried out. This memory can be useful for researchers who have not been directly involved.
  - The filming of interviews: filming interviews with teachers, with learners and/or with a team in charge of implementing innovation in science education. These interviews will make it possible to better understand the context of the experimentation for the quantitative analysis.
  - The documentaries: by using the strong moment of the films and by associating to it the point of view of the author, several documentaries of different length will be created linked to the different themes. Those documentaries will make a synthesis of the entire operation and can be used in the dissemination phase. They will thus be available on the website of the GRID project.

Difficulties met and solutions proposed

- **Regarding report 1**

  Countries across Europe do not have the same culture as to the drafting of reports. Some countries produce many reports on a regular basis while other countries have a limited number of reports and do not produce reports on a regular basis. Some countries do not necessarily make reports themselves but make use of the results of the outcomes of external studies or reports such the PISA studies made by OECD.
Hence it can be clearly stated that the culture of writing reports and building innovative strategies in education, differ greatly across Europe. Some of the partners have gone to great length to find reports but have been unable to do so. In some cases it was especially difficult to find recent reports or studies. The idea being that reports, studies and action plans would be described which are 3 to five years old. In some cases initiatives have been set up based on reports that go back more than five years and which still have an impact today. The LUMA programme in Finland is a good example of this.

- **Regarding report 2**

The main difficulties met while collecting information for QE1 were the following:

- Although it was rather easy to draft lists of organisations (schools, bodies, institutions) involved in innovative science education projects and initiatives, it is hard to make them fill in a questionnaire of from, even a fairly easy and simple one as QE1. Even after related request people are not taken the trouble to fill in QE1. In some cases the partner of the GRID project had to fill in the information he collected over the phone and through websites in the QE1 himself.

- For some of the partners it seemed to be difficult to make a selection of the project to be interviewed for a description in the framework of the QE2 form. It is always difficult to select projects or initiatives based on elements of innovation as many people would disagree on what an innovative project is all about. At the beginning a short texts was circulated which highlighted for the partners what an innovative project could be and which could be the key criteria of an innovative project.
ANNEX 2: REPORTS IDENTIFIED AND ANALYSED

Belgium

- Accent op talent: een geïntegreerde visie op werken en leren (Emphasis on talents: an integrated vision on working and learning), 2003
- Actieplan wetenschapsinformatie en innovatie; (Action plan information on science and innovation) 2004
- Femmes & Sciences: rapport sur la situation en communauté française de Belgique / Women and science : report on the situation in the French Community of Belgium
- La représentation des femmes dans la recherche au sein des institutions universitaires de recherche dans la Communauté Française de Belgique / The presence of women in research within university research institutes in the French Community of Belgium.

Denmark

- Evaluation report of the Natural science classes in gymnasiums

France

- Opération Main à la pâte (Hands on science) et enseignement des sciences à l’école primaire/ Hands on science and the teaching of sciences in the primary school 1999
- Désaffection des étudiants pour les études scientifiques /Students' loss of interest for science studies, 2002
- Les jeunes et les études scientifiques : les raisons de la "désaffection", un plan d’action / Young people and science studies: reasons for their loss of interest: an action plan, 2002
- Rewing the teaching off science in the primary school / La rénovation de l’enseignement des sciences et de la technologie à l’école primaire, 2005 (?)
- Development and dissemination of scientific and technical culture / Développement et diffusion de la culture scientifique et technique, 2003
- Les flux d’étudiants susceptibles d’accéder aux carrières de recherche : Dercourt/ The flux of students likely to access research careers, 2004
- Attrait et qualité des études scientifiques universitaires, 2003 / interest and quality of scientific studies at university
- Principaux enjeux et verrous scientifiques au début du XXIe siècle, synthèse des Rapports sur la Science et la Technologie, Sénat, 2003 / Main challenges and scientific obstacles at the beginning of the 20th Century ; synthesis of the reports on science and technology of the Senat
- Pour la réussite de tous les élèves(78) (Ensuring that all pupils achieve their full potential also called the Thélot report, 2004

78 For the full report in French see the website: http://www.debatnational.education.fr/upload/static/lerapport/pourlareussite.pdf
and for a synthesis in English see: http://www.debatnational.education.fr/upload/static/lerapport/syntheseVA.pdf
Germany

- Framework for science Education in Germany, 4th revised edition 2003
- Innovations report, 2006 by Siemens; for science business and industry
- Innovation: More dynamics for Competitive Jobs; Federal Ministry for economics and Technology, April 2002
- Geographical and lingual preferences in scientific collaboration of the European Union (1994-2003), 2004

Greece

- A Cross Thematic Curriculum Framework for Compulsory Education - Diathematikon Programma

Hungary

- The Hungarian Academy of Sciences for the development of science education, 2003 (Report No. 1120 / 1140)
- National Programme for the Decade of Health (Az Egészség Évtizede Nemzeti Akcióprogram) (Report No. 1168 / 1142)
- LVIIIth Application of Public Foundation for Modernisation of Public Education (KOMA) (A Közoktatási Modernizációs Közalapítvány (KOMA) 58. pályázati kiírása (Report No. 1150)
- Mid-term R+D Plan of National Institute for Public Education; Centre for School Development and Integration (Az Országos Közoktatási Intézet Középtávú kutatási-fejlesztési terve; Az Iskolafejlesztési és Integrációs Központ középtávú terve (Report No. 1154)

Ireland

- Oireachtas Committee on Education and Science, 2000
- Promoting Science in an All Girls Post Primary School, 2000
- The use of graphing calculators in teaching science, 2000
- The use of ICT in teaching Biology and Junior Certificate Science
- Report and recommendations of the Task Force on the Physical Sciences, 2002

Italy

- FOR ICT: Teachers training courses in ICT - National action plan
- How the school is changing
- Law n. 6 - 10/01/2000
- Legislative Decree 17/01/2005
- Official agreement between Deutsches Museum and Regional School Office (USR) - head office - Lazio Region
- Official Agreement between Italian Ministry of Education and Mathesis Association of Mathematics and Physics
- Official Agreement for Science Education signed by Toscana Region, Regional School Office (USR), Regional Institute for the Pedagogical Research (IRRE Toscana)
- Protocol of agreement between the Ministry of Education (MIUR) and Confindustria
- Science Degrees Project
- SET (Science and technology) programme: national programme for the promotion and improvement of scientific and technological culture and education

**Malta**


**Netherlands**

- Delta-Plan / Béta Techniek, 2004 (Delta plan for science and technology)
- Grenzeloze mobiliteit kennismigranten: Hoe krijgen we talent naar Nederland toe? / Mobility without borders for knowledge workers: how to attract talent towards the Netherlands? , 2003
- Vooruit! Innoveren in het voortgezet onderwijs / Forward! Innovate in secondary education, 2005

**Norway**

- Raising standards in mathematics and science, June 2006

**Portugal**

- The Portuguese Educational System: Situation and Tendencies 1990 - 2000
- The Future of Education in Portugal - Trends and Opportunities - Differentiated Modes of Learning and Knowledge of the Future: Overview Document
- The Future of Education in Portugal - Trends and Opportunities - a prospective study (20 years to overcome 20 decades of educational disadvantage)
- Access to ICT - ICT in Education
- Building the Knowledge Society

**Spain**

- Manifesto of Spanish Science Centres, 1997

**United Kingdom**

- A science strategy for Scotland
- Making mathematics Count - The report of Professor Adrian Smith's Inquiry into Post-14 Mathematics Education
- Science Curriculum Review
- Science & Innovation investment framework 2004-2014
- Science Teachers: supporting and developing the profession of science teaching in primary and secondary schools
- Supporting Success: science technicians in schools and colleges
- Why science education matters
- 14 - 19 Education and Skills, DfES, February 2005
European Union

- Europe needs more scientists: a blueprint for action, April 2004
ANNEX 3: QUESTIONNAIRES USED (QR 1 AND QR 2 / QE1 & QE2)

The questionnaires can be found on the GRID website. Here are the direct links:

- QR1 & 2: http://www.grid-network.eu/questionnaires/QR1_QR2_en.pdf