



Efforts to Increase Students' Interest in Pursuing Mathematics, Science and Technology Studies and Careers

National Measures taken by 16 of European Schoolnet's
Member Countries

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EXECUTIVE SUMMARY

In 2001 the Education Ministers of Europe set the objective of boosting enrolment in scientific and technical fields of study to contribute to the Lisbon process of fostering a dynamic and innovative knowledge-based economy. Since then, the European Commission has set up the Maths, Science and Technology Cluster to facilitate peer-learning and development in this area, and various studies/reports at European level (including Eurydice's study¹, King's College London's report² to the Nuffield Foundation and the Rocard report³) have focused on how to improve science education in Europe.

Within the framework of the Spice project⁴ of which it is coordinator, and at the request of its Steering Committee, European Schoolnet (EUN) undertook a comparative analysis of the main, recent Maths, Science and Technology (MST) initiatives, policy actions and reforms in 16 EUN member countries⁵, based on voluntary information provided in answer to a questionnaire. The EUN members and the Spice project's expert panel which answered the questionnaire used to collect information for this report, consisted of a mixture of experts, researchers, policy makers and teachers holding a relevant background and knowledge of MST measures and issues at national level. The questionnaire's responses focused on the measures put in place to meet the challenges facing education systems: modernizing pedagogical methods; enhancing the professional profile of teachers; ensuring transitions from secondary to tertiary level; promoting partnerships between schools, universities and industry; and improving female participation in MST studies and careers.

This report shows that two actions are at the heart of the drive to make MST studies and professions a more popular option for young learners: the development of effective and attractive MST curricula and teaching methods, and improved teacher education and professional development. Some countries (the Netherlands, Norway, Ireland, Israel, Switzerland, and Italy), have implemented national strategies and others have set up dedicated national, regional, or local centres (Norway, Finland, Sweden, the Netherlands, Switzerland, Denmark, the Czech Republic, Portugal, Spain, and Ireland). These centres aim to improve the quality of MST teaching, and sometimes more particularly, to increase science and technology's popularity (also achieved through campaigns and competitions). This holistic approach usually includes all MST subjects, covers the lifelong learning span and involves the government, educational sector and industry. Public-private partnerships are an important feature of these all-encompassing approaches, aimed at developing a sustainable scientific culture which is deep-rooted in society. Other common approaches are to establish networks⁶ of teachers and teacher trainers, as well as other relevant stakeholders, and to implement curricular reform and initiatives favouring inquiry-based learning (e.g. cross-disciplinary, thematic or project work). In some countries, extra time, funding and smaller student groups enable more hands-on MST activities in laboratories and outdoors.

Most countries have invested in teacher training in how to use innovative methods, digital resources and tools in MST teaching, often via eLearning, either for all MST teachers, or mathematics teachers (as a consequence of students' low mathematics results in PISA) or science teachers only. Large

scale in-service teacher training programmes devoted particularly to the teaching of experimental science can also be seen in some countries. Some countries have provided teachers with laptops as a way of increasing their confidence to use ICT based tools in their teaching. The transition from school life to working life is an important aspect of several of the initiatives mentioned in survey responses. One approach is to invite MST professionals or university students to schools to encourage younger learners' interest, while another is to enable teachers and students to visit MST work places. In terms of gender-related issues, national policy action plans to ensure equal opportunities for boys and girls across the education system exist in some cases, and other actions include workshops or summer schools for primary and secondary level female students, a role model approach whereby female MST teachers are matched to female students, and testimonial websites where MST professionals share their career paths with students.

ICT is valued by all countries for its ability to diversify the learning process and make the study of MST subjects more attractive. It is considered to have added value for teaching MST subjects as it facilitates collecting, recording and analyzing data; enables students to carry out safe and quick experiments not otherwise possible in the classroom due to lack of equipment or risk of danger; the simulation and visualization of 3D structures in science; and modelling in mathematics. Although all countries stated that ICT is used in the teaching of MST subjects, the extent to which this happens in practice varies, owing to a lack of computers, teachers' critical attitude, or their unwillingness to change traditional habits.

The majority of the initiatives and reforms identified have only been in place for a limited period of time, and therefore no evaluation is yet available, although sometimes planned. It would be of great value for countries that have not yet planned evaluations of the various initiatives and reforms in place to do so, and those that have, to make the results public when available. This first analysis attempting to give a European overview is inevitably limited as it is based on the survey results of only 16 countries. An analysis examining additional countries would enable a more comprehensive overview and a richer comparison. We look forward to further information from additional countries to integrate into a regularly updated version of this report in the future. Potential synergies with the work of the European Commission's MST cluster are also to be considered within the framework of European Schoolnet's follow-up of developments in the MST field.

INTRODUCTION

Since the Lisbon agenda was launched by the European Council in 2000, a lot of attention has been focused on Europe's need to foster a dynamic and innovative knowledge-based economy, not least by producing an adequate output of scientific specialists. In the light of the current economic crisis, this statement has renewed relevance. To achieve this goal we need to increase participation in Mathematics, Science and Technology (MST) studies and careers, especially the number of women. To help Member States achieve this objective, the European Commission established a Maths, Science and Technology Cluster (a group of countries sharing a common interest in this topic as a national policy priority), in 2006, to facilitate peer-learning and development in this area. Through Peer Learning Activities (PLAs), the voluntary members of this cluster exchange information on different policy options thus helping to advance reform in their own countries. 7 of the 16 countries that answered European Schoolnet's questionnaire on national measures, aimed at dealing with MST issues, are also members of the MST cluster, namely: Denmark, France, the Netherlands, Norway, Portugal, Sweden and the Slovak Republic. The priorities of this cluster, and indeed of all the countries who responded to the questionnaire, albeit to varying extents, are: modernizing pedagogical methods; enhancing the professional profile of teachers; ensuring transitions from secondary to tertiary level; promoting partnerships between schools, universities and industry; and improving female participation in MST studies and careers.

This short comparative analysis is based on the voluntary information provided in answer to European Schoolnet's questionnaire (available in the annex of this report) on national measures to increase students' interest in pursuing MST studies and careers' sent to all European Schoolnet (EUN) members in October 2009. The questionnaire mainly consisted of open questions and was organized in two sections: Part A concerning national measures, and Part B concerning MST priorities at European/international level, and related initiatives developed by countries. 16 of European Schoolnet's 31 member countries provided completed questionnaires: Italy, Switzerland, the Netherlands, Turkey, Spain, Norway, France, Portugal, Finland, Estonia, Denmark, the Czech Republic, Israel, Sweden, Ireland and the Slovak Republic. Relevant references to international and national reports, evaluations, policy strategy documents, manifestos and websites are provided in English⁷ where possible, and if not available, in the original language indicated. Where appropriate, the analysis has been supplemented with extra information provided in the European Commission's MST Cluster reports⁸. This current report focuses on describing examples of initiatives taking place in each country from a comparative perspective, and does not provide an exhaustive list. The report consists of the following 7 sections: global MST national strategies, dedicated centres to improve the quality of MST teaching, curricular reform and inquiry based learning, strengthening teacher training and professional development in MST, guiding students towards MST careers, increasing the participation of women in MST careers, and the use of ICT in MST teaching.

MST PRIORITIES

Issues related to the teaching of MST subjects were considered of highest priority by most countries, when asked to rate in order of importance a series of MST issues (based broadly on the concerns listed above of the MST Cluster).

The development and implementation of inquiry-based learning methods, together with the need to improve teacher education in this area were rated as top priorities. Other aspects related to the teaching of MST were also rated highly, including an effort to focus teaching on the socio-economic aspects of science, as well as integrate the use of ICT. This is a clear indication that the countries who answered the questionnaire are in line with education research in general, which suggests that the quality of teaching has the largest impact on the improvement of students' performance and motivation in any subject⁹. Career guidance and gender balance were considered less of a priority by most countries, but it should be noted that these issues are partly addressed in measures that focus on teaching methods and materials, and there is some evidence of specific initiatives targeting these areas. All these issues are clearly interrelated which explains why many of the initiatives listed by national respondents are multi-faceted, and while they may deal with one or two issues more explicitly, they necessarily have an impact on others also¹⁰. According to the information gathered for this analysis, the development of effective and attractive MST curricula and teaching methods, together with improved teacher education and professional development are at the heart of the drive to make MST studies and professions a more popular option for young learners¹¹. The majority of one-dimensional initiatives focus on one of these issues, and all multi-dimensional national strategies have one or both of these issues at their core.

1. GLOBAL MST NATIONAL STRATEGIES

Almost 75% of all country respondents¹² have a global approach in place to deal with MST issues at national level. Such approaches take the form of a national strategy and/or the setting up of dedicated national and/or regional centres. This holistic approach in most cases addresses all MST subjects, covers the lifelong learning span and involves the government, educational sector and industry. Public-private partnerships are involved, and students, teachers, and society at large are targeted. An important element of such national strategies is the aim to change societies, and particularly young people's perception of the MST world, by fostering a more positive attitude. The rationale behind this encompassing approach is to ensure that the development of a scientific culture starts from a young age and is sustainable to meet society's future requirements for more scientifically and technologically skilled workers.

The **Dutch** Ministry of Education and Science has implemented such an approach through its *Delta Plan Science and Technology* (2004-2010) aimed at promoting science and technology education to increase future skilled employees capable of contributing to innovation. This policy action plan is intended to tackle the country's shortage of scientists and engineers in the years to come. The *Delta Plan* is divided into five sub-programmes each targeting different levels and types of education and preparation for working life. A crucial instrument of the *Delta plan* is the *Beta Techniek Platform* (Science and Technology Platform), which has the task of increasing enrolment in, progression through and graduation from science and technology subjects. The platform has developed various programmes targeted at different sectors of education and the labour market, which give schools, institutes, training centres, universities and businesses the opportunity to collaborate together and take control of implementing their objectives in the MST field. The platform was commissioned by the government, education and business sectors to give concrete support to organizations working on innovation in this area, and offers advice, monitoring and auditing, expert meetings and focus groups. The platform is also dedicated to knowledge development and sharing in the MST field, and supports action-driven research as well as providing an online knowledge bank. To continue this holistic approach beyond 2010 a Master Plan¹³ was published in November 2009 by the Beta Techniek Platform and the Science and Technology Think Tank. The Master Plan is a response to the Manifesto '*Room for Talent! Room for Science and Technology!*'¹⁴ published in November 2008, which called for the need to develop scientific and technological talent, not only for the benefit of every individual child, but society as a whole. It outlines a strategy for implementing the Manifesto's goals during the period 2011-2016, and aims to offer all children aged 2-14 the opportunity to develop their talents for investigation, reasoning and problem solving.

Norway's similar global, national strategy, *Maths, Science and Technology for the Future (2010-2014)*¹⁵ is aimed at strengthening MST competence from kindergarten all the way through to a person's working life. Very much like the Dutch approach, Norway's lifelong strategy is intended to increase synergies and cooperation between education and the world of work, so as to positively impact on recruitment to the MST professions. The strategy's objectives spread across the priority issues shared in part by most European countries, including improving the quality of MST teaching and teacher training, as well as encouraging gender balance and career

choices in this area. Norway's current strategy was developed on the basis of two earlier national MST strategies (2002-2007 and 2006-2009). According to the evaluation of the first strategy, the more qualified teachers are, the more impact they are likely to have on the motivation and attitudes of students. As a result of this evaluation, the subsequent strategies include indicators to measure to what extent goals are met, and focus on improving teachers' formal qualifications. Through the *National Forum for Maths, Science and Technology*, national and local education authorities, education providers, industry and social partners take a joint responsibility for implementing the strategy and achieving its goals.

Ireland's *Discover Science & Engineering (DSE)* programme was developed in response to the key recommendation of the Task Force on the Physical Sciences for a coordinated effort to increase interest in science and encourage young people to consider science as a viable career option. DSE was therefore launched as the national integrated awareness programme for coordinated science promotion in October 2003. DSE brings together many science, technology, engineering and mathematics (STEM) awareness activities that were previously managed by different bodies, public and private. These include STEM career guidance, primary level teacher training and provision of teaching resources¹⁶, as well as projects to promote the teaching of specific areas of STEM, such as sensor technology. DSE aims to build and expand on these activities and to deliver a more focused, strategic and quantifiable awareness campaign for STEM. The target audience for DSE includes students at all levels, their parents and teachers, as well as the wider public. DSE also collaborates closely with industry, the media and other relevant institutions. DSE's mission is to contribute to Ireland's continued growth and development as a society that has an active and informed interest and involvement in STEM. Its overall objectives are to increase the numbers of students studying the physical sciences, promote a positive attitude to careers in STEM and to foster a greater understanding of science and its value to Irish society.

Encompassing national approaches, albeit with a narrower scope, can also be seen in Israel, Switzerland and Italy, where efforts are invested in school level, formal (and in the case of Israel also non-formal) education, rather than spread out across the lifelong learning span.

Israel's *Scientific and Technological Reserves* programme initiated by the Ministry of Education is undergoing a pilot in the year 2010/2011 whereby students participating follow the normal school curriculum with an additional supplementary programme focused on strengthening and enriching the mathematical, scientific and technological content of the existing curriculum. The aim is for the programme to reach 25% of secondary school students in order to help resolve the problem of a relatively small share of students in Israel excelling in science and technology, limiting the country's competitive position on the global map. Schools taking part in the programme receive extra budget for employing the additional teachers/hours required, providing training for the participating teachers, and extracurricular activities taking place outside of school and other enrichment initiatives included in the programme. The programme aims to detect and challenge students with potential to excel in the MST area as early as possible; target students with lower socio-economic backgrounds

by giving them equal opportunities; and encourage girls to participate particularly in the areas of physics and technology. Concretely, the programme's goals are to: increase the number of students who receive a baccalaureate with a strong science-technology component by roughly 78% and reach 25,000 such students in five years; to increase the share of students who receive a quality baccalaureate of science-technology by 100% and reach 18,000 such students in five years; and to increase the share of students who receive an excellent baccalaureate of science-technology by 100% and reach 6,000 such students in five years. Examinations are an integral part of the programme, and students wanting to continue on the programme must receive grades which are one standard deviation higher than the national average in relevant curricular subject examinations. The programme has a national scope, but will initially prioritize the regions of the North, South and Jerusalem as they have a larger proportion of disadvantaged students. Every school which applies must have a good quality ICT and science infrastructure, be recognized by the Ministry of Education and owned by a local authority or non-governmental organization in order to qualify for the programme. Once the pilot is complete, the current programme will be extended until 2016.

Israel's *Young Friends of Science*¹⁷ initiative is a framework for cooperation between the higher education sector and the Ministry of Education focused on non-formal education in science and technology. Several activities, including after school classes, out of school seminars during school time, special projects and research workshops as well as summer camps¹⁸, are all offered in any topic or subject within the MST area to secondary school students. These activities take place at the units for *Young Friends of Science* at participating universities, colleges and research centres. The overall aim is to increase students' interest in MST studies and professions by establishing direct contact between school students and expert universities and research centres specialized in the field.

In **Switzerland**, a policy measure for the *Promotion of young scholars in the fields of maths, science and technology* has been put in place (2008-2011). This policy measure focuses on private-public partnerships between the education sector and industry¹⁹ and is meant to bundle various existing initiatives, create synergies between projects and boost new initiatives for the promotion of MST careers. The policy measure is intended to address Switzerland's lack of skilled workers in industry, particularly in the field of ICT. The majority of Swiss students opt for non-MST based studies and careers, with a very small proportion of women²⁰ choosing to pursue technically oriented professions. This measure aims to involve teachers, teacher trainers, industry and particularly women in innovative partnerships to promote MST careers. Through the measure's *Matching Platform MNT* partners can communicate and exchange information regarding initiatives aimed at the promotion of young scientists.

To tackle MST issues on a national scale, **Italy** has set up an *Inter-departmental working group for the development of a scientific and technological culture*. The working group was established in 2006 on the basis of an agreement between 4 state Ministries: the Ministry of Education, the Ministry of Universities and Research, the Ministry of Cultural Heritage, and the Ministry for Reforms and Innovation within Public Authority. Its mission is to support and enhance Italy's scientific and technological culture, and like the Dutch, Norwegian and Swiss approaches places a strong emphasis on the need to foster public and private partnerships within education.

Indeed, one of its initiatives has been to introduce a competition aimed at improving pupils' scientific competencies, in which networks of schools have to work in partnership with universities, museums and research centres using interactive didactics. Among its tasks also, are the definition of structural actions for schools²¹ and society at large, and providing support for teacher training and the development of ICT within the curriculum. The working group focuses on teachers and students from primary school through to the end of secondary school, and is concerned with all MST subjects within the curriculum.

2. DEDICATED CENTRES TO IMPROVE THE QUALITY OF MST TEACHING

2.1 Centres focused on supporting and improving MST teaching

Some countries, as part of their national approach to dealing with MST issues, have set up national and/or regional centres specifically dedicated to support and improve MST teaching. Establishing networks are an important feature of such centres, whether they include teachers, ambassadors, partners or local annex centres, their aim being to ensure MST efforts are sustainable and live on by embedding them into the nation's culture.

The *Norwegian Centre for Mathematics Education* (set up in 2002) and the Norwegian Centre for Science Education (set up in 2003), support schools and other stakeholders by implementing initiatives focusing on the curriculum, equality and outreach activities, developing teaching materials and training, and producing and maintaining magazines, websites, annual conferences and seminars for teachers. The mathematics centre has a network of resource teachers, while the science centre has a network of ambassadors involved in the in-service training of science teachers. The science centre also has a major focus on research in science education, and this research feeds into the in-service training and support offered by the centre to teachers and schools.

Since 2004, **Finland** also has a national MST centre named LUMA²² (LU standing for 'lunnontieteet' meaning the natural sciences in English, and MA standing for mathematics). The LUMA centre is an umbrella organization coordinated by the University of Helsinki's Faculty of Science, and supported by the Ministry and National Board of Education. The LUMA centre brings schools, teachers, education students, universities and industry together to promote and enhance the learning and teaching of the natural sciences, mathematics, computer science and technology at all education levels. The centre is dedicated to providing new teaching materials, equipment, events and training opportunities to its stakeholders at national level.

Sweden has 4 resource centres²³ for teachers, funded by *Skolverket*, the Swedish National Agency for Education, which each focus on a different area in the MST field (Physics, Chemistry, Biology and Technology). The resource centres provide in-service teacher training, various teaching materials, newsletters, conferences and other relevant pedagogical resources.

The **Dutch** Freudenthal Institute for Science and Mathematics Education²⁴ (FIsmE) aims to improve education in the fields of arithmetic, mathematics, and the sciences, with a focus on primary, secondary and vocational education. The Institute contributes towards this aim through research, teaching, curriculum development and other services.

In **Switzerland** the *MINT (Mathematik, Informatik, Naturwissenschaften und Technik)* Learning Centre at the Swiss Federal Institute of Technology (ETH) was established in 2008 to develop teaching methods, learning objects, programmes and curricula for the teaching of non-life sciences²⁵ throughout primary and secondary education²⁶. Its mission is to develop quality teaching material and methods for teachers from primary and secondary schools, as well as vocational institutions, to improve students' applied knowledge of these subjects and prepare them for science-based studies and professions. In-service teachers develop new tools and then test them in their schools, providing feedback to improve the centre's outputs. Collaboration with science and technology foundations as well as industry takes place when relevant.

Even more recently, in 2009, **Denmark** has set up a similar *Centre for teaching Science, Technology and Health*, which is larger in scope by targeting all MST subjects and age-groups from kindergarten to university. The centre plans to collaborate with private and public companies, universities, museums and other relevant science centres, as well as schools, and to develop a network of relevant partners. Denmark's national centre is intended to be a central resource hub to collect, coordinate and spread best practice in MST teaching, and is aimed at improving the quality of teaching in this field and attracting more students to MST careers. *Naturvidenskabernes Hus* (House of Natural Sciences or NVH) is another newly opened science center which develops tools and techniques for science teaching, intended to motivate students to pursue further studies and careers in the MST field. This centre also provides in-service training for teachers and facilitates contact between schools and companies, in order to build partnerships.

2.2. Centres, campaigns and competitions to popularize science at the level of society

Other dedicated centres also exist in the Czech Republic, Portugal, Spain, the Slovak Republic and Denmark, and although the improvement of MST teaching is part of their goal, their focus is more on the popularization of science at the level of society, to ensure that every citizen is aware of its relevance so that it can become an integrated part of culture.

The **Czech Republic's** *IQ Park*²⁷ and TECHMANIA are both centres with various interactive ICT instalments, aimed at popularizing science and technology for everyone, particularly children. Additionally, the Czech Ministry of Education's initiative entitled *Support for Technology and Science Fields* (<http://ipn.msmt.cz>) also aims at popularizing MST subjects, to increase their take-up for further study at university and other higher education institutions. The project has three major pillars of activity including motivational activities, science communication and teacher support. The project provides methodological support for teaching

science and technology education, promotional materials, as well as analyses and case studies presented at conferences, seminars, workshops, and promotional talks.

Portugal's *National Agency for Scientific and Technological Culture, Ciencia Viva*, was set up in 1996 to promote public awareness of science and technology. The agency organizes work experience placements for secondary students in science laboratories, a Science and Technology Week, debates with scientists and other awareness raising events and activities for the general public. It also has a special school programme to support and stimulate the hands-on teaching of science, helping schools with the practical activities involved in their science and technology projects.

Similarly in **Spain**, FECYT, the *Fundación Española para la Ciencia y la Tecnología* which belongs to the Ministry of Science and Innovation, co-funds various activities developed at the local, regional and national level through a call open to schools, museums, city councils, research centres etc. Examples of funded activities include the regional fairs, such as Madrid es Ciencia which involve schools participating as visitors, as well as exhibiting their own school experiments. Like in Portugal, Spain also has a *Semana de la Ciencia* (Science Week), initiated by FECYT and implemented regionally by each Autonomous Community.

Similarly, the **Slovak Academy of Science** has a Science and Technology Week campaign which takes place annually in November, in conjunction with the conference about teaching and learning science and technology in secondary schools and the competition *Scientia Pro Futuro*²⁸. Since 2007, the Ministry of Education, Science, Research and Sport has been organizing the Science and Technology Week in cooperation with the *National Centre for the Popularisation of Science and Technology in Society* annually. Moreover, the Science and Technology week is part of a global strategy for the Popularisation in Society of Science and Technology²⁹, approved by resolution of the Government of the Slovak Republic.

The Ministry of Higher Education and Research in **France** organizes an annual dedicated week called *La fête de la Science*, which consists in the organization of workshops, exhibitions, visits to laboratories and industrial sites, meetings between researchers and young learners, as well as debates and conferences.

Denmark's *DanskNaturvidenskabsformidling*³⁰ (Danish Science Communication) founded by the Ministry of Education and the Ministry of Science, Technology and Development, is also focused on popularizing science and stimulating interest through its public science events, and the Danish Science Week, involving roughly 40% of Danish schools. The board of this organization consists of leading national representatives from universities, industry, schools, science centres and local governments.

Ireland's *Discover Science and Engineering* programme also organizes in cooperation with education, public, business and regional partners a Science week³¹, a Maths week³² and an Engineering week³³, which are national events gathering between 25- to 100,000 participants each year. Additionally, Discover Science and Engineering, together with Intel and 14 Institutes of Technology are partners in *SciFest*³⁴, a local one-day science fair held in all 14 regional

Institutes of Technology and open to all secondary students. The *SciFest* fair includes a competition and exhibition of projects, a selection of science talks, science demonstrations in the college laboratories and a prize-giving ceremony. *SciFest* aims to encourage a love of science through an investigative project work approach to learning and to provide an opportunity for students to display their scientific discoveries. This national initiative began as a pilot in 2008 and is now an established promotion event of secondary level project work, currently involving 196 secondary schools across the country, displaying 1,097 projects from 2,649 students, and continuously growing. Preliminary evaluation testifies to 99% of students believing *Scifest* to be a “worthwhile learning experience”.

In most countries surveyed, there is a specific effort to popularize MST subjects and professions through campaigns and dedicated MST weeks as described above, or also through competitions, described below.

For example, in **France** there are competitions for secondary level students called *les Olympiades de mathématiques, de physique, de chimie* (the maths, physics and chemistry Olympics), as well as an entertaining maths competition called *Kangourou des maths*.

The **Czech Republic** has similar competitions also called ‘*the Olympics*’ in all MST subjects, organized by the Ministry of Education, Youth and Sports annually, and open to all primary and secondary schools.

Israel also has 11 of its own *OlimpiYeda* MST competitions for secondary school students, including 5 international³⁵ and 6 national³⁶ ones. Between 3- and 6,000 secondary students take part in each of these competitions. The purpose of these competitions is to develop motivated students’ awareness of the importance of these scientific areas of knowledge and to provide them with an opportunity to deepen their learning in an informal framework. The preparation for these competitions takes roughly a year and learning resources are developed which are later used to enrich the formal curriculum of the education system.

In **Estonia**, their national *Competitions for Young Scientists and Inventors* are used as a way to encourage students’ creativity and motivate them to design innovative products and processes.

In **Finland**, various annual MST competitions are set up by universities and other organizations, and supported by the Ministry and National Board of Education. One example is *Tämä Toimii (This Works)*, which is a design competition for young children organized annually by the Federation of Finnish Technology Industries.

2.3. Local specialised centres and municipalities

In addition to their national centres Norway and Denmark have set up other bodies to promote the study and development of MST teaching at a more local level. Portugal, Israel, Ireland and the Czech Republic also have local centres spread across the country to permeate the development of a scientific culture.

In **Norway** 7 science centres have been set up across the country's different regions to support the work of the national *Norwegian Centre for Science Education*. The regional science centres show a significant and steady increase in popularity, with visits having more than doubled since 2003. According to preliminary results from the Norwegian Centre for Science Education's research project *Vilje-con-valg*, 20% of all students enrolling in tertiary MST education in 2008 indicated Science Centres as an important motivating factor, above career guidance provided at school and media campaigns³⁷.

A similar approach has been implemented in **Portugal** where the *Ciencia Viva* agency has set up a national network of 17 interactive science centres with the aim of promoting a scientific culture and improving the awareness and interest of citizens of all ages. The science centres provide the opportunity for scientific, cultural, and economic regional development. In-service training courses are organized to show teachers how they can use the centres to support their science and technology teaching.

Ireland's Discover Primary Science programme coordinates 27 *Discover Science Centres* across the country. These centres are used for school and family visits for their informative, interactive and fun nature. The *Discover Science Centres* community have access to an online forum for discussion and information exchange, and the centres develop various online teaching resources connected to specific topics in the curriculum, covering the areas of living things, energy and forces, materials, and environmental awareness and care.

Sweden also has a series of regional science centres³⁸ which have been receiving government grants since 1997. 14 such science centres received state funding in 2009. The science centres are targeted at teachers, students and the wider community and are committed to spreading knowledge and stimulating interest in the MST field. There are special educational programmes designed for teachers available at the centre, attended by several thousand teachers across the country each year. Many of the centres also arrange outdoor visits and outreach activities to motivate new audiences and the wider public.

Israel's Ministry of Education, the National Lottery and the Center for Local Government have jointly established 80 *Pais Clusters for Science, Technology and the Arts*³⁹ across the country and located near to lower secondary schools. They are community centres which act as learning environments rich in tools for investigation and opportunities for live experiences enabling active and independent learning in the science and technology laboratories available. They can be used within school time as well as for leisure for the benefit of the whole community. The centres allow for multidisciplinary and interdisciplinary investigative learning in 5 multi-purpose laboratories. The students develop innovative projects and there are learning circles, workshops, and ICT based activities. The clusters also serve as in-service teacher training centres.

The **Czech Republic** has a network of special hobby centres for children and young people, set up by local authorities, offering a variety of MST interest groups (such as an ICT club, a programming club, a biology and chemistry club etc.) in almost all Czech towns.

Denmark has also implemented a local strategy whereby 25 of its 98 municipalities have since 2008 become *Science Municipalities*. Each of these Science Municipalities has a mission to strengthen the study of science with the help of a local tailored strategy, science board, coordinator etc. These Science Municipalities are intended to strengthen Denmark's scientific culture by building bridges between compulsory education, post-compulsory education and private and public companies. This initiative has been based on a pilot project (2003-2007) involving one municipality, and is being continuously evaluated by researchers in science didactics, at the University of Copenhagen.

3. CURRICULAR REFORM AND INQUIRY BASED LEARNING

The majority of countries that replied to the questionnaire mentioned that national curricular reform impacting on MST subjects has recently taken place, or is currently or will be soon taking place at primary and/or secondary level.

Israel is beginning in 2010/2011 to revise the science and technology curriculum of primary schools, with the purpose to clearly define the knowledge and skills every student should acquire by the time he/she finishes the final year of primary school. Moreover, the science and technology curriculum for lower secondary students is also being updated and schools are being given more resources to deal with the requirements of this new curriculum beginning in 2010/2011, and eventually to be applied fully to all schools. Despite official recommendations, less time is usually spent by schools on teaching the science and technology curriculum than is suggested. For this reason the Ministry of Education has increased the allocation of weekly teaching hours for science and technology with a minimum of 4 hours per week in the 7th grade and 5 hours per week in the 8 and 9th grade. An important aspect of the newly revised curriculum is that science and technology will be taught in the laboratory with groups of no larger than 28 students. For this purpose each two classrooms will be divided in three groups and schools will receive an additional budget to cover for the of 2.5 additional teaching hours required by the third group.

Thanks to the **Danish** upper secondary school curricular reform of 2005 (focusing more on competencies than content) the role of cross-disciplinary work is developing in importance in the teaching of MST subjects.

In **Turkey**, a new science curriculum has been designed to integrate constructivist and student-centred learning. ICT-based laboratories with hand-held computers and sensors have been built in secondary schools to support the constructivist characteristics of the new science curriculum.

The **Swedish** government is currently reforming the curricula for compulsory level schooling in the *Skola 2011*⁴⁰ reform for students aged between 7 and 16 years old and for upper secondary level schooling in the *GY 2011*⁴¹ reform for students aged between 16 and 19 years

old. The upper secondary curriculum reform is based on recommendations given in the government's report entitled '*Higer standards and quality in the new secondary schools*'. The report states that each course should clarify what content is essential and therefore should be covered in class teaching. This will create fairer conditions than are currently available, as assessment will be strictly based on the content covered in lessons. These reforms are accompanied with the implementation of a new grading system for assessment purposes. All subjects are concerned, including mathematics, physics, biology, chemistry, technology and general science studies. The overall intention is to create curriculum syllabuses with a clearer structure and coherence, and to raise pupils' interest and achievement at school. The new curriculum will come into force in the autumn term of 2011.

Switzerland's ongoing *Bildungsstandards* inter-cantonal project⁴² aimed at harmonizing cantonal school curricula has also given a special priority to MST subjects.

Finland has recently set up a working group proposal for a renewed curriculum. All curriculum subjects will now be part of one of six clusters, including one cluster on mathematics and another comprising all remaining MST subjects. The importance of using technology will also be more present in the teaching of all MST subjects.

In **Ireland** key curriculum developments include the re-introduction of science teaching in primary schools in 2002, the introduction of points for science project work in the Junior Certificate in 2006, and the piloting of project work in Maths fostering a more inquiry based approach from 2008 which has in 2010 commenced its full roll out to all secondary schools.

In the **Czech Republic's** reform of primary and secondary school curricula, MST subjects are now taught under thematic headings, such as 'Man and Nature' (including physics, chemistry, biology, geography and geology) and 'Man and the World of Work' (including technology), and there is an emphasis on increasing the pedagogical autonomy of teachers, and supporting them to use new and innovative methods. The Czech Republic also currently has a national curricular project called "Literacy Support" covering five areas including mathematics, science and ICT literacy. The project is an initiative of the Ministry of Education and is being implemented by its Research Institute of Education. The project which focuses on primary education is a reaction to deteriorating results of Czech pupils in the international PISA and TIMSS surveys. The aim of the project is to find out whether the current curriculum adequately supports the development of students' literacy or not. It should also provide teachers with effective methodological support for further development of students' literacy. The project is running in 2010, and recommendations for curricula innovations may follow in 2011.

A special focus on inquiry based learning can be seen in the initiatives and reforms mentioned by France, Portugal, Estonia, the Slovak Republic, Ireland and Norway, while in Finland it has since 2004, been a principle underlying all curriculum subjects, including MST.

France's well known *La main à la pâte*⁴³ initiative focuses on hands-on science, and has been the basis for the reform of science education in primary and lower secondary schools since 2002. The *La main à la pâte* approach is inquiry-based and gets students to develop

hypotheses and experiments to raise interest and motivation for studying the sciences. Students are the key actors and teachers are facilitators. The focus is getting students to investigate real applications of MST to everyday life. This new approach involves teacher training and thorough evaluation. The *La main à la pâte* initiative also cooperates with numerous countries abroad which are actively involved in implementing this teaching and learning method. At secondary level in France the *BAC Professionnel* has been shortened to 3 years instead of 4, and accompanying practical training has been reformed so that a thematic approach has been implemented together with an investigative aspect.

In **Portugal** a curricular reform at secondary level affecting students aged 10-15 has taken place whereby extra time for science lessons has been granted to schools so that students can be split into two groups, allowing each group the opportunity to work in the laboratory and do more hands-on activities⁴⁴.

In **Estonia**, a new curriculum is to be launched in 2011, which gives a strong emphasis to inquiry-based learning. Science lessons will be taught in smaller groups enabling more time and teaching resources to be available for hands-on activities, inquiry-based learning, outdoors learning and problem solving tasks.

In the **Slovak Republic** there are initiatives⁴⁵ focusing on hands-on science teaching, where the method used involves teaching through projects and asking pupils to solve mysteries. The schools involved in these small-scale initiatives claim that this method of teaching increases pupils' interest in problem solving tasks.

The *Discover Sensors*⁴⁶ pilot project in **Ireland** focuses on developing inquiry based learning using ICT. The pilot is being run by the National Centre for Technology in Education and involves the participation of 200 secondary schools.

Norway's *Natural Schoolbag* pilot programme gives schools money to support teachers to teach outside of the classroom, so that more practical, hands-on teaching can take place⁴⁷.

4. STRENGTHENING TEACHER TRAINING AND PROFESSIONAL DEVELOPMENT IN MST

4.1 Online initiatives

Several in-service teacher training efforts are happening via e-Learning.

One such example is the **Italian** national action plan, *Mat@bel*, providing training for mathematics teachers in the format of blended eLearning on the national teachers' *PuntoEdu* portal. The action plan implemented by the Ministry of Education comes as a direct result of the low performance of Italian students in PISA's mathematics tests. For the moment the training is given only to teachers of 11-15 year-olds, but it will eventually be expanded to all education levels.

Like Italy, **Portugal** has also reacted to Portuguese pupils' low achievement in the international survey PISA by implementing an in-service teacher education programme (only small parts of it online however) for mathematics teachers teaching younger pupils aged 6-11. During 2005-2008 approximately 12,600 teachers successfully took part in the training, which is part of an ongoing programme.

Another example of eLearning for teachers is the **Czech** *RVP.CZ porta*⁴⁸. This portal provides teachers with methodological support for increasing the quality of their teaching. Training and resources for in-service teachers focusing on various subjects including MST, are offered through various digital tools, including wiki's, digital learning objects and digital portfolios. The portal is being monitored and at present 28% of teachers are using it.

The **Dutch** *Beta Techniek Platform* has introduced a stimulation programme for MST in-service as well as newly qualified teachers in primary education. The programme aims to reach 5000 in-service teachers and 5000 newly qualified teachers and promotes innovative methods and daily practice examples.

In **Finland**, MST in-service teacher training is subsidized by the government, and through the *Arithmetic, Science, Technology and e-Learning project (ASTeL)* teaching material for physics and chemistry teacher training is available on the internet.

In **Estonia** there is a national programme running from 2008-2013 to train teachers and school administrators in how to use eLearning and advanced ICT tools in the classroom.

Norway's *Programme for Digital Competence*, which ended in 2008, also focused on improving teachers' e-Skills and providing them with digital teaching resources and new methods of working.

Ireland's National Centre for Technology in Education provides primary⁴⁹ and secondary⁵⁰ school teachers with digital content for teaching MST subjects.

4.2 In-service Teacher Training Programmes

The teaching of experimental science has been the subject of in-service teacher training programmes in Ireland, Portugal and Italy.

Ireland's *Discover Primary Science*⁵¹ is a flagship teacher training project under the *Discover Science and Engineering* national programme. The project is run by a partnership comprising of the Ministries of Education and Enterprise and the Irish National Teachers Organization, with industrial partnerships being developed in 2011. Primary school teachers are provided with training, useful online resources and classroom activity packs. Activities include hands-on induction days for teachers which are hosted throughout the country in colleges of education, institutes of technology, universities and education centres. This training programme began as a pilot in 2005 to support the re-introduction of science teaching in primary schools, helping non science specialist teachers to successfully manage the practical

aspects of the exploratory approach used for science and mathematics teaching. The programme is ongoing has evolved into an established network of 4,300 teachers who are provided with support on specific topics (such as mathematics currently in 2010). Over 3,100 primary schools across the country are involved. An annual evaluation to determine the success and future directions to follow takes place. These evaluations have shown that teacher satisfaction has always been high and remains so, and overall participants in the scheme continue to grow. Discover Primary Science also manages the *Awards of Science Excellence*⁵² each year. Schools registered on the Discover Primary Science project can opt to apply for an *Award of Science Excellence*. Schools that register for the award must keep a log of their science activities, and accumulate credit for inviting speakers to the school to talk about science, displaying their work and other explorative activities.

In **Portugal** there is a current in-service primary teacher training programme (2006-2010), aimed at increasing teachers' use of experimental work. Generalizing practical work in school science is one of the Portuguese Ministry's main goals to achieve scientific literacy for all pupils.

Italy's IIS action plan: teaching experimental science was a national in-service teacher training initiative promoted by the Ministry of Education in cooperation with the teachers' disciplinary associations, and the Museums of Science and Technology in Milan and Naples, which took place in 2006-2007. The training was aimed at teachers teaching pupils aged 6-16 and concerned all MST subjects.

Sweden's Boost for Teachers Initiative⁵³, is a much wider government initiative aimed at further educating teachers and raising their status. The continuous professional development programme within the initiative covers all subject areas, including MST, and is implemented by the Swedish National Agency for Education, *Skolverket*, in partnership with various universities. It aims to raise the competence of qualified, practicing compulsory and upper secondary level teachers in order to better support students attain their learning goals. Through this continuing professional development for teachers, school organizers have the opportunity of strengthening teacher's competence, both in the theory of their subject and pedagogical approaches to teaching. The organizers receive 56 percent of the cost of a teacher's average salary as a state grant, allowing teachers to receive at least 80% of their salary whilst studying. Both national and international examinations show that students' performance has deteriorated in several areas, and the national evaluation of compulsory school (NU-03), conducted by the National Agency for Education, found it has lowered since the analysis was conducted in 1992 and 1995. This teacher training initiative is therefore based on evidence coming from research and evaluations illustrating that educated teachers with up to date knowledge and skills are a prerequisite for improving student achievement. A survey questionnaire carried out by the National Agency for Education in 2008 shows that the majority of teachers consider they have increased both their subject knowledge and enhanced their pedagogical competence as a result of the programme. Most teachers state that they either have or will be changing their approaches to teaching and learning in MST subjects (as in others) as a consequence of this professional development. During the period

2007-2011 the programme will provide 30,000 teachers with: the choice of 200 courses at higher education level in both subject theory and educational pedagogy; the opportunity to choose regular courses provided by universities; the exchange of views and experience with other practising teachers; opportunities to study using distance technologies; and courses available in various part time modes or full time. The competence development training programme for teachers has been evaluated and the report⁵⁴ is available in Swedish.

Sweden also has an initiative, *Matematiksatsningen*⁵⁵, which consists of a government grant available to state and independent school principals to invest in development projects and training to enhance the quality of mathematics teaching at compulsory school level, during the period 2009-2011. The national evaluation of compulsory school NU-03 showed that mathematics teaching is not excelling as teaching and discussion has been reduced and individual work has increased. The study also indicated the need for teaching time to be used in a more constructive way in order for students to develop their maths skills more effectively. Moreover, the analysis of the results of the TIMSS international assessment in 2007 shows that many Swedish students make systematic errors in calculation procedures that need early detection and processing. The aim of the government grant, together with the provision of teaching support materials from the *National Centre for Mathematics Education* at Göteborg University, is to stimulate and strengthen the schools' own development efforts to enhance the quality of mathematics teaching. Many of the development projects use modern technical tools such as interactive whiteboards and laptops in their attempt to improve teaching effectiveness. The initiative will be evaluated by several universities in terms of its success in increasing the number of students leaving school with at least a passing grade in mathematics.

Sweden also has a specific policy measure entitled *NTA - Naturvetenskap och Teknik för Alla* (Science and Technology for All)⁵⁶ which is a school development programme run jointly by the Royal Swedish Academy of Sciences and the Royal Swedish Academy of Engineering Sciences in cooperation with municipalities throughout Sweden. In the participating municipalities, NTA provides support for local development of the curriculum in primary level science and technology. The programme is currently primarily aimed at classes from kindergarten through to 7th grade (children aged 13 years old) but will be expanded to cover all grades of compulsory school. NTA aims to stimulate interest in science and technology, to enhance scientific literacy, and to encourage more young people to choose an education which leads to careers in science or technology. NTA started in 1997 and has been financed by the Ministry of Education and Science and by different private funds. This Swedish measure is again based on evidence from international reports such as the Rocard report, which emphasises the need to develop science and technology education in the early years of schooling. Swedish primary school teachers, like in many other countries, are not necessarily specialists in science and technology, having various other disciplinary backgrounds. This measure therefore particularly targets these teachers needing support in providing interesting and effective lessons in these fields. The overall aim of the initiative is to provide the government with a knowledge base for deciding a future position on investments in science and technology in early year's education.

4.3 Updating teachers' ICT skills

The ongoing curricular reform in the **Slovak Republic** has marked ICT competence as a key competence for all pupils since 2008. To make this a reality, there is a need to ensure that ICT teaching is up to standard. To meet this need the Ministry of Education in cooperation with 5 faculties of different higher education institutions has implemented the *DVUI national training for 1500 informatics teachers* from the period 2008-2011, involving each teacher receiving a notebook for learning purposes.

Portugal has a similar national initiative, whereby school teachers at all levels are offered the possibility of buying laptops at special prices in order to promote their confidence and use of ICT-based tools in their teaching⁵⁷.

To start monitoring teachers' progress in the **Slovak** initiative, the National Inspectorate of Education has carried out an initial ICT focused inspection in sample schools at all education levels, throughout the country in 2008-2009. Evaluation reports have been made on the basis of the school observations and on the questionnaire responses of head teachers and teachers, and future policy making in this area will be based on this evidence.

Turkey is another country in which curricular reform has instigated new developments in teacher training. Initial teacher training institutions have adapted their training programmes according to the new Turkish science curriculum, and in-service teacher-training has been provided by the Ministry of Education to help teachers integrate new ICT-based science laboratories⁵⁸ and the education portal into science teaching.

5. GUIDING STUDENTS TOWARDS MST CAREERS

The transition from school life to working life is an important aspect of several of the initiatives mentioned by various countries. In order to encourage students to choose MST careers, they need a better idea of what working in the MST professions is actually like. Countries have taken different approaches to meet this need. One approach is to invite MST professionals or university students into schools to work with teachers and students, while another is to allow teachers and students to visit MST work places. An online platform dedicated to MST career guidance is an alternative that has been opted for.

In **Norway**, a pilot programme entitled *Teacher II – a support from working life* is currently taking place (2009-2010), involving representatives from industry coming into 40 schools and teaching alongside the ordinary teachers in special parts of the MST curriculum. This initiative has the goal of making teaching more up to date and relevant to the current MST world of work. It also allows students to see how MST subjects are used in industry, and brings a taste of working life into the classroom.

In a much wider programme with a similar aim, **Israel's TaasiYeda** (Industry Knowledge) initiative has been implemented in the school year 2010/2011 in partnership between the

Ministry of Education's Administration for Science and Technology and the educational branch of the Manufacturer's Association of Israel, *TassiYeda*. The initiative's goal is to increase students' and teachers' acquaintance with the actual activities of the industry in Israel, through a variety of means. These include partnerships between schools and industry, specific workshops and programmes on the application of MST learning to everyday work in industry, as well as competitions and practical study visits to industrial plants. This large cooperation programme also aims to bring managerial know-how from the industrial sector to support school principals through its special sub-programme, Manager adopts a Principal, whereby a dialogue between industry managers and school directors is established. The purpose is to help the educational system to generally progress successfully and in particular in the disciplines of science and technology. The application of technologies and advanced management methods from industry will concretely be implemented through 80 pairings of managers and principals together with 12 workshop meetings and lectures, alongside interpersonal dialogue.

In **Estonia** since 2007 there has been a national initiative called *Science Bus tours* to Schools involving groups of university students organizing science activities and discussions in schools for students. The initiative's main goal is to increase students' interest in and awareness of the possibilities to study MST subjects at university level and beyond. So far over 300 schools have been involved and responses from students have been positive. There is a high demand for other schools to take part in the initiative. Similarly, the Estonian ICT Roadshow was a campaign involving university students encouraging school pupils to take up ICT studies and careers in 2006-2008, organized together with the private Association of Information Technology and Telecommunications. Additionally, the *Õpikodade Programm*⁵⁹ (Science Workshops Programme) is the most recent national initiative implemented in Estonia in 2010 to encourage upper secondary school students aged between 17 and 19 years old to continue further studies and careers in the MST field. Teams of science specialists and professionals organize monthly special science activities and courses in regional centres located in schools across the country. The workshops are open to every student, and the initiative is being run by the Ministry of Science and Education in cooperation with the Estonian Physics Society of the University of Tartu. Currently 1,400 students are participating in this Estonian programme, and the preliminary responses from students and teachers alike are very positive. This has resulted in a high demand for students to attend from schools especially where there is a lack of qualified MST teachers.

In **Finland** rather than organizing for MST higher education students or professionals to come into the school, there are programmes in place allowing teachers and students to visit industrial organizations to increase their knowledge of MST professions.

Switzerland's *SimplyScience* web portal (<http://www.simplyscience.ch>) includes a career guidance platform targeting students aged 12-16, and covering all MST areas. In future the platform will also cater for age groups below 12 and above 16, vocational education, teachers, and career consultants. Boosting young learners' dwindling interest in MST subjects is the main objective of Simply Science. The platform will be expanded in future to include technology and engineering sciences. The *SimplyScience* web portal was initiated by SGC1 Chemie Pharma Schweiz, the Swiss association of chemical and pharmaceutical companies.

6. INCREASING THE PARTICIPATION OF WOMEN IN MST CAREERS

Switzerland, the Netherlands, France and Norway have initiatives targeted at increasing the participation of girls in MST careers.

In September 2009, the foundation **Swiss Science and Youth**, in cooperation with the University of Basel offered a workshop for girls aged 10-13 on various MST topics, with a view to raising awareness of gender roles in this area, and increasing interest. On the 12th of November of each year, school girls in Switzerland have the possibility of accompanying one of their parents to work, in the 'take-your-daughter-to-work day'⁶⁰ annual project, which has been very successful over the last nine years. As part of this project they can also take part in a national programme which introduces them to professions in the technical sector and computer sciences, usually mostly filled by men. More than 10,000 girls have taken part in the project so far⁶¹.

The Emancipation Department of the **Dutch** Ministry of Education and Culture has launched a policy measure involving the development of special projects to get girls interested in MST. The Netherlands are also beginning to try a role model approach, whereby female MST teachers are matched to female students to inspire them to take up MST careers. Another Dutch initiative using a testimonial approach is a website where mathematics teachers provide information about their own personal paths leading to their careers in mathematics⁶².

France has a similar website, *Elles en Sciences*, dedicated to the testimonials of women working in the MST sector, targeted at secondary and university level students, their parents and teachers. Gender issues related to MST is a particularly high priority in France where an inter-ministerial covenant has been set up for the period between 2006 and 2011 to promote equal opportunities between girls and boys in the education system. The covenant states that the proportion of girls choosing to follow the scientific and technological strands of study in the final years of secondary education should be increased by 20% by 2010. Additionally, France has various competitions and financial prizes to encourage women to enter the MST professions. For example, the national competition *Conjugez les métiers du bâtiment au féminin!* organized by CAPEB⁶³, with the support of the ministries in charge of equality and education, is open to students aged 15-16 who are required to design projects on the theme of women in the construction professions. *Le prix de la vocation scientifique et technique des filles (PVST)* is an example of an annual grant of €1,000 awarded to 650 students in their last year of secondary education who decide to go on to study MST subjects at higher education level, in areas with very few female students.

Norway also has an Action Plan for Gender Equality across the education and training system, and a part of this action is focused on increasing the number of girls choosing to study MST subjects.

Swedish school boards since 1985 and for the last year in 2010 have been providing grants for *Teknik för Flickor*⁶⁴ (Technology for Girls) summer schools. School principals from both municipal and independent schools can use this funding to send female students of compulsory school age (between 6 and 16 years old) to a summer school lasting a minimum of one week and involving at least 5 students. The purpose of these technology summer schools is to encourage girls' interest in studying and pursuing a career in the natural sciences and technology fields, to strengthen their confidence in working in these areas, and to ensure that their involvement in MST can benefit them as individuals as well as society and the environment as a whole.

7. THE USE OF ICT IN MST TEACHING

Roughly half of the countries surveyed state they only have general statutory documents detailing how ICT should be used throughout the school curriculum, whereas in Finland, Norway, France, Denmark, Spain and Portugal, specific guidelines are given for its use in MST teaching and learning.

ICT is generally valued by all countries for its ability to diversify the learning process and make the studying of MST subjects more attractive. Several reasons are given for the added value of using ICT for teaching MST. These include: collecting, recording and analyzing data; allowing the possibility to carry out safe and quick experiments otherwise not possible in the classroom due to lack of equipment or risk of danger; simulation and visualization of 3D structures in science; and modelling in mathematics. Countries also mention the more general learning benefits associated with ICT, also applicable to MST subjects, including: the ability to display information in different formats (such as graphs and pie charts); access to the internet and multimedia digital content; sharing information online through collaborative web environments; allowing more active and self-regulated/personalized learning; and allowing students to practise repeatedly. Incorporating ICT into MST teaching and learning is also highly rated for providing students with the latest e-skills and opportunities for international networking, needed for effective participation in today's globalized world.

Roughly half of all countries surveyed state that there are general statutory documents detailing how ICT should be used for teaching and learning throughout schooling, but no specific guidelines for the use of ICT in MST subjects. The opposite is the case for the following countries, including: Finland, where guidelines to this purpose are given in the national core curriculum; Norway, where the use of ICT is detailed in the competence aims of each subject at every level in the new *Knowledge Promotion* curriculum; Sweden, where similarly subject specific ICT competences are integrated into each subject in the new curricula for compulsory education (7-15 year-olds) and upper secondary school education (16-19 year-olds) to be enforced in the autumn term of 2011; France, where there is a chapter on the use of ICT in the official programme of each subject; and Denmark, Spain and Portugal⁶⁵ where how ICT should be used is outlined in the methodological recommendations of the syllabus for each MST subject. Moreover, in Estonia and Finland the use

of technology is a cross-curricular theme, which has to be respected in the teaching of all subjects, including MST. In Ireland the integration of ICT in the teaching of all subjects is also guaranteed by its National ICT Framework where the use of ICT is stipulated as a pedagogical method to be used throughout the curriculum. In Norway it is defined as a basic skill to be used throughout schooling, as is the case also in France, where the fourth skill of the *Socle Commun de Connaissances et de Compétences* (Common Base of Knowledge and Skills) is devoted to the use of ICT. The Netherlands is the exception, where no specific ICT objectives or recommendations are given in the country's national education targets, and are not specified in relation to any subject⁶⁶.

ICT is used in the teaching of all MST subjects in all countries surveyed, albeit to varying extents.

In the **Slovak Republic**, ICT use is rare in this area, primarily due to the general lack of computers in schools.

Estonia also claims that while a considerable amount of teachers do use ICT in the teaching of MST subjects, many do not mainly because this would require changing traditional teaching habits and a willingness to leave their comfort zone.

Interestingly in **Finland**, ICT is in fact used significantly more in other subjects (as illustrated by the results of SITES 2006), and MST teachers are said to be very critical about the use of ICT and educational software. This seems to be in direct contrast with Italy, where there is evidence that many MST teachers produce digital learning objects which are collected on the national education portal for the training of teachers, *PuntoEdu*, and made available to all teachers.

CONCLUSION

This comparative overview of the various national initiatives, policy actions and reforms taking place in 16 European Schoolnet member countries demonstrates that increasing students' interest in pursuing MST studies and careers is still very much an issue of importance for Ministries of Education across Europe. The report highlights that these countries are facing the same challenges and are often opting for similar solutions.

The development of effective and attractive MST curricula and teaching methods, and improved teacher education and professional development are at the heart of the drive to make MST studies and careers a more popular option for young learners. The most comprehensive approach is taken by countries that have implemented national strategies and/or set up dedicated national or regional centres to improve the quality of MST teaching and enhance its popularity. This holistic approach usually includes all MST subjects, covers the lifelong learning span, and involves public-private partnerships between the government, educational sector and industry.

National and regional actions identified in the report include curricular reform favouring inquiry based learning, the establishment of networks of teachers and other stakeholders, teacher training, campaigns and competitions targeting students, as well as initiatives encouraging the uptake of MST careers and the participation of women. The long term goal of these different measures is to develop a sustainable scientific culture, deep rooted in society, to ensure Europe's contribution to and benefit from a bright future of scientific and technological innovation.

However, the majority of the initiatives and reforms identified have only been in place for a limited period of time, and therefore no evaluation is yet available, although sometimes planned. It would be of great value for countries that have not yet planned evaluations of the various initiatives and reforms in place to do so, and those that have to make the results public when available. While useful, this first analysis attempting to give a European overview is inevitably limited as it is based on the survey results of only 16 of Europe's countries. An analysis examining additional European countries will however follow this report, within the context of the Spice project as well as European Schoolnet's general work in this area. This follow-up catalogue of MST policy initiatives will be available by the end of 2011 and will enable a more comprehensive overview and a richer comparison to feed into the Spice project's MST Policy and Practice Observatory. Subsequently, we look forward to integrating further national information into a regularly updated version of this report in the future. Potential synergies with the work of the European Commission's MST cluster are also to be considered within the framework of European Schoolnet's follow-up of developments in the MST field.

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ENDNOTES

- 1 Eurydice (2006) *Science Teaching in Schools in Europe, Policies and Research*
- 2 Osborne J. and Dillon J. (2008) *Science Education in Europe: Critical Reflections*:
http://www.nuffieldfoundation.org/fileLibrary/pdf/Sci_Ed_in_Europe_Report_Final.pdf
- 3 Rocard et al. (2007) *High Level Group on Science Education, Directorate General for Research, Science, Economy and Science, European Commission, Science Education Now: A Renewed Pedagogy for the Future of Europe*:
http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf
- 4 The Spice project is a European Commission funded project, under the Lifelong Learning programme, which aims to collect, analyse, validate and share innovative pedagogical practice, particularly focused on inquiry-based learning, whilst enhancing pupils' interest in the sciences. The SPICE project will single out best practice teaching approaches in maths, science and technology, and share them throughout Europe. The best practice criteria will provide guidelines to guarantee the quality and innovative nature of new projects. The Spice project is coordinated by European Schoolnet (EUN) in partnership with Direcção Geral de Inovação e Desenvolvimento (DGIDC) from Portugal and Dum zahraničních služeb MSMT (DZS) from the Czech Republic. See <http://spice.eun.org>.
- 5 Italy, Switzerland, the Netherlands, Turkey, Spain, Norway, France, Portugal, Finland, Estonia, Denmark, the Czech Republic, Israel, Sweden, Ireland and the Slovak Republic
- 6 The Rocard report recommends the development of teachers' networks as being valuable for improving the quality of teaching and stimulating motivation.
- 7 Where footnotes providing references to websites or online/offline reports are given with no language indication, the information is available in English. When the information is not available in English the language it is available in is indicated.
- 8 See <http://www.ksll.net/PeerLearningClusters/clusterDetails.cfm?id=12>
- 9 For example, see: McKinsey & Company (2007), *How the World's Best-performing School Systems Come Out on Top*, http://www.mckinsey.com/client/service/socialsector/resources/pdf/Worlds_School_Systems_Final.pdf, and Hattie, J. (2003, October), *Teachers Make a Difference: What is the Research Evidence?* Paper presented at the Australian Council for Educational Research Annual Conference on Building Teacher Quality, Melbourne
- 10 In other words, it seems logical that the better the quality of MST teaching, the more attractive careers in this area will be to learners, just as the more MST teaching focuses on socio-economic issues of interest to girls, the more likely the gender balance issue in MST studies and careers will be resolved.
- 11 Of course other factors, including making employment opportunities in the MST market more attractive for young people, are also part of this drive.
- 12 Netherlands, Norway, Ireland, Israel, Switzerland, Italy, Finland, Denmark, the Czech Republic, Portugal and Spain
- 13 See <http://www.manifestwt.nl/images/manifest/MasterplanPOdef.pdf> (Full text in Dutch with a management summary at the end of the document in English)
- 14 See <http://www.manifestwt.nl/images/manifest/Manifest-EN.pdf>
- 15 See <http://www.regjeringen.no/upload/KD/Vedlegg/Strategi-%20Realfag%20for%20framtida.pdf> (in Norwegian)
- 16 See *Discover Primary Science Programme* in section 4.2 *In-service Teacher Training Programmes*
- 17 See <http://cms.education.gov.il/EducationCMS/Units/Scitech/TchumMadaim/NoarShocherMada/> (in Hebrew)
- 18 These summer camps offer activities on science and technology which are integrated with subjects from the humanities.
- 19 The private partners involved are: ABB Schweiz AG, Cisco Systems, IBM Forschungslabors Zurich, Lonza AGs, Meyer Burger AG, and OC Oerlikon
- 20 17% of Switzerland's work force are women working in technically oriented careers – a small proportion, very low by international standards.
- 21 The first of the Working Group's actions has been an enquiry into the laboratory equipment in schools. The enquiry analyzed the situation in 11,000 schools, with a more in-depth analysis on a sample of 1,400 schools. The results were presented in May 2008 and suggest that schools need a better supply of equipment and also teacher training in order for staff to be able to use this equipment effectively. The report is available on the Ministry of Education's website at www.istruzione.it.
- 22 See <http://www.helsinki.fi/luma/english/introduction/shtml>
- 23 <http://www.skolverket.se/sb/d/3631/a/12119> (in Swedish)
- 24 See <http://www.fi.uu.nl/en/welcome.html>
- 25 Mathematics, physics, chemistry, computer science and technology

- 26 *Mainly targeted at students aged 7-18*
- 27 *See <http://www.iqpark.cz/en/> and <http://www.techmania.cz/> (in Czech)*
- 28 *See <http://www.tyzdenvedy.sk/information-in-english>*
- 29 *See http://www.minedu.sk/data/USERDATAEN/VaT/veda_technika_ENG.pdf*
- 30 *Other activities undertaken by this organization include Science Team K, a Danish regional development project highlighted by the OECD as best practice, as well as international collaboration projects in association with the European Science Events Association (EUSCEA), of which it is co-founder.*
- 31 *See www.scienceweek.ie*
- 32 *See www.mathsweek.ie*
- 33 *See www.engineersweek.ie*
- 34 *See www.scifest.ie*
- 35 *The International Olympiad on Computer Science; The Asian Olympiad and the International Olympiad on Physics; The International Olympiad on Mathematics; The International Competition for Young Scientists*
- 36 *Competition Olympi Da (Olympiad Knows); Competition on Biology; The Shalhevet Fraier Physics Competition; The Olympiad on Astronomy and Space; The Mathematics Competition by mail*
- 37 *See <http://www.regjeringen.no/upload/KD/Vedlegg/Strategi-%20Realfag%20for%20framtida.pdf> (in Norwegian)*
- 38 *See www.skolverket.se/matematik (in Swedish)*
- 39 *See <http://cms.education.gov.il/EducationCMS/Units/Scitech/EshkolotPays/MateHaHala/TafikidHamate.htm> (in Hebrew)*
- 40 *See www.skolverket.se/skola2011 (in Swedish)*
- 41 *See www.skolverket.se/gy2011 (in Swedish)*
- 42 *See <http://www.edk.ch/dyn/12930.php> (in German)*
- 43 *See http://www.ksll.net/Documents/PLA_Renovation%20in%20science%20education_Oct.%2007_final%20report.pdf; <http://www.education.gouv.fr/bo/2000/23/ensel.htm>; http://www.education.gouv.fr/bo/2008/hs3/programme_CE2_CM1_CM2.htm (in French)*
- 44 *It is up to each school whether to use this extra time or not.*
- 45 *For the initiative Vyhrrme si rukavy (Hands on) see <http://pdfweb.truni.sk/vsr/> (in Slovak). For the initiative Krimichemia (Crimichemistry) see <http://vsemba.wordpress.com> (in Slovak).*
- 46 *See www.discoverensors.ie*
- 47 *See www.naturesekken.no (in Norwegian)*
- 48 *See <http://www.rvp.cz> (in Czech)*
- 49 *See www.scispy.ie*
- 50 *See www.scienceunleashed.ie*
- 51 *See www.primaryscience.ie*
- 52 *A total of 512 schools received awards during the 2008/09 academic year.*
- 53 *See <http://www.skolverket.se/sb/d/2725/a/17208>*
- 54 *See http://www.statskontoret.se/Statskontoret/Templates/NewsPage____4476.aspx (in Swedish)*
- 55 *See www.skolverket.se/matematik (in Swedish)*
- 56 *See <http://www.nta.kva.se/index.php?categoryid=39>*
- 57 *This initiative accompanies the Laptops for Students initiative, and the two go hand in hand. See <http://www.eescola.pt> (in Portuguese)*
- 58 *See <http://fenlab.meb.gov.tr> (in Turkish)*
- 59 *See <http://www.fysika.ee/opikojad/> (in Estonian)*
- 60 *See <http://www.tochtertag.ch> (in German)*
- 61 *This career day is also open to boys, who have the opportunity to discuss career options that until recently have been considered to be only for women (e.g. becoming a nurse). The number of boys taking part is also on the increase.*

- 62 See <http://www.fi.uu.nl/perpectief/overons.html>
- 63 Confédération de l'artisanat et des petites entreprises du bâtiment (CAPEB)
- 64 See <http://www.skolverket.se/sb/d/382/a/15285> (in Swedish)
- 65 For example in Portugal the methodological recommendations for the Mathematics syllabus suggest the use of graphic calculators, and geometry software such as Geogebra.
- 66 It is the responsibility of the school to formulate an ICT vision within its annual school plan, meaning that the way and extent to which this is done varies across schools.
- 67 Rocard et al. (2007) High Level Group on Science Education, Directorate General for Research, Science, Economy and Science, European Commission, Science Education Now: A Renewed Pedagogy for the Future of Europe: http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf
- 68 An issue can be considered a priority whether or not your country has a specific initiative dedicated to it.

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ANNEX

Questionnaire on national measures to increase students' interest in pursuing MST studies and careers.

Introduction

Rationale: Europe needs an adequate output of qualified scientific specialists to foster a dynamic and innovative knowledge-based economy. To achieve this goal we need to increase participation in Mathematics, Science and Technology (MST) studies and careers, especially the number of women. This short questionnaire is aimed at collecting up to date information regarding measures in your country to increase students' interest in studying MST subjects at primary and secondary levels. This information will be collated and used to draft an analysis of the situation across Europe, to help you reflect on your own countries measures in comparison to others.

Definition: Mathematics, Science and Technology subjects (MST) include: Mathematics, Physical Sciences, Life Sciences, Computer Science, and Technology⁶⁷. In some curricula MST subjects may also appear under the titles of Physics, Biology, Chemistry, Earth/Environmental sciences, Astronomy, Engineering, and IT (Informatics).

Deadline: Please fill in the questionnaire in the present Word document (writing 'not applicable' where appropriate).

Structure of the questionnaire: The questionnaire is divided into two parts: Part A asks about your country's national MST initiatives. Part B is concerned with MST priorities at European/international level, and initiatives your country may have developed in relation to these.

Respondent's name:

Respondent's email address:

Respondent's organization and country:

Respondent's position:

PART A: NATIONAL MEASURES

- 1) a.** Please list the MST subjects exactly as they are mentioned in your national curriculum at **primary level**, related to the areas covered by the definition of MST subjects given above. Please explain any relevant details (e.g. the distinction between compulsory and optional subjects, subjects which are only taken by students following special science oriented programmes etc.)

- b.** Please *list the MST subjects* exactly as they are mentioned in your national curriculum at **secondary level**, related to the areas covered by the definition of MST subjects given above. Please explain any relevant details (e.g. the distinction between compulsory and optional subjects, subjects which are only taken by students following special science oriented programmes etc.)

- 2) a.** Has your country recently taken (in the last 3 years), and/or is planning to take in the near future, **any measures** (initiatives, pilot programmes, policy reforms, promotion campaigns etc.) to increase students' interest in studying MST subjects at primary and secondary levels of education?

Yes / No

- b.** If you answered 'no' please **explain briefly why** (e.g. this is no longer a priority for our Ministry of Education and our limited budget is currently focused on other priorities).

- 3)** If you answered 'yes', please use the 2 boxes below (and create as many further boxes as necessary) to **provide information about each undertaken or planned measure**.

Measure 1	
Name/title (e.g. 'laptops for female scientists')	
Short description summary (few lines needed only)	
Rationale (reasons for introducing this measure)	
Type (e.g. initiative, pilot programme, policy reform, promotion campaign etc.)	
Scope (e.g. national, regional, local etc.). Include specific numbers where possible.	
Target group/(s) (e.g. teachers, students, parents etc.)	
Age-group of students concerned (e.g. 11-15 year-olds)	
MST curricular subject/(s) concerned	
Partners cooperating with the Ministry of Education (e.g. an industry partner, such as Microsoft)	
Time span (e.g. 2007-2009)	
Involvement of ICT (description of the role of ICT in this measure)	
Evaluation of the measure (Please specify if any evaluation is planned or has been undertaken, and if so provide references to relevant material e.g. evaluation reports, survey analyses etc. which critically assess the measure)	
Impact of the measure on e.g. the education system, students' attainment etc. (Please specify if any impact assessment is planned or has been undertaken, and if so provide references to relevant material e.g. statistics, media articles etc. as evidence of the measure's impact)	
Additional information (e.g. URL links, references to relevant documentation etc.)	

Measure 2	
Name/title (e.g. 'laptops for female scientists')	
Short description summary (few lines needed only)	
Rationale (reasons for introducing this measure)	
Type (e.g. initiative, pilot programme, policy reform, promotion campaign etc.)	
Scope (e.g. national, regional, local etc.). Include specific numbers where possible.	
Target group/(s) (e.g. teachers, students, parents etc.)	
Age-group of students concerned (e.g. 11-15 year-olds)	
MST curricular subject/(s) concerned	
Partners cooperating with the Ministry of Education (e.g. an industry partner, such as Microsoft)	
Time span (e.g. 2007-2009)	
Evaluation of the measure (e.g. availability of evaluation reports, survey analyses etc. which critically assess the measure)	
Impact of the measure on e.g. the education system, students' attainment etc. (availability of statistics, media articles etc. as evidence of the measure's impact)	
Involvement of ICT (description of the role of ICT in this measure)	
Additional information (e.g. URL links, references to relevant documentation etc.)	

PART B: SPECIFIC AREAS OF INTEREST (pedagogy, teacher education, gender, career guidance, and ICT)

If your country has an MST measure/(s) which corresponds to one of the following areas of interest at European/international level, you may have already answered some of the questions below in the information you provided in Part A, in response to question 3. If so, simply write 'see above' where appropriate. The following questions can be used to provide answers not given above, as well as supplementing information already provided, with additional relevant information. For each answer, please specify whether you are referring to all MST subjects or only to one/some.

- 1) In the box below please rank the issues from 1 to 6 (1 being the most important and 6 the least) by putting an 'x' in the appropriate space to illustrate **your country's priorities**⁶⁸ regarding the development of MST teaching and learning.

	1	2	3	4	5	6
Promotion of inquiry-based learning (experimental/investigative activities)						
Focus on socio-economic aspects of science (linking science with everyday life and current issues)						
Addressing gender balance of MST teachers and students						
Improvement of MST primary and secondary teacher education						
Integration of effective use of ICT in MST teaching and learning						
MST career guidance						

- 2) Please describe any recent developments of interest (undertaken or planned) in relation to the **teaching and learning of MST subjects** (e.g. development of innovative curricula, such as a focus on 'hands-on' experimentation).

- 3) Please describe any new developments (undertaken or planned) in **initial teacher education or continuous professional development** (such as new methods, tools or content) aimed at promoting *innovative teaching* (engaging the learner more actively in his/her own learning and knowledge building) in MST.

- 4) a. Please describe any recent initiatives (undertaken or planned) to address the **gender balance** in those participating in MST studies and careers.

- b. Approximately what percentage of **current secondary school MST teachers are female**?

- 5) a. Please describe any special initiatives (undertaken or planned) regarding **career guidance for students** interested in potential **MST careers**.

- b. Is it **compulsory** for your country's secondary schools to **provide some form of career guidance** for students?

- c. Please describe any initiatives **to improve teachers' and career officers' knowledge of the work of MST professionals** and their **ability to advise students on MST careers**?

- 6) a. Is **ICT** used in the teaching of MST subjects?

Yes / No

- b. If not, why not?

- c. Please specify what statutory documents state about **how ICT should be used** in the teaching of MST subjects (e.g. ICT should be used to teach students how to design charts and other diagrams in Mathematics; for the recording of experiments in Science subjects; for simulation purposes, for word processing or to create PowerPoint presentations etc.)

- d. **Why has ICT been specifically chosen** for this/these purpose(s)? In other words, what can ICT offer for this/these purpose(s) that other tools/methods cannot?

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