NORWEGIAN MINISTRY
OF EDUCATION AND RESEARCH

Strategi

Science for the Future

Strategy for Strengthening Mathematics, Science and Technology (MST) 2010–2014

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Contents

Preface

High competencies in Mathematics, Science and Technology (MST) are prerequisites in order to meet the great challenges of today and tomorrow. We need sufficient numbers of people with insight in MST in order to understand our challenges and to act in the right way. Many exciting opportunities exist; ready to be discovered by curious scientists.

Knowledge in scientific subjects and technology provides much of the basis for productive work and welfare in our own country. This expertise creates jobs and provides important contributions to health and welfare. In the future MST will have a larger impact. A growing world population must have access to new and climate-neutral energy sources necessary for a sustainable development. We need to fight diseases and new threats. We must develop new technologies such as biotechnology, ICT and nanotechnology. These are global challenges that require cooperation across borders and companies. Norway has a responsibility to contribute to finding solutions, and in order to be able to play a part, Norway must strengthen competencies in and recruitment to Mathematics, Science and Technology.

Not everyone shall specialize in MST, but all require knowledge in Mathematics and Science topics. Knowledge in MST is important for all people in a modern society and is part of the general education. Science and mathematics are key components of our heritage, and science has largely shaped our philosophical thinking, our world-view and the human understanding of itself. It is important for young people to carry with them this ballast into the future. Also in vocational subjects, social sciences, economic sciences and health sciences competencies in MST are of importance.

The education sector and trade and industry have for several years collaborated to enhance science and technology subjects in education. It is gratifying that the long-term negative trend is about to turn around. The competencies in the lowest grades in the primary education have become somewhat better, and the recruitment to MST is starting to increase. Still there is a long way before the common goals are reached. The level of education must reach a high international level. Recruitment to studies and employment must be excellent in order to be self-sufficient to the greatest possible extent with highly competent scientists and engineers, skilled workers and technicians. It is further important to stimulate the recruitment of researchers and ensure a good environment for research in Norway This is a prerequisite for creating the values that are necessary for Norway to be a good society for all also in the future.

The Ministry of Education and Research will consequently in collaboration with the entire education system, the working life and trade and industry continue the efforts to improve the education in the science subjects and to increase the recruitment to studies and careers in MST. The effort must include all levels of education from kindergarten on and to the research and work areas. Early efforts will provide motivation and knowledge that will create positive ripple effects throughout the chain of education. The overall objectives of the present initiative is to reinforce pupils' and students' competencies in science subjects, increase the interest in MST and strengthen the recruitment and implementation at all levels, not the least among girls.

The current strategy *Science for the Future 2010-2014* has been developed in collaboration with the education sector, the research sector and trade and industry. The actors have different roles; all have, however, a mutual commitment to a new initiative with a common direction and greater effect in this effort. Through the cooperation in the National Forum for Science, the partners contribute to the joint effort and to a stronger commitment from all stakeholders in order to strengthen mathematics, science and technology in Norway.

Kristin Halvorsen
Minister of Education

Tora Aasland
Minister of Research and Higher Education

[1] A Joint Effort

1.1 The National Forum for Mathematics, Science and Technology

The National Forum for Mathematics, Science and Technology (MST)[1] gathers the central organizations and participants in education and the working life in Norway. The Forum is established as an advisory body for the Ministry of Education and Research regarding all matters considering the status and development of MST. The Ministry's Strategy for strengthening the sciences is embedded in the National Forum, and the members have by their participation undertaken a joint responsibility for the work to achieve the objectives formulated in the strategy document. The National Forum for Science monitor the developments in MST, enhance the cooperation between the partners and propose measures. The partners of the National Forum for Science stand behind the goals of *Science for the Future, 2010 – 2014*, contributing actively to the realization of the goals. Each Partner has responsibility for the measures they themselves want to implement in order to realize the objectives of the strategy.

The National Forum for Science shall consider implementing measures to create high-quality science education at all levels and to improve recruitment to education and working life. The partners of the National Forum for Science define their responsibilities and their roles according to their individual

[1]Translated from "Nasjonalt forum for realfag". The Norwegian term "realfag" means Mathematics and Natural Sciences. In the context of this document the choice was made, in reference to the Rocard report "Science Education NOW: A Renewed Pedagogy for the Future of Europe" ((EU 2007), to use the word "science" to refer more precisely to all of physical sciences, life sciences, computer science and technology, and for the purpose of this document includes mathematics. Internationally the abbreviation MST for Mathematics, Science and Technology is used

interests and are responsible for monitoring their own measures. The participants in the Forum represent their organizations and each partner participates with one person from the management level as well as one executive officer.

One of the Ministers from the Ministry of Education and Research chairs the meetings. The agenda and items of the meeting are prepared by the secretariat consisting of representatives of the Ministry of Trade and Industry and the Ministry of Education and Research. The Ministry of Education and Research heads the secretariat.

1.2 The Roles of the Partners and their Aspirations

The focus on MST is broad and long-termed. A key ambition is that the partners in the National Forum for Science align themselves with the goals and contribute in their own way in order for the goals to become realities. This requires that the roles, responsibilities and aspirations of the different partners be clearly defined.

The National Forum for Science shall consider implementing measures to create high-quality science education at all levels and to improve recruitment to education and working life

The Ministry of Education and Research has a primary responsibility for the strategy and its follow-up. The Ministry reports annually on its actions relating to the strategy. A report regarding the goals shall be made by the end of the strategy period. The other partners may, in various ways have responsibility for parts of the strategy, or they may have aspirations in their own interest to strengthen MST. The variation of the roles is a major factor in the implementation of this broad commitment. Without this breadth it will not be possible to implement the comprehensive effort that is needed to make the goals a reality. During the period of the strategy, the Ministry of Education and Research makes the necessary reviews and adjustments of the strategy in cooperation with the partners.

The key success factor is the participation from public and private sectors and from the employees. The sectors can complement each other, but not replace each other. An ambitious public education sector depends on a committed business community to provide relevance and practice in education. A competitive trade and industry is dependent on a high quality education sector. Both are dependent on well-motivated employees with a high degree of competence.

If we are to succeed, cooperation on national level must have an impact on the regional and local level.

National Education Authorities will

- take overall responsibility for the development, implementation and monitoring of the efforts to provide good training in MST and strengthen the recruitment
- on the basis of the annual national budgets contribute with grants from the government in order to strengthen the training in and recruitment to MST
- contribute to continuing and further education and training in mathematics and science
- use and develop the National centres and Science Centres in the priority work and contribute to enhanced cooperation between centres and the participants in the National Forum for Science

KS[2] will

- inform and motivate municipalities and counties to participate in the effort to reinforce science
- assist school owners in their efforts to acquire and develop necessary skills in MST, see the Education Act § 10-8
- contribute to local cooperation with the business community for local implementation of the initiative to strengthen education in and recruitment to MST

[2]The Norwegian Association of Local and Regional Authorities (KS)

Organizations of Employers in Trade and Industry will

- in collaboration with national and local participants implement measures to motivate, create relevance and provide knowledge about the importance of MST
- motivate employers nationally and locally to participate in the effort to reinforce MST

Trade Unions will

- follow up the effort to ensure that teachers professionally are committed to maintaining, updating and further developing their competence through systematic continuing education and training
- contribute to anchoring the commitment to MST among members and to encourage participation
- contribute to local cooperation with the employer regarding the implementation of the initiative to strengthen education in and recruitment to MST

An ambitious public education sector depends on a committed business community to provide relevance and practice in education.

The Higher Education Sector will

- provide education of high quality in MST to a high degree of completion
- provide basic education for teachers and high quality professional development and training in MST
- cooperate with trade and industry in order to reinforce education and training in and recruitment to MST

The Research Council will

- contribute to better research conditions in MST, including inter alia, investment in advanced equipment and research infrastructure
- through its own actions and measures in cooperation with other participants, increase the understanding of the importance of research in MST among children, adolescents and the public generally.

[2] Science in the Future

We have no overview of how the future industrial structure and labour market will look like. Among other things this depends on the educational choices done today - the limits of our future society will be determined by our competency. However, it is not a question if development of technology will continue, but in which areas it will do so. A long-term growth of prosperity will occur as a result of technological innovations. We must have a solid basic competence in order to ensure that the development is going in the right direction, and that we will be able to enjoy the opportunities technological development will bring forward.

A highly educated work force has a key role in the development and adoption of new technology. Qualifications in MST are a prerequisite for continuing to do so. Basic research in MST develops expertise, methods and instruments that open for new commercial opportunities. Such competence is therefore of fundamental importance for innovation and change and to ensure that we in the future will have a knowledge-based society that asserts itself in international competition.

A highly educated work force has a key role in the development and adoption of new technology. Qualifications in MST are a prerequisite for continuing to do so.

MST topics are a complex group of subjects, but with some important common characteristics. This area is covered by Mathematics and Natural Sciences in the primary and lower secondary school. The main subject area *Technology and Design* in Natural Science has a responsibility for education in the technological subjects in the primary and lower secondary school. In upper secondary education and training the common core subjects Mathematics and Natural Science are represented in all programmes of education. In addition, the Programme for Specialization in General Studies has a programme area *Natural Science and Mathematics Studies* with programme subjects in Mathematics, Natural Science topics, and Technology and Theory of Research. In a number of vocational and training programmes as the Programme for Electricity and Electronics and Programme for Technical and Industrial Production emphasis is on science and technology. In higher education, it is to a large degree up to the individual institution to define the subjects that are offered in each discipline. Regarding higher education, we primarily refer to technology as a part of education in engineering. In general context this strategy document uses the term science in a very broad sense and includes use in the kindergarten, the primary and secondary education, higher education and research that relate to Mathematics, Science and Technology (MST).

Many challenges in today's society are, and will increasingly be, of technological or scientific character. The world of work requires a large degree of understanding of Mathematics and Technology in order to solve tasks. In several areas, such as within the health care sector, new technological solutions may be needed to meet the major challenges of the future. To an increasing degree everyday life requires that everyone has technological insight. Just as important is the ability to understand social issues, economy and key information regarding development of the society. Knowledge in Mathematics is required in order to understand numbers and to be able to interpret graphs. In order to function in a modern working life and society and to participate in democracy, scientific knowledge is necessary.

According to projections from Statistics Norway, the demand for candidates having higher education in science and technology will increase within existing businesses in the coming years. Progress within areas such as the oil and gas industry, the process industry, the maritime industries and other technology-driven businesses depends to a large degree on access to scientific expertise. Within the public sector there is also an urgent need for scientific qualifications, for example in the health care sector, the highway authority and railroad-related operations, planning and building authorities, water supply and pollution inspection. Within agriculture, expertise in MST is necessary in order to maintain production-related considerations and environmental and climate concerns.

At the same time the Report No 44 to the Storting (2008-2009) *Education strategy emphasizes* that future developments in the labour market among other things depend on the political choices that will be made. Historically, the labour market is also affected by the qualifications that are actually made available.

The world is facing major challenges related to climate changes and energy needs as examples. These are challenges that cannot be resolved without research and experimentation in science. Researchers in science can solve exciting assignments related to, among other things, renewable energy, capture and storage of CO_2, nanotechnology and biotechnology.

Increased use of renewable energy will create new jobs and a great need for knowledge and competence in planning, production and processing of energy.

In addition, the sciences have an even greater significance in the future based on new technologies that will appear and affect our everyday lives. Areas where we can expect major progress are among other things biotechnology, nanotechnology, ICT and the environment. We face a major restructuring of the world's energy systems. The aim of the European Commission is to have renewable energy covering 20 per cent of the energy production by 2020. This is also a priority area for the Norwegian government. Increased use of renewable energy will create new jobs and a great need for knowledge and competence in planning, production and processing of energy. In addition Norway aims forcefully on developing technologies for capture and storage of CO_2. This will be essential in order to achieve a significant reduction in global emissions of climate gases. High prices for CO_2 quotas will stimulate technological development in this area, and demands for competency will increase. The Journal "Arbeidsliv i Norden" (Employment in the Nordic countries) has done estimates showing that there may be a need for 425 000 new green jobs in the Nordic countries by 2020. These jobs require workers with solid education and competence, and there will in particular be a great need for engineers and skilled workers with expertise in MST.

The Norwegian labour market has relatively few scientists compared to other OECD countries. There are about 1000 having education in MST per 100 000 workers between 25 and 34 years, (The OECD average is 1600). For women, the number is 600 per 100,000, while for men, the number is 1400 per 100 000. The proportion of scientists will probably deteriorate in the coming years as a result of a high average age among engineers and science teachers. Both trade and industry and the public sector have in recent years had difficulties recruiting sufficient numbers of people with expertise in MST. Recruitment to science and technology within higher education and research has been too low. The recent number of applicants shows that this condition may be changing, but not to a sufficient large degree to be able to meet future challenges.

THE FIRST OSMOTIC POWER PLANT

On November 24th 2009 Her Royal Highness Crown Princess Mette-Marit opened the world`s first osmotic power plant at Tofte near Oslo. Creative engineers in the company Statkraft have managed to transform osmotic pressure into electrical energy. All places where fresh water meets seawater, i.e. where the rivers flow into the ocean, it is possible to exploit osmosis in power plants. Tofte is a test facility that shall try out the technology. If the technology is satisfying, osmotic power will be an important renewable energy source. Osmotic power is a safe source of energy that does not depend on sun or wind. It emits only plain water and pollutes neither water nor the atmosphere. Osmotic power will therefore be a very environmentally friendly energy source. Osmotic power is produced by freshwater and seawater led to separate chambers divided by a membrane. Fresh water is drawn through the membrane by the salt molecules in the seawater. This creates a pressure used to create energy. Statkraft is currently working to develop a commercial osmotic power plant from 2015. The osmotic power plant at Tofte is a good example of how curiosity, creativity and good science competence can make a contribution to a better climate.

[3] Status and Challenges

3.1 Previous Priorities

This strategy is the successor of the strategies *Mathematic, Science and Technology – naturally… 2002-2007* and *A Joint Promotion of Mathematics, Science and Technology (MST) 2006-2009*. Rambøll Management evaluated the strategy for 2002-2007. The strategy was criticized for having greater focus on activities than on measurable results. As it furthermore was pointed out, lack of documentation of the results made it difficult to see the connection between actions and effect in the education. The second strategy (2006-2009) has not been evaluated. Evaluation of the strategy for 2002-2007 pointed out that it would be important in the further work

- to ensure local foundation, measurable objectives and reporting on results
- to ensure clear responsibilities among the actors regarding implementation, follow up and dissemination
- to strengthen the competence of teachers in primary and lower secondary schools
- to strengthen teachers' didactic skills
- to illustrate the usefulness of science both in society and in the classroom in order to create more positive attitudes toward science among the pupils

The first two points are followed up in the present strategy. KS is an important supporter in order to ensure local foundation. The strategy has clear objectives

that will be followed up through annual reports. The strategy describes moreover the roles of the various players who work to reinforce the position of science in education and employment. The last three points match actions that are found in *A Joint Promotion of Mathematics, Science and Technology (MST)* and in the recent reports; Report to the Storting No. 31 (2007-2008) - *Quality in Schools*, the Report to the Storting No. 11 (2008 - 2009) - *The Teacher. The Role and the Education*. The Report to the Storting No. 30 (2008-2009) - *Climate for Research*, the Report to the Storting No. 41 (2008-2009) - *Quality in the Kindergarten* and the Report to the Storting No. 44 (2008-2009) – *Education Strategy*. The present strategy will build on relevant sections of these reports.

Despite the efforts, Norwegian pupils still, to a certain degree, perform considerably below the international average. Lacking recruitment to science is a common challenge for countries in the OECD area and is described by many as a phenomenon of affluence. Nevertheless the problem seems to be greater in Norway than in other countries. We are therefore facing more demanding challenges than other Western countries.

3.2 The Kindergarten

The kindergarten is in a unique position in order to meet, stimulate and support the natural desire of all children to explore and their joy to discover. It can be able to facilitate for experimental and exploratory play indoors and outdoors. Experience shows that early stimulation has a positive impact. *The Framework Plan for Content and Tasks in the Kindergarten (2006)* provides staff, owners and the supervisory authority a binding framework to follow. Furthermore the framework gives information to parents about what they can expect from kindergarten services. It emphasizes children's social, linguistic and cultural competence and seven subject areas that the kindergarten should work with. The science area is made clear and concrete in the presently introduced subject areas; *Numbers, Spaces and Shape* and *Nature, Environment and Technology*. The framework plan emphasizes that the kindergarten should facilitate for fine experiences and adventures stimulating curiosity, and children's own desire to learn and explore. The strong emphasis on children's participation gives the staff opportunities to provide a basis in contexts and situations in everyday life that the child is genuinely concerned about. Through adventures and experiences, children can gain insight and understanding of basic science topics and problems. The importance of the staff's knowledge and attitudes in order to create a stimulating environment in the kindergarten is also pointed out in the framework plan. The Ministry of Education has developed theme booklets on *Nature and Environment (2006)* and on *Numbers, Spaces and Shape (2008)* in order to provide ideas and inspiration for the work in the kindergarten concerning the science areas.

Many kindergartens work with Numbers, Spaces and Shape as shown by surveys[3], and the introduction of the topic area has made staff more aware of mathematical concepts and their use. It seems like they are working more with numbers and numeracy than with space and shape. Kindergartens that work extensively with the topic area are using both formal and informal learning situations related to activities involving all parts of the topic area. Increased competence among staff members will help to equalize the imbalance in emphasis that exists. The Ministry of Education and Research has in 2009 given priority to Numbers, Spaces and Shape as topic area in continuing and further education for preschool teachers and in studies with a subject profile in pedagogical development work in kindergartens (PUB).

Kindergartens have a long tradition of using nature and outdoor areas in the local environment both in hikes and outdoor play. During the last few years the number of open-air kindergartens with their base in the nature has increased. Yet focus on working with the subject area of Nature, Environment and Technology in the kindergartens have been declining in recent years. One works less with technology than with nature and the environment. This may be due to staff having less knowledge about technology and that the biology part is easily compatible with hikes and outdoor play. The Ministry of Education and Research will consider measures in the science area on the basis of NOKUT's[4] evaluation of the pre-school teacher education (2010).

[3]Aina Winsvold and Lars Gulbrandsen (2009) Kvalitet og kvantitet, Kvalitet I en barnehagesektor I sterk vekst, NOVA Rapport 2 / 09 Solveig Østrem et al (2009) Alle teller mer, En evaluering av hvordan Rammeplan for barnehagens innhold blir innført, brukt og erfart, Vestfold University College Rapport 1 / 2009.
[4]Norwegian Agency for Quality Assurance in Education (NOKUT).

THEMATIC BOOKLETS ABOUT SCIENCE SUBJECTS FOR THE KINDERGARTEN

Mathematics surrounds us and affects us through all life. The newborn child uses shape recognition to distinguish the face of its mother from unknowns, two-year-olds explore volume and shape by using sand and water in the sandpit, the four-year-old needs money for the "Princess game", and the six-year-old discusses whether one hundred thousand is more than one million or not. The thematic booklet on *Number, Spaces and Shape*, issued by The Ministry of Education and Research, provides good examples on how basic mathematical topics are included as a natural part of children's play and in their exploration of the environment around them. The adults' attitude and ability to meet children's curiosity with shared inquisitiveness are highlighted as important, both as a recognition of the child's expression and as support in order to ask further questions.

Similarly the thematic booklet *Nature and Environment* shows how nature can serve as the good playground that encourages movements, aesthetic experiences and the acquisition of new knowledge. This is done in an environment that is constantly changing character. The thematic booklet furnishes the staff in kindergartens with concrete examples of how to facilitate for nice nature experiences both indoors and outdoors. This in order to make the children aware about relationships in nature and the environment we are influencing around us. The child's playful approach to nature is highlighted as a good starting point for learning and exploration. The adults' task is to ask good questions that help the child finding their explanations and solutions.

3.3 Primary and Secondary Education and Training

Challenges

Norwegian school has many qualities from which science topics can benefits . Everyone has equal access to education regardless of his or her parents' background. We have a public school where the pupils learn together, which is underpinned by research showing that this gives the best results. Pupils thrive generally well in school and have good self-esteem and confidence. The relationship between student and teacher is generally very good. Most children and young people also are interested in learning and experience a sense of belonging to the school. This is a good starting point for learning and improving performance in science.

It is well documented that Norwegian pupils in primary and lower secondary schools are performing below average in science subjects in the international PISA and TIMSS surveys. The reasons for this are complex and therefore difficult to front. Norwegian pupils score lower than the OECD average both in mathematics and in natural science, and Norway has the lowest score values in the Nordic countries as shown in the PISA survey from 2006. At the same time, the results show a steady decline since 2000. The study TIMSS Advanced shows the same trend in upper secondary education. It is a clear decline in the results for students with full specialization in physics and mathematics. In particular, the results in mathematics give reason to concern. Students are performing worse than their peers in countries with which it is natural to compare ourselves, and the results are far below the international average. The reports point to choice of working methods as a possible explanation for the weak and declining results.

The international PISA study shows that there are small differences between girls and boys regarding achievements in mathematics and in natural science. However, in the national tests for the 8th grade boys score significantly better than girls. For students with full specialization in physics, TIMSS Advanced shows that the boys are in a clear majority and perform best. In mathematics there are no significant differences in achievement between boys and girls.

The Knowledge Promotion Reform assumes that teachers have good expertise in developing local plans in order to offer good education.

As a result of the past years' efforts to improve the quality in primary and secondary education in general and in science in particular, there are indications that the downward trend is about to turn around, as TIMSS 2007 shows. The effort over many years begins to be fruitful. Pupils in the 4th grade show significant progress both in Mathematics and in Natural Science compared to 2003, while there is some progress in the 8th grade in Mathematics, but decline in Natural Science. The TIMSS 2007 Report gives further advice concerning what can result in good learning - and what does not. It points out that Norwegian schools only to a low degree follow up and give feedback on the pupils' work. Moreover, the report shows that the pupils in Norwegian schools do a great deal of individual work.

Still, Norwegian pupils perform poorer than pupils in countries it is natural to compare with. Many pupils are below the minimum level of competence, and almost no one is at its highest level. Moreover, Norwegian students in particular are missing skills in formal Mathematics and in Physics. Therefore it still is important to improve education in MST.

Stakes in Primary and Secondary Education and Training

The main effort in the reinforcement of MST is the *Knowledge Promotion Reform*. The curricula in Mathematics and in Natural Science in this reform specify the competence pupils should acquire at various grade levels. *The Knowledge Promotion Reform* assumes that teachers have good expertise in developing local plans in order to offer good education. To provide the schools with help in this work, guidance to the curriculum in Mathematics has been prepared, and guidance to the curriculum in Natural Science will be prepared.

National tests in arithmetic for the fifth and eighth grade have been introduced. The schools use these as a basis for improvement and development. Mapping test in numeracy and calculation skills for the second grade (mandatory) and the third grade (optional) have also been introduced. In upper secondary education a mandatory mapping test in arithmetic in the 11th grade (1th year of Upper Secondary Education) has been introduced. The central examinations in mathematics given in both lower and upper secondary education are divided into two parts, one part to be performed without aids and one part with the use of aids. Dividing the examination in this way has been well received.

The number of lessons in science subjects in primary school has been low compared to other countries. During the previous two strategy periods the number of lessons has been increased. In primary schools, the number of hours in Mathematics has increased by 160 hours and in Natural Science by 29 hours. In the lower secondary school there is no increase in the number of hours. Norway still has a low number of lessons in Natural Science compared with other countries.

The municipalities are required to increase the teacher-density in the Norwegian language and in Mathematics for the first 4 years of primary school from 2009. This will be done in order to particularly to help students with weak skills in among other things arithmetic. In order to achieve this, the municipalities are given extra resources. If the pupils have trouble with Mathematics during the first school years, they will often have problems later on in the educational pathway (course).

The national centres for education in *Mathematics* and in *Science* have a mission to provide excellent ways of working with MST in education throughout the whole educational pathway from kindergarten to adult education. The centres shall develop and distribute experiences regarding working methods and teaching material in MST that has been proven effective, in line with the competence objectives of the *Knowledge Promotion*. They are central in the work providing schools and the individual teachers with knowledge and practical help regarding the kind of teaching that provides education of high quality.

Practical Training in the Sciences

Concepts in Science are basically abstract. Thus it is important to concretize the concepts in order to provide the pupils with the possibility of understanding at their own level. This means that training in science to a sufficient extent has to be practice-oriented for the student to be able to learn. Furthermore, even in the Programme for Specialization in General Studies a more practical approach will be of importance for many pupils.

The experimental and research character of Natural Science is given a particular obligation in the main subject area: *The Budding Researcher* in the curriculum. Mathematics does not have an equivalent main subject area. However, varied ways of working are a professional responsibility for the individual school. The challenge is that some teachers and schools do not have the necessary competence to realize how to make teaching science subjects sufficiently practical. *The National Centre for Mathematics in Education* has developed practical teaching materials that are used by a number of schools. *The National Centre for Science Education* provides extensive information for school owners and schools regarding the importance of experimental work in Science, and for necessary and adequate equipment to achieve this. Agreements for cooperation with local companies through the programme *Trade and Industry in Schools* have contributed to more practical knowledge about how MST can be used.

The National Centre for Science Education has submitted a report on the equipment situation regarding Natural Sciences in Norwegian schools. Although the report does not give a complete picture, there is reason for concern. Much of the equipment is old and less suitable, and teachers have sometimes little knowledge in how the equipment should be used, particularly so in primary schools. Funding from school owners to make necessary purchases are limited. Both natural science and mathematics need supplies

THE BUDDING RESEARCHER LOOKS AT THE LOBSTER

Risør Primary School has through The Natural Satchel programme developed a teaching plan; The Budding Researcher looks at the lobster for the 6th grade. Pupils have been working on activities where they are challenged to be a budding researcher and to do research themselves. In addition, they have been participants in a larger research project in collaboration with the Aquarium in Risør. There, students have participated in detecting the development of the lobster population in the lobster reservation in Risør. Pupils have closely gained knowledge about the relationships in nature and the interaction between the catch made by humans and the lobster stock. The concept of sustainable development is thus associated with a local problem. The students themselves have made hypotheses, planned and carried out research work regarding the lobster. The pupils have presented their results and work to their parents. The teaching scheme shall be a permanent element in the school's outdoor education plan for natural science and social studies.

and equipment of a more permanent value. The conditions regarding equipment are somewhat better in upper secondary education and training than in primary and lower secondary school.

TIMSS points out that work practices in science subjects in Norway consist of individual work to a larger degree than in other countries. It may have the effect that the practical element in science is taken care of in a weaker manner, although this is not specifically studied. Practical activities in science precisely require teacher-guided activities.

Natural science subjects will provide knowledge of nature, positive experiences in nature and through this a strong awareness about environmental protection. This is only possible if the different natural environments are used deliberately as a practical arena in natural sciences. In 2008 the Ministry of Education and Research launched *The Natural Satchel (DNS)* together with the Ministry of the Environment. DNS will help to foster curiosity and knowledge of phenomena in nature, awareness of sustainable development and increased environmental commitment by pupils and teachers in primary and lower secondary school. DNS is rooted in the curricula for the common core subjects Natural Science, Social Studies, Food and Health and Physical Education.

The Role of the Science Centres

The regional Science Centres are established to create interest in Mathematics, Science and Technologies. In 2009 the Ministry allocated a total of 20.3 million Norwegian kroner to the regional Science Centres. Their aims are to strengthen understanding and usefulness of science in society and in the workplace. The Science Centres are popular science adventure and learning centres for MST, targeting pupils, students and the public. The number of visitors to the regional Science Centres has been more than a doubled during the former strategy period, from 225 000 visitors in 2003 to 520 000 in 2008. Growth from 2007 to 2008 was 24 per cent. In 2008, more than 164 000 pupils came during organized school visits. Preliminary results from the research project "*Vilje-con-valg*" done in the National Centre for Science Education shows that 20 per cent of all students who started studies in Science in 2008, referred to science centres as a source for motivation and inspiration to choose science studies. Science Centres were mentioned to be more motivating for their choice than school counsellors and advertising campaigns. This shows that good results are achieved for a relatively modest input of resources supporting the Science Centres.

Choice of Science in Upper Secondary Education and Training

A relatively stable number of pupils have been choosing Science in upper secondary education during the period 2001-2006. After the introduction of the *Knowledge Promotion*, we have seen a positive development regarding attendance in science taking place in the Programme for Specialization in General Studies. To motivate more pupils to choose MST subjects extra grade points are awarded.

According to an analysis done by the Norwegian Directorate for Education and Training regarding the pupils' choices in the Programme for Specialization in General Studies after the introduction of the *Knowledge Promotion*, the largest (in attendance) programme subjects in the Natural Science and Mathematics Studies are Mathematics, Physics and Chemistry, followed by Biology, Information Technology, Technology and Theory of Research, and Geosciences. The number of students in some demanding programme subjects in the 13th grade is lower than the number who started the subject in the 12th grade This especially applies to physics, where one third of the students in Physics 1 do not continue with Physics 2. In Mathematics there are more students who choose the practical (P) than the theoretical (T) variant of the common core subject Mathematics in 1th and 12th grade.

In the vocational education science topics are central in a number of vocational education and training programmes. In order to have a sufficient number of qualified skilled workers in occupations requiring high technological and scientific competence in the future it is therefore important that training in MST subjects are related to the actual vocational training.

It turns out that difficulties in Mathematics are one of the reasons for the lack of completion in upper se-

condary education and training. The majority of pupils leaving school quit because they do not master Mathematics. A condition for more pupils to manage the requirements in mathematics is a solid basis from primary and lower secondary education together with a higher degree of understanding of what the subject will be used for. It is therefore important to make education in the MST subjects related to the actual practice of vocational education and training. In addition improved information regarding the application and more practical approach of MST in the Programme for Specialization in General Studies will increase the motivation and understanding among many pupils.

Working Life

Adults in the workplace often have a need to increase or update their qualifications in science related subjects. A number of organizations and companies provide extensive development in such competence for their employees. The measures partly are directed towards the needs employees have related to their current work tasks, and partly are directed towards skilled employees in order to give them opportunity for education to become qualified engineers. As an example, the Federation of Norwegian Industries College in collaboration with the University College of Sør-Trøndelag conducted an experiment in which an employee takes a two-year engineering education over three years while at work, with the possibility of a third year to complete with a bachelor's degree.

VOX[5] is working to raise the level of competence for adults and is developing an offer of adult education in everyday Mathematics on a national level. Competence goals for everyday Mathematics are aimed towards mastering situations where numeracy, measurement skills and number processing are included. A programme for basic competence in the workplace allows for grants for adult education in arithmetic and data among other things.

Recruitment

Generally pupils have a positive relationship regarding the significance of science topics and their role in society. Nevertheless most people do not choose science education, this especially being the case for girls. We still have a big challenge to motivate young

ENHANCEMENT OF COMPETENCIES AT SØRAL

SØRAL (South Norway Aluminium) has in the past ten years focused intensively on enhancement of qualifications among the employees. The result is that the company has a well-educated workforce, which is an important competitive advantage. Competitiveness is easiest to discover when the company is compared with other aluminium plants in Europe. Scientific literacy is important for most of the processes in SØRAL. The operators in the company have a better understanding of the processes and are able to make the necessary corrections in the daily operations. In addition, they have the expertise to come up with good suggestions for improvements. In the same way high competence in MST for engineers is a prerequisite for development. SØRAL has implemented competence development in science at many levels. Courses in MST have been completed, both as individual courses and as a common preparatory course for education in engineering. The company has developed courses for further education in electrolysis in collaboration with Norwegian Hydro, Elkem and the Federation of Norwegian Industries. SØRAL has in addition during several periods contributed to engineering education for their own operators through collaboration with the University College of Sør-Trøndelag and the University College of Stord / Haugesund.

[5]Norwegian Agency for Lifelong Learning (VOX)

people to select specialization in scientific subjects in upper secondary education by highlighting the importance of these subjects in the future. The business sector will be an important partner for collaboration.

The projects *TENK* and *SEIRE* have increased interest for choosing science education. In these projects students at the University of Oslo, (UIO) and at The University of Trondheim(NTNU) are providing training in Mathematics for pupils in secondary schools outside of school hours. The local business community is supporting the programme by highlighting the importance of Mathematics in their companies.

For better use of the business community in order to strengthen education in MST, trials regarding a "*Lektor 2*" scheme are initiated. The aim is to get employees to teach part time in primary and secondary education and training in subjects where the schools need specific help. The scheme shall contribute to increased recruitment to MST, create a good contact with the business community and provide better training in science.

Attitudes and motivation for the subjects do influence the choice of disciplines and education. The topics must be viewed as useful and meaningful in order to be objects for choices in education according to the study (*Vilje-con-valg*) conducted by the National Centre for Science Education. Possibilities for self-realization and social benefits are also significant reasons for the choices young people make. Many of youngsters asked in the survey answers that they would work with renewable energy and create something that matters to others. The choice can be inspired by popular science and advertising, visit to Science Centres, brochures and websites. The teacher is an important motivator, while the counsellor only to a limited extent seems to motivate for choice of Science.

All students are entitled to necessary counselling. In order to strengthen guidance, a guiding competence requirement for school counsellors has been prepared and partnerships for career guidance in all counties have been created.

3.4 The Teacher

Highly professional and pedagogical skilled teachers are an important precondition for the pupils' learning and contribute to good results for the pupils. This is confirmed by many studies. OECD's Economic Review of August 2008 recommends Norway to pursue further education, especially in the fields of MST.

The proportion of teachers with specialization in Mathematics and Science compared with other countries is shown in the TIMSS 2007 survey. The share of Norwegian teachers in the 8th grade with specialization in Mathematics and Natural Science is considerably below the international average. The figures for qualifications in subject didactics in Mathematics and Natural Science are even worse. This underlines the challenge the sector has in order to strengthen teachers' professional competence. Norwegian teachers also participate in continuing and further education and training to a clearly lesser degree than the international average as shown by TIMSS 2007.

A Norwegian study found that increased formal qualifications in Mathematics for teachers improve the performance of the pupils in the subject[6]. The effect is particularly strong when the teacher is a "lektor", that is a teacher with at least a Master's degree with subject specialization in MST. Teachers who used exploratory teaching in order to engage the pupils and increase their ability to understand and act, got pupils that performed significantly better than pupils not being taught this way, an American study[7] shows.

A challenge is therefore that about 35 per cent of the teachers in primary and lower secondary schools have no specialization in the science subjects they teach, and only about 15 per cent have at least one year of specialization[8]. Mathematics is still the subject where fewest teachers have at least 60 credits specialization (At least one year) The subject specialization is clearly most common among teachers in lower secondary schools. Four out of five teachers teaching science subjects in lower secondary schools have some subject specialization.

[6] Falch, Torberg and Linn Renée Naper (2008): Lærerkompetanse og elevresultater I ungdomsskolen. SØF Rapport 01/08
[7] Johnson, C.C., Kahle, J.B. & Fargo, J.D. (2007): «Effective Teaching Results in Increased Science Achievement for All Students.» Science Education, 91 (3), p. 371-383. De nasjonale sentrene
[8] Lagerstrøm, Bengt Oscar (2007): Kompetanse i grunnskolen: Hovedresultater 2005/2006. SSB Rapport 2007/21

Teacher training recruits traditionally students without special interest in MST. Admission figures from 2008 show that just ten per cent of the applicants to general teacher training programme have specialization in Mathematics from upper secondary education and training, five per cent have specialization in Physics, 15 per cent have specialization in Chemistry or Biology. The corresponding ratio for the five-year integrated teacher training is 28 per cent. A study done by the Council of Mathematics shows that students starting teacher training have a low competence level in Mathematics.

This may indicate that the commitment through previous strategies has resulted in some increase in subject specialization among teachers in primary and lower secondary school

In upper secondary education and training, where regulations set the highest standards for subject specialization, significant differences exist among teachers[9]. Teachers in upper secondary education and training have more often subject specialization in MST. Nevertheless, there are only eight per cent of the teachers in the Vg1 level who have a master or corresponding degree in Mathematics. Teachers, who teach Natural Science, have strongest educational background in Biology. About one third has a master or similar degree in Biology. In Physics, the situation is particularly serious with nearly 40 per cent having less than one year of education in the subject and only seven per cent have a graduate degree. The survey TIMSS Advanced shows that Norwegian teachers have the least competence in didactics of Mathematics compared to the teachers in the countries participating in the survey. This may explain the report's criticism concerning the use of working methods in the subject.

The age of teachers in upper secondary schools with specialization in MST is high. 52 per cent of Science teachers in 1998 were older than 50 years. TIMSS Advanced shows that 73 per cent of teachers in Mathematics in 2008 were more than 50 years old, 36 per cent were older than 60 years. Without a conscious recruitment and comprehensive, targeted further education, upper secondary education will in a few years time have a significant shortage of teachers in Mathematics, Physics and Chemistry.

In order to stimulate more teachers to gain high competence in science subjects an arrangement was introduced in 2009 giving students completing teacher training in Science partial remission of educational debt. This applies to students taking an integrated master programme in teacher education with science subjects, a two-year master programme in didactics for teachers in science or a one-year practical-pedagogical training for students who have completed a 3-year engineering education or a graduate degree in MST subjects.

The proportion of teachers with some subject specialization in Mathematics and Natural Science has increased during the period 1999 to 2005. This may indicate that the commitment through previous strategies has resulted in some increase in subject specialization among teachers in primary and lower secondary school. The Ministry of Education and Research's strategy Competence for Quality – a durable system for further education puts priorities to Mathematics in lower secondary schools and Physics and Chemistry in upper secondary education and training for the period 2009-2012.

TEDS-M is an international research programme evaluating the education of primary and lower secondary school teachers in Mathematics. TEDS-M examines the plans and standards for teacher education in Mathematics and evaluates future teachers' competence in Mathematics, Mathematics didactics and Pedagogy. The main report will be published in 2010 providing the basis for an eventual strengthening of teacher education in Mathematics.

[9] Turmo, Ari and Per O. Aamodt (2007): Pedagogisk og faglig kompetanse blant lærere I videregående skole: en kartlegging NIFU STEP Rapport 29/2007

3.5 Higher Education

Choice of Science and Technology in Higher Education

There has been a clear increase of applicants to studies in MST in 2009. The number of applicants to science studies, having the study as a first priority, has increased from 1.00 in 2008 to 1.22 in 2009 given as the ratio between the number of applicants and the number of students that can be admitted. For technological studies the ratio has risen from 1.77 to 1.83. Looking at developments over the period from 2005 to 2009, the figures show an increase of 12 per cent in first priority applicants for studies in science subjects while applications to studies in technology have increased by about 30 per cent during the same period. Nevertheless, it's a long way reaching the OECD level, and the Ministry of Education and Research considers that recruitment is still a major challenge that must be met with strong measures in the strategy period. Figures mentioned above are gathered from the national admission made through the Universities and Colleges Admission Service (SO) not including local admission. No national overview of local admission arrangements exists so far. Local admission has increased significantly during the previous strategy period, especially within the two-and three-year education programmes in engineering. Local admission now counts for about 25 per cent of the total admission in this field. The increase in recruitment to technological studies is in reality higher than the figures are showing.

The proportion of the students with background in Science from upper secondary education and training who choose to proceed in MST studies is very small. Some are applying to other studies that require science subjects from upper secondary education, such as studies in medicine and in dentistry, but there is still a large proportion of those students choosing completely different directions.

Currently there is insufficient research-based knowledge concerning recruitment to science studies in higher education. What is known, however, is that lack of knowledge concerning different career directions has a clear impact on not choosing education that qualifies for occupations in MST. The proportion of young people with good knowledge about the engineering profession is very low, especially among girls. As one of the measures in the previous strategy period, the ministry has supported the research project "*Vilje-con-valg*" at the National Centre for Science Education. The project is just looking to find reasons for students choosing or not choosing studies in science. The knowledge gained from this project will be important in the future work concerning recruitment to MST.

Students report that many of them studying MST do not understand the relevance of the study for employment.

The National Centre for Recruitment to Science and Technology (RENATE Centre) is the Government's national resource centre for recruitment to MST. The centre was established already in 1998, but was renewed in 2007 with an expanded mandate. The RENATE Centre has during the previous strategy period been built up considerably and is now a very important actor in the work regarding recruitment to education in MST.

Implementation in Higher Education

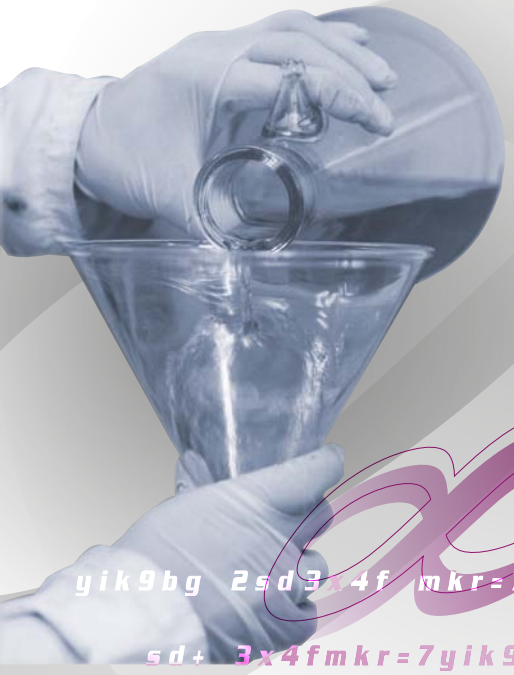
Science and technology education has during a long period struggled with both a high drop-out-rate and a relatively large per centage of students being delayed in their education. There are complex reasons for this. Among other things, students experience to a lesser extent the studies as useful, they question the structure of the studes and the teaching methods, and they may lack prior knowledge and in addition the guidance to students might be lacking.

Evaluations including NOKUT's evaluation (2008) of the two-and three-year education programmes in

Having research-based knowledge about young people's attitudes and choices regarding education has been a great challenge to face using large resources during the previous strategy period.

engineering have shown that subject didactics in science and technological studies totally does not reach a satisfactory level. At the same time, many students experience Mathematics as particularly demanding, and high failure rate in the subject leads both to a higher dropout rate and lower academic progress. Students report that many of them study-ing MST do not understand the relevance of the study for employment. They do not see the applicability of what they are being taught, and the study is experienced as less work-related. This is particularly a problem for the new students.

Girls are underrepresented in MST studies. To ensure a more even gender balance is not only about recruiting more female applicants, it is also about preventing girls to have a higher dropout rate than boys; this being the case in many MST studies today. Figures from the Database for Statistics on Higher Education (DBH) show that girls who are applying to studies in Science and Technology have clearly higher average grades from upper secondary school than their male counterparts. This disproves the hypothesis that it is primarily the weakest students who are dropping out. This, however, coincides with reports saying that girls to a greater extent than boys do not see the applicability of the subjects and thereby switch to other studies they consider more useful.



OSLO CANCER CLUSTER

Oslo Cancer Cluster (OCC) was established in 2006 in order to build a bridge between research, education, and trade and industry concerning development of diagnosis and medicines against cancer. OCC has 55 members ranging from small biotechnology firms to large pharmaceutical companies, in addition to the University of Oslo and the Radium Hospital. Oslo Cancer Cluster brings together skilled researchers and innovative businesses with the aim of strengthening cancer research and treatment. It has become one of the world's most foremost environments for development in this area and has status as a centre for expertise. An innovation park covering 40 000 square meters will be completed in 2013 where Ullern Upper Secondary school is today. The new school will be an integral part of the innovation park and will specialize in science, entrepreneurship, health and social care, and electricity and electronics. Starting in 2013 800 pupils will attend a school that offers the latest in technology and laboratory equipment. Teachers will have a systematic development of qualifications offered by scientists and business leaders. The pupils who choose one of the vocational subjects will get apprenticeships in the hospital or in the companies in the OCC. The "Knowledge country Norway" needs success stories concerning what is being possible when trade and industry, research and education work together. This is one of the stories.

The National Centre does research on choice and opt-out of science among young seekers of education in the project "*Vilje-con-valg*" managed for Science Education. Having research-based knowledge about young people's attitudes and choices regarding education has been a great challenge to face using large resources during the previous strategy period.

Quality in Higher Education

Both choice of studies in MST and completion of these programmes are affected by the quality of education. If we are going to succeed reaching the objectives of the strategy, we must provide high quality education that can stand comparison with any equivalent education internationally. A large national quality assessment in the area of MST has been undertaken during the last few years. As mentioned before, NOKUT in 2008 presented an evaluation of the two- and three-year engineering educations. The main conclusion of the report was that the Norwegian engineering education generally is good, but with some distinct challenges. On a general level the evaluation shows that the education in engineering needs to be renewed in accordance with the pace of developments in society, without undermining the solid foundation. The NOKUT evaluation pointed to the following challenges in education:

- Lacking extent of research-based teaching
- Internationalization
- Relevance of the education / collaboration with trade and industry
- Organisation / co-operation between educational institutions
- The pedagogical competence of the academic staff
- Recruitment
- Throughput of students

There is reason to believe that these seven points are not specific for engineering education, but that they, although to varying degrees, also have relevance for other scientific and technological educations. Some

of the points mentioned here have also been mentioned, inter alia in the Report No 44 to the Storting (2008-2009) *Education strategy* and the action plan for *Entrepreneurship in Education and Training (2009)*.

3.6 Research

Recruiting for Researcher Training and the Researcher Profession

The trend in the recruitment to education of researchers in MST has been positive during recent years. An increase in the proportion of women that defends their doctoral thesis within these disciplines is taking place. 1520 new doctoral agreements were signed in 2008. The largest part of these (385 agreements or 25 per cent) was in the field of Mathematics and Natural Sciences while the third-largest part with 264 agreements (17 per cent) was in the field of Technology. Placed in between is medicine with 21 per cent of the contracts.

Figures show that MST is in surprisingly well off in terms of recruitment of researchers, particularly seen in relation to the share of students studying these subjects.

Mathematics and natural science subjects had the largest part (354 doctoral degrees, or 28 per cent) of the 1,244 doctoral degrees offered in 2008, and Technology subjects had the third largest part with 165 degrees (13 per cent). Medicine had 24 per cent of the doctoral degrees earned at this time. Figures show that MST is surprisingly well off in terms of recruitment of researchers, particularly seen in relation to the share of students studying these subjects.

Subject-didactic research in science subjects is important in order to give increased knowledge about good teaching. In recent years there have been initiated several research projects concerning research in science didactics.

Although the development has been positive, it is still a challenge to strengthen the recruitment from Norwegian higher education to education of researchers in MST.

Although the development has been positive, it is still a challenge to strengthen the recruitment from Norwegian higher education to education of researchers in MST. About one-third of those who earned a doctorate in MST in 2008 were foreign nationals.

The number of temporary positions (total for all subjects) at the universities has increased by 39 per cent from 2002 to 2008. The number of permanent positions has increased by 7 per cent during the same period. When PhDs who have left research, are asked about the reason for this, general lack of prospects for a permanent position within a reasonable period is given as the reason.

[4] The Main Target for the Commitment

1) Increase the interest in MST and strengthen the recruitment and implementation at all levels

2) Strengthen the competence of Norwegian pupils in science subjects

3) Increase the recruitment of girls to Mathematics, Physics, Chemistry and the technology subjects

Subsidiary Objectives of the Strategy Period

Kindergarten

SUBSIDIARY OBJECTIVES:

- **Increase qualifications in science for the staff in the kindergarten**

Primary and Secondary Education and Training

SUBSIDIARY OBJECTIVES:

- **Norwegian pupils should perform at least as well as the international average in international studies in science subjects**
- **The proportion of pupils who *choose* specialization in Mathematics, Physics and Chemistry at the highest level in upper secondary education and training, shall increase by at least five per centage points**
- **The proportion of pupils who *complete* specialization in Mathematics, Physics and Chemistry at the highest level in upper secondary education and training, shall increase by at least five percentage points**

The Teacher

SUBSIDIARY OBJECTIVES:

- **The number of teachers with at least 30 credits in Mathematics and Natural Science in the 1st to 7th grade and at least 60 credits in the lower secondary level shall increase by at least 1000**

Higher Education

SUBSIDIARY OBJECTIVES:

- **The number of graduates with education in MST shall increase by at least 15 percentage points**
- **The subject didactics in MST studies shall be strengthened**
- **Improved quality of education in MST**
- **Increased social relevance of education in MST**

Research

SUBSIDIARY OBJECTIVES:

- **The quality of strategic areas shall be increased**
- **Research relevant to trade and industry in key areas is to be promoted**
- **The proportion of research fellows who finish their doctorates in MST within six years after commenced education, shall be increased to 85 per cent**

[5] Focus Areas

5.1 The Kindergarten

SUBSIDIARY OBJECTIVES:

- **Increase competence in science for the staff in the kindergarten**

As described in the *Framework Plan for Content and Tasks in the Kindergarten (2006)* the Ministry of Education and Research will continue the work of increasing the competence of the employees in order to cover all aspects of the science subject areas. The Ministry of Education and Research will consider new initiatives regarding basic education and continuing and further education and training based on the results from the NOKUT evaluation of preschool teacher education to be presented in the autumn of 2010. The National Centres for Mathematics in Education and for Science Education will continue to develop and disseminate good working methods in science subjects.

The Ministry of Education and Research will consider ways to renew and strengthen the work with gender equality in the kindergarten; see Report to the Storting No. 41 (2008-2009) *Quality in kindergarten*. Increased awareness concerning gender equality in the kindergarten can help to provide both girls and boys with the opportunity to participate in various formal and informal learning situations, related to all aspects of the science subject areas.

5.2 Primary and Secondary Education and Training

SUBSIDIARY OBJECTIVES:

- **Norwegian pupils should perform at least as well as the international average in international studies in science subjects**
- **The proportion of pupils who *choose* specialization in Mathematics, Physics and Chemistry at the highest level in upper secondary education and training, shall increase by at least five percentage points**
- **The proportion of pupils who *complete* specialization in Mathematics, Physics and Chemistry at the highest level in upper secondary education and training, shall increase by at least five percentage points**

Better Results

The Government presents in the Report to the Storting No. 31 (2007-2008) *Quality in Schools* a continuous chain of actions in order to raise the quality of the education in general. These measures will also have a bearing on the quality of education in Science. Several of the measures are followed up in this strategy.

Early efforts are especially important in Science because the subjects have a strong incremental construction. What is not learned in early stages will become a barrier for later learning. It is important that school owners and schools follow this up by taking advantage of the increased density of teachers in grades 1 to 4. The number of lessons in natural science in the primary and lower secondary education is still low compared with other countries. In a long turn perspective, the aim isto increase the number of lessons in Natural Science in order to make room for practice and, by doing so, providing a better education.

Completion of upper secondary education and training is a challenge mainly to be solved by efforts in the earlier grades. It will be difficult for pupils to keep up, especially in Mathematics, but also in Natural Science if necessary knowledge is not present. In order to provide for necessary competence and increased motivation for science subjects schools and school owners must therefore put greater emphasis on providing opportunities for good, systematic and practice related education in primary and lower secondary school. In order to increase competence and motivation necessary in order to give the pupils the opportunity to finish education and training, emphasis should be on adaptation and practice relation in Mathematics and Natural Science in vocational education and training programmes in upper secondary education and training.

Selection of good working methods is a professional responsibility for the teacher and school management. KS will help to motivate and pave the way for school owners to strengthen the quality of education in science topics. The schools must emphasize the use of working methods that provide for good learning in line with what the reports from international studies point out regarding use of working methods. The schools need to a larger extent use the national centres for Mathematics and for Science for guidance and support in the pedagogical practice. The national centres will continue to play a central role in developing working methods that provide for good learning, make these known and contribute to the development of material and teaching aids for good working methods. The national centres will further intensify the efforts to inform the teacher training and manufacturers of educational tool about what provides good learning. The centres shall in collaboration with the National Centre for ICT in Education contribute to the use of ICT in Mathematics and Natural Science in the school to provide education of good quality and increased competence for the pupils.

In order to strengthen the development and dissemination of good practical ways of working in science subjects, a separate development programme for practise related training in Science will be started. Awareness of the perspective of content, working methods and materials that take care of both boys and girls will be created in the development programme. Good specialist environment in each school and between schools in the local community has proved essential for operating well functioning development

work in Science. It provides opportunities for sharing experience, joint development of new teaching plans with emphasis on practice, assessment culture and better use of the school's equipment. As part of the development project experiments to develop good models for professional collaboration shall be initiated. The experiments with the *"Lektor 2"* scheme shall be continued and developed to make education more relevant and practice related. The use of appropriate and modern technical equipment in the company through the collaboration between the school and local employment in the "*Lektor 2*" arrangement means that students get more practice related training.

Education of high quality requires the schools to have sufficient and suitable equipment, and that teachers use this together with working methods that provide good learning conditions. Improving the equipment situation and the framework for the use of the material in Science and Mathematics will be an important task for the schools and school owners in the time to come. It is important; in particular, that safety including the size of the student group is taken care of. The national centres for Science and Mathematics will enhance their information to the school owners concerning the importance of practice in science subjects and what is necessary and adequate equipment to achieve this.

In order to increase recruitment to MST subjects in higher education, research and employment, it is also important to make Science more realistic and meaningful for pupils.

Many pupils have difficulties with Mathematics when it comes to both skills and motivation. The Ministry of Education and Research has therefore established a broad working group with the Mathematics Centre as secretariat. The working group will consider future subjects in Mathematics and how Mathematics can be more relevant and engaging for all pupils. Schools and school owners must exploit the possibilities for pupils in lower secondary schools to take courses in subjects in upper secondary schools and for pupils in upper secondary schools to attend studies in higher education in order to encourage pupils with special interests in science subjects.

GIRLS AND TECHNOLOGY

Girls and technology is a collaborative project The University in Agder (UiA) has with NHO, NITO, Tekna, LO[10], and the two county municipalities Øst- and Vest-Agder. Every year (since 2004), the project has transported hundreds of girls from lower and upper secondary schools in the Agder counties to technological experiences at the University of Agder. The adventure day "Girls and Technology" lets the girls meet female role models from trade and industry, laboratory work is demonstrated and they are entertained with a «Science show» and musical performances. UiA has directly benefited from this career guidance by a significantly increased number of female applicants to their engineering and technology studies. In 2004, 45 new female students started studies in UiA's engineering education. After four years of focus on girls as a target group in general and on girls and technology in particular, 114 new girls started the same studies in 2008.

[10] The Confederation of Norwegian Enterprise (NHO), The Norwegian Society of Engineers and Technologists (NITO) The Norwegian Society of Graduate Technical and Scientific Professionals (Tekna)The Norwegian Confederation of Trade Unions (LO)

The Science Centres have been a success in the effort on sciences. A relatively modest government effort has triggered large funds from the business community and local actors. The Government will therefore continue and further develop the Science Centre Programme for the period 2010-2014. The Science Centres will to a greater degree gain position as regional resource centres. Existing Science Centres must be strengthened before new ones can be established.The regional Science Centres shall have a lifelong learning perspective and aim at the general public and education. Science Centres shall have competence in interactive communication and be a resource in teacher education. Furthermore, they shall develop the cooperation with various local communicators of scientific information within their region, as science and natural history museums, Newton room and other conveyors of scientific competence. The Ministry of Education and Research wants the centres to have improved dialogue with the users to insure that their services increasingly will be sought after, and to insure that they are better suited to be able to provide answers to the actual needs of the school.

Increased Recruitment

In order to increase recruitment to MST subjects in higher education, research and employment, it is also important to make Science more realistic and meaningful for pupils. The individual school and school owners shall be motivated to make the education in Science relevant and practical through deliberate choice of activities and equipment that will be motivating for both boys and girls. On the basis of the importance the Science Centres have concerning the choice of science subjects, the use of the Science Centres makes a good contribution.

In order for students to understand what Science is used for and to see Science as relevant for their own choices, the schools shall to a larger extent have regular contact with the trade and industry. Not the least, it is important that employers contribute themselves to present careers based on competence in MST as attractive. The NHO project "Business and Industry in School" will continue to develop partnership agreements between schools and local businesses in order for the companies to act as arenas of concretisation for schools.

A two-year project regarding girls and Science as a part of the action plan for gender equality 2008-2010 will be started. The project aims to develop measures in order to increase recruitment of girls to Science. The project will look at content, organization and working methods. The national centres for Mathematics and for Science are together responsible for the project. The work will build on experiences from the project Minerva and from the knowledge base developed through the research in the project "Vilje-con Valg" at the National Centre for Science Education.

Experiences from the projects *TENK* and *SEIRE* will be continued in the national programme *ENT3R*. *ENT3R* will be a student-driven motivation programme where students in science subject studies are mentors who provide training in mathematics and act as role models for pupils in lower secondary schools and in upper secondary education and training. The RENATE Centre will be responsible for implementation of *ENT3R* and is aiming that *ENT3R* will be established at each of the 23 actual higher education institutions in Norway during 2012.

Work will be done in order to expand the competence requirements to apply to all teachers in Mathematics and Nature Sciences at the primary and secondary levels of the school.

Interest in Science increases as pupils and students experience the relationship between knowledge contents, teaching methods and applications. Training for entrepreneurship is an example of such a successful way to create context and motivation. Through the recently adopted action plan for entrepreneurship interesting opportunities to strengthen interest in Science are opened.

Pursuant to the Report to the Storting No. 44 (2008-2009) Education strategy greater focus should be put on content and quality of career guidance for pupils

regarding study choices. Government funding regarding competence development for school counsellors should still be given through the strategy Competence for Quality. The RENATE Centre will work in order to offer school counsellors good competence regarding MST in higher education and in working life.

The subject Education Options and the experiments with the subject Working Life in lower secondary schools provide opportunities to show application of Science and the importance they have in education and employment. It will among others things give understanding of the importance of Science in different parts of employment.

5.3 The Teacher

SUBSIDARY OBJECTIVES:

- **The number of teachers with at least 30 credits in Mathematics and Natural Science in the 1st to 7th grade and at least 60 credits in the primary and lower secondary level shall increase by at least 1000**

It is a primary assignment to increase teachers' qualifications in science subjects. Through the new teacher education the students have greater opportunities to specialize in Mathematics and Natural Science. Students' choices and the offers given in teacher education programmes must be followed closely in order to ensure that sufficiently many choose specialization in Science and receive education of high quality.

Because so many teachers lack the necessary competence in science subjects, it will be necessary with a systematic enhancement of competence through continuing and further education and training for teachers. A new competence regulation requires new teachers hired to teach Mathematics in lower secondary schools to have 60 credits in the subject. The change in the regulation also provides guidance regarding the competence level necessary for all teachers who teach Mathematics in lower secondary schools. In order for the pupils to gain knowledge and motivation for the subject it will be very important that the further education not only offers subject specialization, but also didactic specialization. Work will be done in order to expand the competence requirements to apply to all teachers in Mathematics and Nature sciences at all levels of the primary and secondary school.

It is the responsibility of the school owner to ensure the necessary competence and to offer competence development. Through local priorities and national initiatives, including the strategy *Competence* for *Quality*, Science must still be given priority.

In order for the individual continuing and further education and training at each school to take full effect, the individual teachers' newly gained competence must at the same time be met with local school development in subjects. This takes place today in some schools, but the topic is not treated systematically on a larger scale. A model for professional network building in the science subjects at schools and between schools locally will be tested in order to strengthen the local professional school development related to the subject environment at the individual school. The local network works together with a supervisor from a teacher education institution. The national centres for Science and for Mathematics have the responsibility to develop the project and to monitor the supervisors.

We must expect that very many science teachers in upper secondary education and training will retire during the next few years because of high age. We are facing a generation shift; hence we need to strengthen both the competence of teachers in Science, and to recruit more teachers. On a general basis the partnership *GNIST* has initiated measures to increase recruitment of teachers. Special recruitment of teachers with good competence in science subjects will be done within the *GNIST* effort. Areas of cooperation for teachers and working life and exchange arrangements will be developed further for mutual learning and exchange of experience.

The experiments with the "*Lektor 2*" scheme will be continued and developed further. In this scheme expertise from working life is used to assist in education

THE ROLE MODEL SIRI KALVIG

Role models are important to motivate young people to choose higher education and professions in MST. There have been few female role models in these areas. Girls have thus had few to identify with. Therefore it has been easy to get a picture of science as something masculine. However, there are good role models who also inspire girls to choose science. Meteorology is a good example , being a subject where physics, among other, is weighty. In a few years, the subject has gone from being one of the most male-dominated to at the present being among the more popular subjects among female students. A key reason for this trend is likely the meteorologist Siri Kalvig. By her entry on Norwegian TV screens, Kalvig has appeared as an interesting role model for her profession. At the same time she has shown that Science may have a practical and socially beneficial function, strengthening the motivation to choose the subject. As a meteorologist and climate campaigner she has helped to create a new image of the characteristics of a meteorologist. Kalvig is now working on an "Industrial PhD" while working in business.

in science subjects. The school collaborates with local business and industry in development of training measures that highlights the relevance of subjects and contributes to fulfilling competence goals. A broad reference group will help to realize the scheme. The role of the teacher will also in other manners be made visible and made more attractive to attract strong candidates for the profession. The system of remission of student loans for master students, who choose education as teachers, will be followed up in order to make the arrangement known and to make possible adjustments.

Science subjects are still topics where the boys show the greatest interest and are most motivated. To some extent they perform better than girls. It is an aim to give teachers increased awareness concerning choice of content and working methods that satisfiy both boys and girls and to provide assistance to translate this into practice in education. The RENATE Centre is working to increase awareness of female role models in education.

5.4 Higher Education

SUBSIDARY OBJECTIVES:

- **The number of graduates with education in MST shall increase by at least 15 per centage points**
- **The subject didactics in MST studies shall be strengthened**
- **Improved quality of education in MST**
- **Increased social relevance of education in MST**

Increased Recruitment

The Government wants to continue the focus on the RENATE Centre. The centre has during the previous strategy among other things developed a national model for training in Mathematics for pupils in upper secondary school and national distribution of this model was agreed on in 2009. The RENATE Centre has an important role not only in relation to general recruitment to MST studies but also specifically in relation to improving the present lopsided gender balance.

The National Centre for Science Education will also, through the research project "*Vilje-con-valg*", be an important contributor regarding knowledge about the adolescent's choice and opt-out of science subjects studies. This is a responsibility that the Ministry of Education and Research, educational institutions and trade and industry together must follow up.

The Ministry will consider several alternative career paths to higher education in technological subjects based on the positive experience with the so-called VET-pathway to engineering[11], where pupils from selected vocational education and training programmes complying with given conditions are given admission to education in engineering. Candidates admitted to studies through the VET-pathway complete the study in the same manner candidates admitted through the regular admission do, and they have proven to be attractive in the labour market. The Ministry wishes therefore to pursure alternative routes into higher education. The extent of admissions through the VET-pathway has increased sharply, and it is important to ensure the quality and national coordination of this arrangement. In line with the recommendation of NOKUT, the Ministry will look at the arrangement with an eye to quality assurance. Local admission, particularly the VET-pathway and the three-semester system (TRES), will be assessed and quality assured during 2010.

The experienced work relevance and applicability of the studies is a challenge for the educational institutions.

Gender balance in MST studies is still lopsided. The Ministry of Education and Research has during several years allocated funds to the RENATE Centre in order to increase diversity in MST education. It's also an effort the Ministry wants to continue in the present strategy. Both the Ministry and the educational institutions must have a special focus on better gender balance in their recruitment initiatives. Recent measures to improve the gender balance are the use of role models, mentors and the development of female networks. It will be important for the educational institutions to promote women in managerial positions.

One way of motivating young people to choose science is to show how the education can be used in the workplace and especially to point to attractive career paths. The National Centre for Science Education has already mapped out what motivates young people to pursue science. The results from the project will be a very useful base of knowledge for the development of measures under the present strategy. Te sell the importance of studies within MST will be an important priority area regarding young people's transition from upper secondary school to higher education. Thus, mentor arrangements and role models from both higher education and employment will be very relevant . At this point, both employers and employees' organizations should enter the field and contribute to more and better information for the applicants to higher education.

The RENATE Centre has initiated the establishment of a national role model agency, consisting of good ambassadors for a variety of educational pathways and professions in MST. Lower and upper secondary schools can book visits from role models and may also visit them at their workplace. This measure will be important in the continued motivational work in order to increase recruitment of young people to MST.

Throughput of Students

Regarding students` completion of MST studies, as mentioned earlier two challenges are evident; 1) the dropout rate is too high, and 2) the students who finish/graduate have too low progress in relation to the normalized 60 credits per year and, thus, are delayed in their educational pathway/track. This requires cooperation between the Ministry of Education and Research, institutions of higher education, and primary and secondary education and training.

To counteract a disproportionately high rate of dropouts among female students work should be done to make studies more relevant for them through both content and method within the studies. This is the responsibility of the higher education institutions to follow up.

[11] Y-veien

The experienced work relevance and applicability of the studies is a challenge for the educational institutions. This challenge can be met by using the work place as the venue also for education. MST studies should be experienced as useful and relevant to working life for the students, even for studies that initially have the highest degree of research-based and academic structure. Such cooperation between educational institutions and working life can take many forms. It could be about more practice in education (also practice in use of English as working language is important), it may be cooperation in research, the institutions can bring educators from working life (such as the introduction of the "*Lektor 2*" scheme in the higher education sector), and it can be internship for teaching staff. Different career paths must be made clearer for both students and potential applicants. This is the responsibility of the institutions of higher education to follow up. We will look deeper into the social importance of education below.

Strengthen the Quality of Education

Higher education in MST in Norway is of good quality. Still there is room for improvement as showed in the 2008 evaluation of the educations in engineering. It is necessary to strengthen the pedagogical and didactical competence of the teaching staff. The Norwegian Council for Higher Education was assigned funds in 2009 from the government, in order to develop a course in engineering didactics to be offered for the first time in 2010. After the testing of a pilot course it is the Ministry's wish an adapted form of this course to be offered to all teachers in engineering education in Norway. Subject didactics in sciences studies must also be improved. In the context of the teacher education reform the Ministry has investigated the possibility of creating Centres of Excellence in Teaching after the model of Centres of Excellence in Research. After testing this in teacher education it will also be relevant to transfer the model to education in MST. Both the Ministry of Education and Research and the institutions of higher education have to work determined in order to strengthen the competence in subject didactics in the educational system.

Work to provide an education that is largely based on research must be given priority by the boards and other leadership of educational institutions.

COMPUTER SCIENCE IN EDUCATION

The CSE-project (Computer Science in Education was developed by the Faculty of Mathematics and Natural Sciences at the University of Oslo (UiO). The project involves students learning to solve mathematical problems using computer from the very start of the bachelor studies. The discipline is named Numerical Methods. The problems are realistic tasks where students are experimenting with the reality they are concerned about.

The University is the first university in the world where first-year students are using advanced calculations on a computer. Other universities wait to introduce numerical methods to a much later part of the studies, usually not before the graduate studies. As the UiO views it, it is a pedagogical measure to start this interaction at once. Thus the studies becomes alive and relevant from the first day, and a long initial period of theoretical character that makes many students losing motivation is avoided. In addition the students get a view of what is happening in the research front.

All higher education in Norway shall be research based. Evaluations of various educations have shown that one must work further on regarding this point, this also being the case in MST education.

The Research Council in 2009 offered eight research environments status as Research Centres for Environment Friendly Energy (FME). An effort has to be done in order for these centres, as well as other major commitments in research, to benefit primary and secondary education. Work to provide an education that is largely based on research must be given priority by the boards and other leadership of educational institutions.

We live in an increasingly globalized world. Candidates with education in MST increasingly have a global labour market to relate to. It is therefore important with internationalization in higher education. This can be done in different and complementary ways. Increased proportion of students who take part of their studies abroad is a contribution. In addition Norwegian institutions of higher education are becoming even better in attracting foreign students who will give exciting input to the studies and education environment. A higher proportion of academic staff with international experience is also important for the quality of education in the field of MST.

All evaluations points to small and fragmented groups as a central problem in Norwegian research and higher education. Many settings appear to be relatively vulnerable having low academic quality. This is not an ideal situation. The Ministry's opinion is that putting greater emphasis on cooperation might strengthen academic communities, work sharing and subject focus (SAK). This will have a significant positive effect on the quality of studies in MST. Many cooperative projects at regional level have already been implemented. An example is the technology pilot in the Oslofjord Alliance. Cooperation, work sharing and concentration can take many forms and it is important for the institutions to find a form that is suitable for their own academic communities. The Government has supported this type of processes so far, and will continue to do so.

Strengthen the Social relevance of the different Educations

The Government wants to strengthen the cooperation between education and working life. This may be especially important in Mathematics, Science and Technology. Social relevance is an important aspect in qualitatively good education and we will work to strengthen this feature. It is important that each candidate graduating with an education in MST is well

prepared for a long working life with several job changes during his/her career. Higher education does not provide completely qualified candidates; however, higher education shall provide a basic education forming a foundation for professional practice and further learning in the workplace. In the Report to the Storting No 44 (2008-2009) *Education strategy* the Government has, among other things, proposed the formation of councils cooperating with the working life (RSA).

Educational institutions shall continue, in cooperation with the councils, to draw up strategies for cooperation with employment. This includes the strategy for further and continuing education and training, a field that is increasingly important in a working life that to an ever-expanding extent is based on human resources. This Report to the Storting also describes practice as an integral part of the education. At this point several different solutions exist. Some are already being tried out and several more are put to trial. The government wants to strengthen practice in the education.

The National Qualifications Framework was decided on in March 2009, and this framework will be implemented in all institutions of higher education by 2012. The qualifications framework describes on a superior level the competence the candidates must possess when they complete their degree. The implementation of the qualification framework will be important in order to ensure relevance in education.

The Government also considers increased focus on entrepreneurship as an important contribution to increased social relevance. In September 2009 an action plan *Entrepreneurship in Education* and Training was presented. In this action plan there are several measures that will strengthen the relevance of scientific and technological education.

5.5 Research

SUBSIDARY OBJECTIVES:

- **The quality of the strategic areas shall be increased**
- **Research relevant to trade and industry in key areas is to be promoted**
- **The proportion of research fellows who finish their doctorate within six years after commenced education, shall be increased to 85 per cent in MST**

Enhanced Quality

Norway has excellent research communities in several science-related fields, including polar research, climate and environmental research, energy research

THE ABEL PRIZE

The Abel Prize is awarded annually to international researchers who have excelled in the field of Mathematics. The award will help to raise the status of Mathematics in society and to stimulate children and young people to become interested in Mathematics. Niels Henrik Abel's Memorial Fund was established 1. January 2002 with the main goal to hand out the Abel Prize for outstanding scientific work in Mathematics. The prize is worth 6 million Norwegian kroner, and has been awarded annually since 2003. The prize is awarded by The Norwegian Academy of Science and Letters, having appointed an Abel Committee consisting of five mathematicians to assess the nominated candidates and to recommend a worthy winner of the Abel Prize. The Abel Prize is named after the Norwegian mathematician Niels Henrik Abel.

and marine research. In the coming years we will further develop research where we have good communities and natural advantages. At the same time, we will focus on new areas where we have good prospects of creating research of high quality. An example on such a topic is marine bio prospecting. During the past years there has been a large activity in marine and biotechnology research and innovation and through strategic initiatives expertise and infrastructure have been developed. This forms a good basis for further efforts. Another example is solar energy, where Norwegian researchers and actors in industry over the last few decades have developed world leading settings in solar technology based on already existing communities.

The research policy has specifically been focused on building sturdy knowledge communities within selected areas. Establishing the system of Research Centres for Environmentally Friendly Energy (FME) is one such initiative where selected research communities and business and industry work together to invest in technology within particular themes. The communities involved get predictable frameworks and are given the opportunity to invest strategically in selected research areas, making it possible to do research and technology development of high international standard. The centres will also stimulate education of researchers. The eight centres established, include science-related themes such as carbon capture and storage, offshore wind power, bio energy, solar cells, energy-efficient and environmentally friendly buildings and design solutions for renewable energy.

In the coming years we will further develop research where we have good communities and natural advantages.

The effort, Large-scale Programmes, in the Norwegian Research Council provides strong and long-term financing of priority areas in the research policy. All together there are seven programmes covering research in science-based subjects such as Biotechnology, ICT, Nanotechnology, fisheries, climate, clean energy and petroleum.

Research is the basis for the solutions of many great knowledge challenges facing the society, related to among other things health, climate and energy.

Funding of research is also used strategically to encourage quality both in top and width. The Government will now introduce the Centres of Excellence in Research (SFF) as a permanent arrangement. The scheme shall stimulate Norwegian research institutions to establish centres devoted to long-term, basic research at a high international level, and aims to raise the quality of Norwegian research. There are several established centres of excellence in science subjects, including Centre of Mathematics for Applications at the University in Oslo, and these also serve as sources of inspiration for increased recruitment to Science through increased awareness around the subjects. In addition Centre of Mathematics for Applications has started a new educational programme Applied Mathematics and data.

Future businesses and solutions of future challenges facing society will build on knowledge that originates from all the research communities.

In connection with the agreement on Norway's climate policy reached between the main political parties in Norway, the Norwegian Government has increased spending with about 600 million NOK on research and development within the areas of renewable energy sources and carbon capture and storage The establishment of the eight centres for environmentally friendly energy (FME) has been funded by this. In addition 50 million NOK in the government budget strengthened the remaining climate research for 2010. These funds will include creation of a climate research centre in Bergen. The Ministry of Education and Research wants to prioritize basic research, infrastructure, education of researchers and recruitment and international research cooperation within these funds. A significant proportion of the funds used to the follow-up of the agreement on Norway's climate policy are linked to Science in general and Technology in particular. This goes for renewable energy and for carbon capture and storage and for science related to climate changes and the consequences thereof.

The Report No 30 (2008-2009) to the Storting, *Climate for Research* points to an increased investment in research infrastructure. The aim of the investment in research infrastructure is to provide researchers with the equipment they need to meet the major challenges of knowledge and to meet the needs of business and industry regarding efficiency and high quality research. A large proportion of the funds for equipment and infrastructure will be allocated to science. From the government budget for 2010 and on, separate funds taken from the returns of the research foundation are assigned to research infrastructure, this amounting to about 280 million NOK in annual funding from 2011. According to the research report these funds should be used to ensure research infrastructure of national interest, and with stronger requirements for cooperation.

International cooperation helps strengthen the quality in research. The research report provides for increased internationalization in research, and work is carried out regarding this area both through bilateral agreements with selected countries and in multilateral forums such as the EU's 7th Framework Programme and in UNESCO. In the research collaboration with a number of countries as the United States, China, India and Japan, emphasis is put on climate, energy and health. A large percentage of the funds in international research collaboration are assigned topics that are science-related.

Quality in research depends on the success to recruit the ablest among both women and men. In general, there are few women in academic top positions, and the least is the proportion within MST. In 2007 the percentage of female professors was 10 in Mathematics and Natural Sciences and there was 6 per cent in Technology. Measures are therefore needed in order to contribute to more women wishing to continue doing research and qualifying for top positions. Institutions of higher education have action plans for equality. Mentor programmes, networks, start packages and leadership development programmes are examples of

measures that the institutions adopt. The research report puts forward proposals for two new measures in order to promote gender equality in research. On this basis, an incentive scheme to increase the proportion of women in higher academic positions within MST will be implemented. In addition, new qualification measures to maintain and develop competence for women in male-dominated environments in order for them to qualify for higher positions will be examined.

Promoting Industry Relevant Research

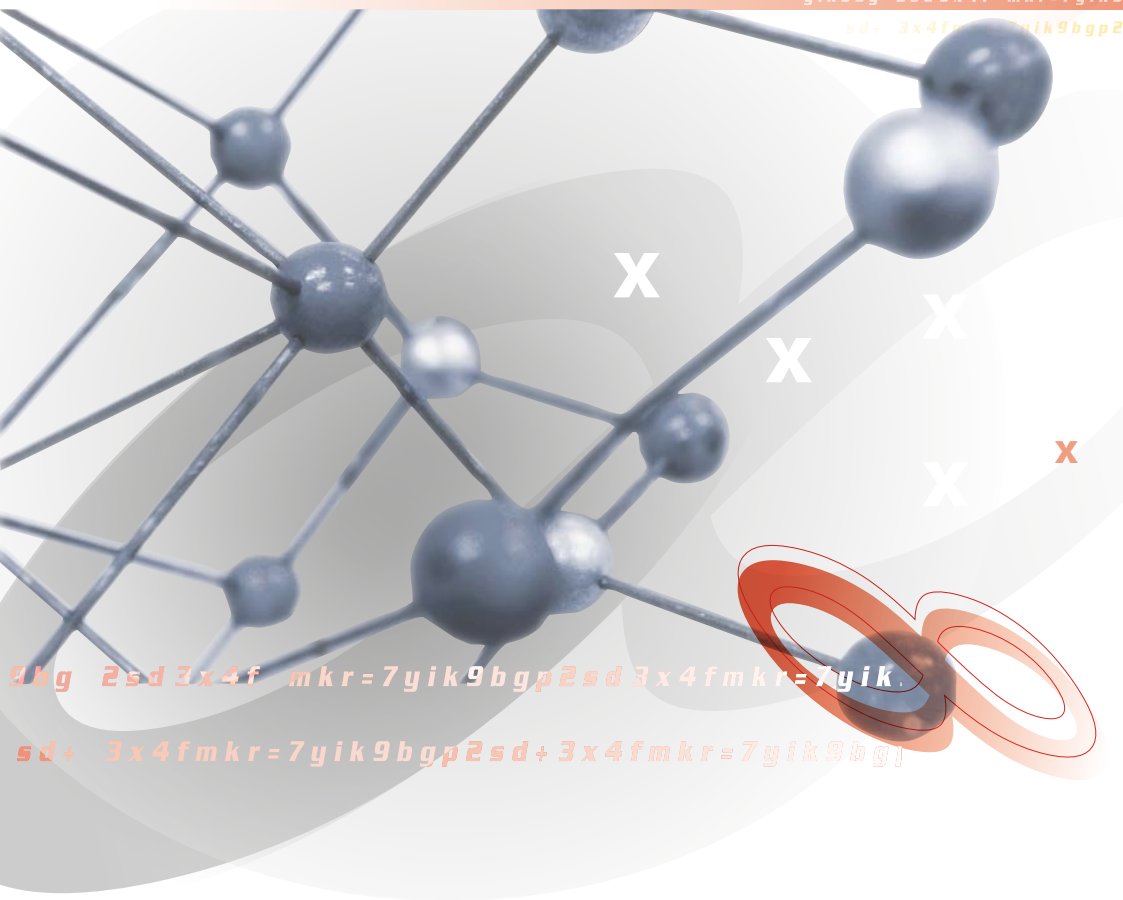
The research report states that we shall work systematically to develop a base of knowledge in the broad technology areas (ICT, biotechnology, materials science/nanotechnology) with an idea to develop balanced strategies for basic research, industry-oriented research, development and commercialization within these areas. ICT, Biotechnology and materials science/Nanotechnology are generic technologies that have large and long-term impact on industrial and social development and scientific development in general. Innovations in these technologies often interfere with and reinforce each other. In this context, science researchers with qualifications in Science are important. ICT is growing rapidly in Norway, and is today one of the nation's largest industries.

First-hand knowledge of production technology, processing and use of different materials is a prerequisite for maintaining a competitive commodity production.

Norway is a major producer and an advanced user of materials. First-hand knowledge of production technology, processing and use of different materials is a prerequisite for maintaining a competitive commodity production. When the NANOMAT commitment expires in 2011, a new nano-strategy will form the basis for further work. Internationally biotechnology is one of the key growth sectors. All development in biotechnology industry strongly needs research-based knowledge. In order to

CHANGE FROM THE TOP

At the very male-dominated Department of Physics and Technology, University of Bergen (UiB), the number of female scientific employees increased from one to four of a total of 35 employees within six years. New promising female postdoctoral and doctoral fellows are now part of the system. The explanation is conscious, purposeful recruitment efforts from the management. The leader Jan Petter Hansen has always been clear on that if you are to recruit the very best future scientists, you increase your chances to acquire them by choosing among the entire population, instead of one half. Students need to experience this through female lecturers. Gender equality must be part of the academic strategy, i.e. one need to consider gender balance when positions are available in areas where developments are desirable. One needs to actively look for skilled women that can be encouraged to apply. Hansen also says that the female researchers have been very able to promote the areas externally, and have accounted for a much larger relative proportion than men in the externally-oriented activities at the institute.



develop and implement Biotechnology in Norway, we must have broad scientific expertise, also in MST, while at the same time efforts must be done in areas where we have national advantage.

Good framework conditions in terms of modern laboratories and access to necessary equipment is essential to attract the best brains.

Increased Recruitment to Education of Researchers and the Research Profession

Student active research, i.e. to involve students in research projects in parallel with their ordinary courses, is important for future recruitment. By assisting in research projects students get more insight in both academic issues and in being a researcher.

PhD studies starting at Master's level with direct transfer to PhD programmes after one year may enhance the recruitment to research. The measure will prevent skilled and motivated students dropping out, after finishing their Master, because no research fellowships are available. The arrangement must be studied closer before increasing the number participating in this type of education.

The arrangement of taking an "Industrial PhD" enhances researcher recruitment to trade and industry. Companies are employers for the students while they acquire a PhD, and cover half the cost for such a fellow. In 2008 10 grants were announced in this programme, this increased to 50 in 2009. The requirement to join the programme is that the candidate is approved as a doctoral candidate at an institution of higher education and that the candidate can receive guidance both in the enterprise and from the educational institution. Admittance, quality requirements and approval are the same as for ordinary doctoral degrees. It is the needs of the business community that governs the subject area and topic for the doctoral degree. In the nearly two years the programme has existed, almost exclusively projects in technology or science have been started. Although this is not an aim in itself, it suggests that this programme

EUROPEAN SPALLATION SOURCE IN LUND, SWEDEN

European Spallation Source (ESS) is one of 44 projects that have been selected for the EU's roadmap for Pan-European Research Infrastructure (ESFRI). The ESS will be the world's leading research infrastructure for the use of neutrons in materials research and life science. Scientists will get a tool with much higher performance than similar research facilities, and the neutron source is expected to bring fundamental new knowledge in areas like health, food safety, Biotechnology, Nanotechnology and energy. ESS will serve about 5000 scientists and have great significance for the development of the European Research Area (ERA). området (ERA).

will provide a solid contribution to the recruitment of doctoral students in technology and science in the future.

About one-third of those who earned a doctorate in technology and science in 2008 were foreign citizens. Although developments have been positive, it still remains a challenge both to strengthen the domestic recruitment to research in Technology and Science, and to keep on the excellent foreign candidates after they have completed their doctorate degree.

Continued investment in equipment and infrastructure is crucial. Good framework conditions in terms of modern laboratories and access to necessary equipment are essential to attract the best brains. In order to encourage young recruits to contact international interdisciplinary research communities in the top class good access to international research infrastructure is imperative. A good example is the Institute for Energy Technology (IFE) at Kjeller, which has entered into close research collaboration with the European Spallation Source Scandinavia under construction in Lund in Sweden. Through this partnership Norway will, through the IFE, offer young researchers in a number of subjects access to a totally unique European research infrastructure.

The research sector as an employer does also has a need for recruiting, not least essential for competitiveness in businesses in a long perspective. In order to ensure good and strong research communities in the higher education sector a part/proportion of doctora candidates must continue their careers in academia. Future companies and solutions of future challenges facing society will build on knowledge that originates from all the research communities.

Due to the society's need for researchers and in order to encourage a more research-intensive industry, the government will, among others, request institutions to consider research track master programmes in subjects with poor recruitment and consider research schools in priority areas and disciplines where the need for competence development and capacity expansion through recruitment is large. This will also be of importance to Science.

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