Table ronde 3: Sciences expérimentales et mathématiques : quels bénéfices mutuels ?

- Présentation du modérateur Michèle Artigue
  - ** **présentation Michele Artigue**
  - ** **résumé Michele Artigue**
- Mathematics and Science : Ideas for a Swedish project
  - ** **présentation Ola Helenius**
  - ** **résumé Ola Helenius**
- Science learning in a Europe of Knowledge: a perspective from England
  - ** **présentation Celia Hoyles**
  - ** **résumé Celia Hoyles**
- Innovations in Mathematics Education on European Level: a systemic approach
  - ** **présentation Volker Ulm**
  - ** **résumé Volker Ulm**

Table ronde 3
Experimental Sciences and Mathematics : What mutual benefits ?

Michèle Artigue, Université Paris-Diderot – Paris 7

This round table addresses a crucial issue both for mathematics and sciences teaching: that of their mutual relationships. It is usual to stress the specificity of mathematics among the other sciences, by arguing of the abstract nature of its objects and of its specific deductive method of proof. Such visions tend to occult the constitutive role that mathematics have always played and increasingly play in scientific conceptualizations, and conversely the role that problems emerging outside its own domain play in mathematical developments. Such visions also present a very limited vision of mathematical activity which is far from being restricted to the elaboration of deductive proofs. They are very often reinforced by school curricula and practices where each scientific discipline appears as an isolated continent. Such situation serves neither the cause of mathematics, nor that of sciences. As President of the International Commission on Mathematical Instruction (ICMI), I was thus very happy when I was informed that, in this conference focusing on the teaching of sciences, a place would be open for discussing the issue of relationships between mathematics and sciences teaching, and what we can do at the European level for improving the current situation.

Many questions immediately arise, and among these the followings:

- What can be expected from improved connections between mathematics and sciences teaching and why?
- How can these expectations be progressively achieved along the school grades, and what is needed for that?
- How can Europe support efficiently such efforts?
- What priorities, what agenda could make sense?

There is no doubt that the reflection to be developed does not start from scratch. Educational research has already addressed the issue of relationships between mathematics and sciences teaching from a diversity of perspectives. Many experiments, innovations, institutional actions have already been carried out. What can we learn from these? How to think and manage the up-scaling of the existing successful experiments often of limited scope?
Even if the question of relationships between mathematics and sciences education is not new at all, and can be traced in the history of mathematics and sciences education, there is no doubt that the technological evolution affects both our vision of it and the strategies and means at our disposal for addressing it. How can we put the digital world at the service of the required changes?
Whatever be the affordances of technology, the key of evolution in that domain as in any educational domain is the teacher. How can teacher initial preparation and continuous professional development support the required changes?

The round table is devoted to these questions. We will focus in it on compulsory schooling, having in mind that the mathematics and science teaching we consider aims at being accessible to all students, and make the success of all possible. Four experts have been invited to contribute. I will introduce them now, following the order in which they will speak.

Manuel de Leon Rodriguez, who is the current Director of the Institute of Mathematical Sciences in Madrid and vice-President of the International Mathematics Union, will thus speak first, pointing out that a major difficulty in mathematics education consists in making our students perceive that mathematics is a living discipline, closely connected with the most relevant problems of the modern world. He will advocate that the connection between mathematics and sciences on the one hand, the transposition into primary and secondary schools of mathematical research practices on the other hand, can help us overcome this difficulty.

Ola Helenius, who is Deputy Director at the National Center for Mathematics Education, University of Goteborg, will pursue the reflection, relying on ideas from a national project he is involved in, aiming at the improvement of mathematics education and co-operation between education in science, technology and mathematics in compulsory school. He will address the three following issues:

- the role that concrete objects and contexts can play in the emergence of mathematical concepts and how this can be combined with the development of mathematical abstractions; the ways relationships between mathematics and natural sciences can be efficiently transposed into education for the mutual benefits of mathematics and science education, and the students' diversity made a power not an obstacle.
- the evolution of mathematical tools required by scientific and technological education along the grades.

Celia Hoyles, who is professor at the London Knowledge Laboratory, University of London, and the current Director of the NCETM (National Centre for Excellence in Teaching Mathematics) will rely on her research experience on the use of technology for mathematics learning and on teachers' preparation and professional development for approaching the issues at stake from the technological and the teacher perspectives. She will stress the potential offered by digital technologies for establishing productive connections between sciences and mathematics teaching, through modelling activities, but also the attention to be given to continuing professional development (CPD) for teachers if one wants this potential become effective, and she will present some ideas of effective.

Finally, Volker Ulm who is professor at the University of Augsburg, and Head of the Chair of Didactic of Mathematics, adopting a systemic approach, will address the crucial issue raised by the successful development and subsistence of substantial innovations, pointing out the problems raised by the steering of complex systems such as educational systems are, and making suggestions for overcoming these at the European level inspired by the Pollen and SINUS programmes.

After their presentations, the word will be given to the floor, and I invite you to prepare reactions to the contributions, comments and answers regarding the questions at stake, and also raise important points that we could have missed.

Table ronde 3
Sciences expérimentales et mathématiques : quels bénéfices mutuels ?

Michèle Artigue
Manuel de León Rodriguez
Ola Helenius
Celia Hoyles
Volker Ulm

Les relations entre enseignement des mathématiques et des sciences

- Une question importante et complexe du fait :
  - des liens profonds qui unissent les mathématiques et les sciences, en tant que champs scientifiques,
  - des perspectives et pratiques dominantes dans l’enseignement qui tendent à considérer chaque discipline scientifique comme un continent isolé, et à opposer les mathématiques aux autres champs scientifiques.

Une multiplicité de questions

- *Que peut-on attendre d’une meilleure articulation entre enseignement des sciences et des mathématiques, et pourquoi ?*
- *Comment ces attentes peuvent-elles être satisfaites, progressivement, au fil des niveaux d’enseignement, à quelles conditions et avec quels moyens ?*
- *Comment l’Europe peut-elle soutenir efficacement de tels efforts ?*
- *Quelles priorités ? Quel agenda ?*

Une réflexion qui ne part pas de rien

- De nombreuses recherches, expériences, innovations, actions institutionnelles ont déjà été développées.
- *Quelles leçons peut-on en tirer ?*
- *Comment dépasser le caractère souvent local des expériences réussies, penser et organiser leur extension à plus grande échelle ?*

La technologie

- La question des relations entre l'enseignement des mathématiques et des sciences n'est pas une question nouvelle mais aujourd'hui les avancées technologiques nous la font percevoir différemment et nous donnent de nouveaux moyens pour l'aborder.
- *Comment mettre efficacement le monde numérique au service des changements nécessaires ?*

Les enseignants

- Comme pour toute question posée dans le domaine de l'éducation, aucune avancée durable ne peut être atteinte sans l'adhésion, la contribution, l'engagement des enseignants.
- *Comment la formation des enseignants, formation initiale et formation continue, peut-elle soutenir les évolutions souhaitées ?*

Les quatre experts contribuant à la table ronde

- *Manuel de León Rodriguez*, Directeur de l'Institut de Sciences Mathématiques de Madrid
- *Ola Helenius*, Directeur du Centre National pour l'Education Mathématique à l'Université de Goteborg
- *Celia Hoyles*, Professeur au London Knowledge Laboratory, Université de Londres, et Directrice du NCETM
- *Volker Ulm*, Responsable de la Chaire de Didactique des Mathématiques à l'Université d'Augsburg

Mathematics and Science

Ideas from a Swedish project

Ola Helenius, ola.helenius@ncm.gu.se
National Center for Mathematics Education, Göteborg University
Department of Science and Engineering, Örebro University
Department of Science, Engineering and

I will touch upon three aspects proposed for our group discussion

- the role that “concrete” objects and contexts can play in the emergence of mathematical concepts, and how this can be combined with the development of mathematical abstractions;
- the ways the productive relationships existing between mathematics and natural sciences can be transposed into education for the mutual benefit of mathematics and sciences education, benefiting from students’ diversity thanks to the development of adequate pedagogical strategies;
- the evolution of mathematical tools required by scientific and technological education as far as this education progresses along the grades;

Mathematics:

An abstract and general science for problem solving and method development.

Competence/proficiency based descriptions of what it means to know mathematics.

Working with mathematics means using natural sense making powers.

Science:

Knowledge about:

nature and human

scientific activity

how the knowledge can be used

Inquiry based - but with progression.

A relevance paradox

Mathematics is effective for solving many problems...
...but in many distinct situations it is more effective to do it without mathematics (if you do not already know the mathematics).

This is a problem when trying to use science to create relevance in mathematics.

...and maybe even a bigger problem when working inquiry based.

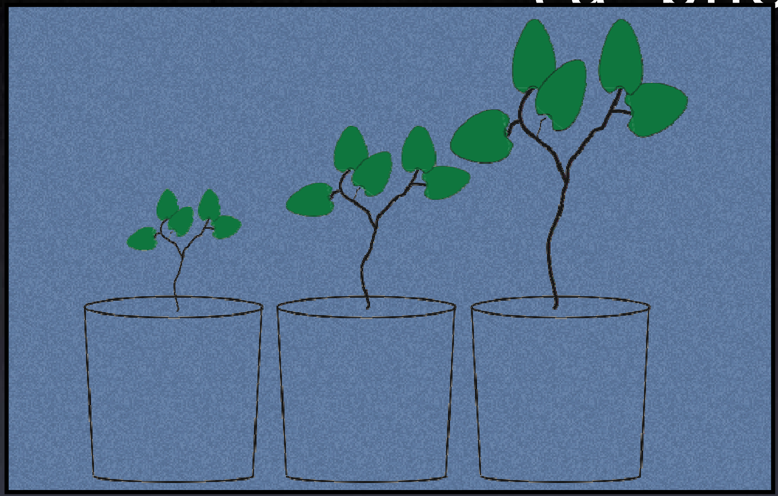
(“Without mathematics”: subtle distinction)

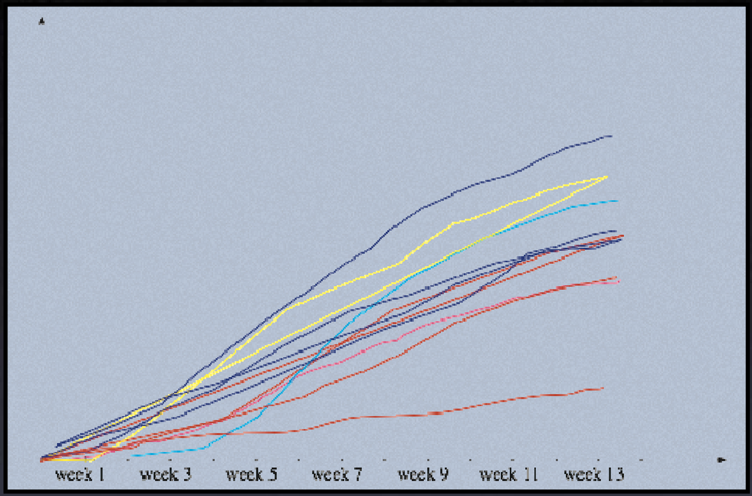
Separation of

- Progression in content
- Progression of scientific thinking and working
- Progression in working with mathematics and in using mathematical tools

Example: Sowing seeds

(a phenomenon)





Biological questions:
How many sprout?
How fast do they grow?
Environmental dependencies?
basic (light, water)
- advanced (photosynthesis, cell biology)

Scientific progression:
How specific questions?
How advanced discussions?
How sure about results?

Doing mathematics
Measuring (using ru
Coordinate systems
Mean values
More advanced stati
(significance etc)

Using mathematics:
Graphical representa

All four aspects can be varied from pre school level to university level independently of the others in this example.

Summary

- Inquiry based science teaching in three variants: Based around *phenomenon, concept* or *artifact*.
- Very adaptive. Opens up for progression in many dimensions. Can handle student diversity and still allow classroom discussions.
- Many different types of connections between science and mathematics
  (math as tool - conceptual connections - working aspects (inquiry) - relevance).
- Takes the relevance problem of mathematics seriously.

Short summary

Grenoble 15 min talk, Ola Helenius

By taking some examples from an ongoing science*-mathematics collaboration project in Sweden I will discuss primarily the three first points proposed for our panel, namely the relation between concrete objects and mathematical abstraction, the relationship between mathematics and science and the co-progression of science and mathematics through the school system (grades).
We characterize between a few different types of connections between mathematics and science, some related to the “content” and some related to what it means to work with the subjects. In an inquiry based approach, we identify three different ways of working: phenomenon centered, concept centered or artifact centered, that can be used for specific purposes. In an example from biology I will indicate how we can separate between four dimensions: content, “scientific thinking”, usage of mathematical tools and working with mathematical objects. In the same basic example, it is possible to vary each of these aspects from pre school level to university level. This does not only open up for possibilities to address pupils’ diversity while maintaining a base for classroom communication. I will also indicate how I think this can help in handling the relevance problem that mathematics is often plagued with.

*Science is used in the same way as in the Rocard report, ie to mean the physical sciences, life sciences, computer science and technology.

Science Learning in a Europe of Knowledge

Grenoble 8-9th Oct

Professor Celia Hoyles
Director of the NCETM

National Centre
for Excellence in the
Teaching of Mathematics

uniqueness of Mathematics

National Centre
for Excellence in the
Teaching of Mathematics

multliple faces of mathematics

- core skill for all
- subject in its own right
- **service subject for science, technology & engineering (STEM) &**
  - **... more and more subjects & careers**

each face has different demands for mathematics in terms of

- content & skill
- language & structure
- pedagogy & trajectory of learning

issues in teaching mathematics …and STEM

National Centre for Excellence in the Teaching of Mathematics

girls are

- less likely to be confident & take risks
- stress enjoyment & coping rather than usefulness
- continue if they feel encouraged

more issues for STEM

National Centre for Excellence in the Teaching of Mathematics

mathematics is the enzyme that catalyses STEM investigation & activity

les mathématiques agissent comme enzyme pour les matières scientifiques

Potential of digital technologies

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can make it easier to connect with

- learners’ agendas & culture
- goals in outside world
- the STEM agenda
  - explore a situation
  - build a **model** &
  - share, discuss, improve model

Modelling for STEM

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examples

- energy & movement
  - rolling marbles down a ramp, what for what angle does marble travel furthest? is it true for all marbles? predict & test for different marbles
- population growth
- predator/prey models
- disease
- poverty
- living graphs

modelling can be interesting, challenging & relevant for each component of STEM

but

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need to agree the vision in STEM community

- **joint** planning
- **iterative** design
- **joint** evaluation

importance of time and space for professional development for teachers

The National Centre for Excellence in the Teaching of Mathematics (NCETM)

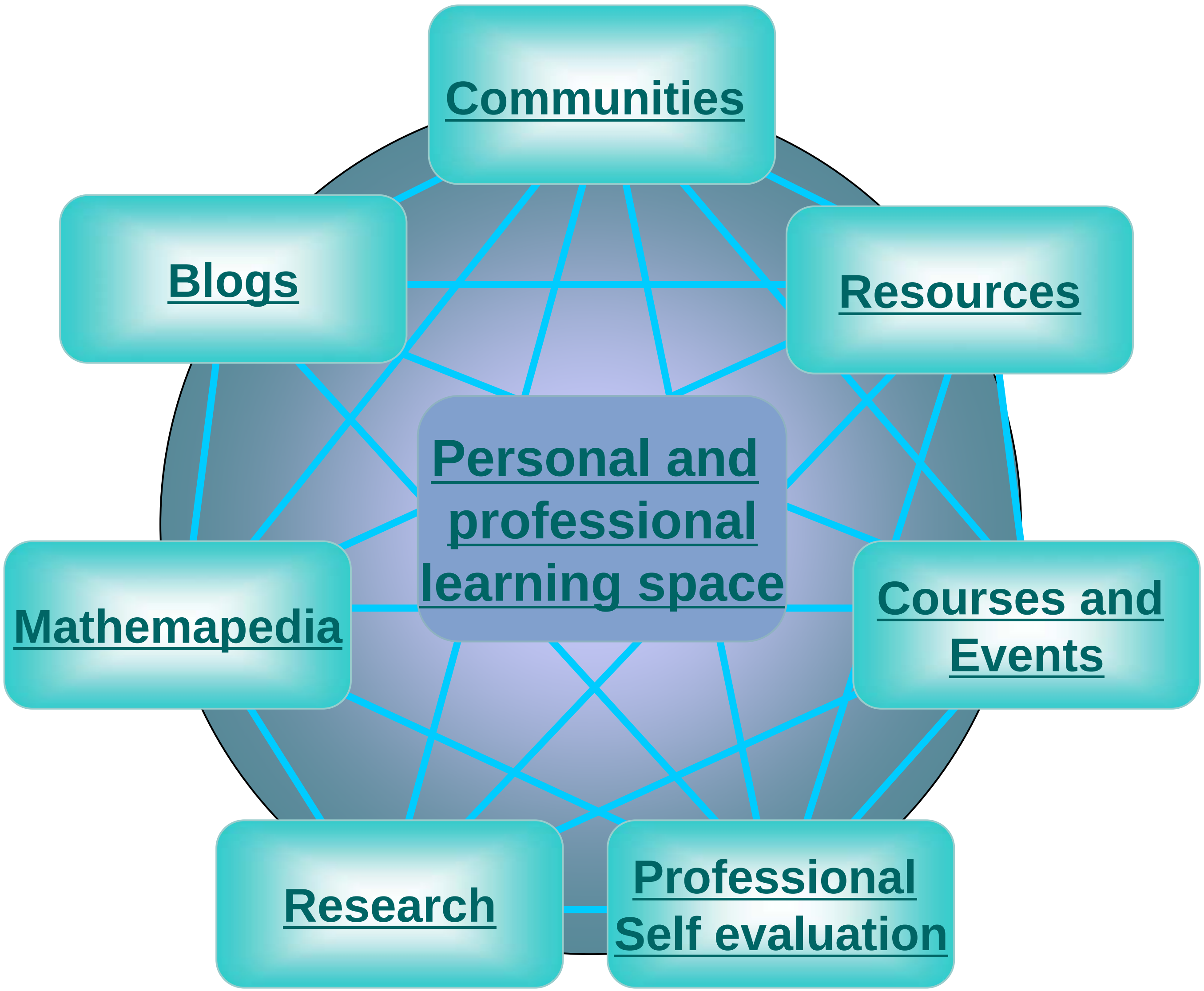
the Centre promotes a **blended** approach to professional learning through a combination of

- funded by Government
- **face-to-face** national & regional activity
- interactions with NCETM's **on line** portal

see www.ncetm.org.uk

NCETM's Professional Learning Framework

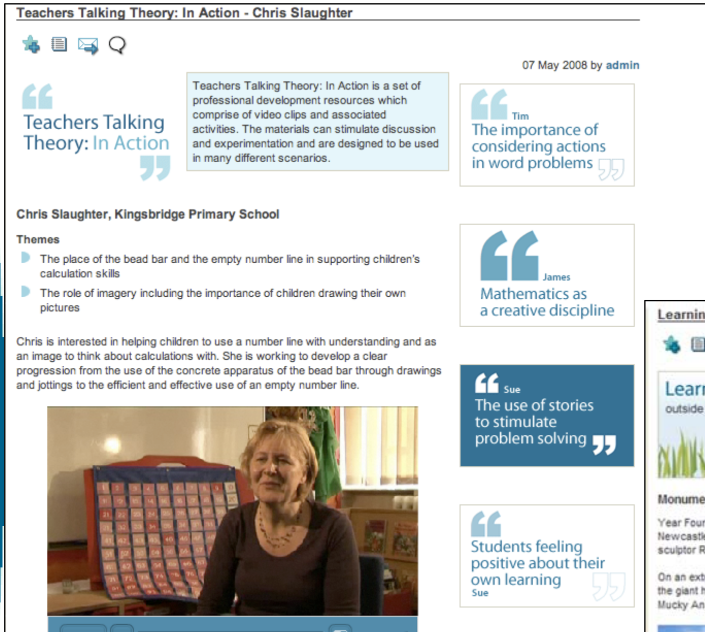
National Centre for Excellence in the Teaching of Mathematics



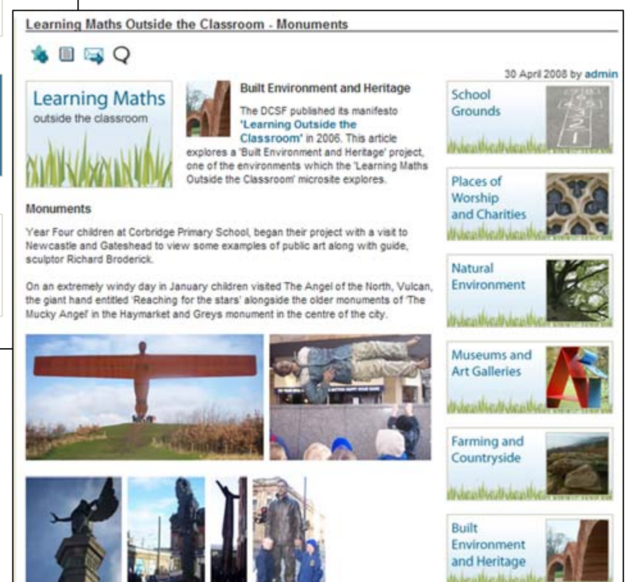
Resources

NCETM portal Micro-sites

National Centre
for Excellence in the
Teaching of Mathematics



Teachers Talking Theory in Action



Learning Outside the Classroom

Maths at Work: video clips "What mathematics would be involved in the work you have just watched?"

other initiatives in England

National Centre for Excellence in the Teaching of Mathematics

national network of Further Mathematics Centres. http://www.fmnetwork.org.uk/

every elementary school will have a mathematics specialist by 2012




National Centre
for Excellence in the
Teaching of Mathematics

NCETM community

Can we foster a European community around Mathematics in STEM?





thank you

merci

National Centre
for Excellence in the
Teaching of Mathematics

Science learning in a Europe of Knowledge: a perspective from England

Professor Celia Hoyles,
London Knowledge Lab, Institute of Education, University of London, U.K.
Director of the National Centre for Excellence in the Teaching of Mathematics NCETM

In thinking about the role of mathematics in science learning it is important to consider all the different roles that mathematics has to perform: as a core skill, as a subject in its own right and as a service subject for science. engineering and technology - as well of course for many other subjects. Each role places constraints on mathematics and the way it is taught. There are other issues that make teaching mathematics complex, for example, its reputation as being more difficult than other subjects, the stereotypes of success and the limits placed on expectations for example through setting, and the negative attitudes often held towards the subject. All these factors have led to some groups of students not persisting with mathematics, a trend widely noticed among girls; even girls who achieve highly tend to express lack of confidence in their mathematics ability and drop out as soon as they can.

Most concerned with science, would acknowledge the importance of fluency in mathematics but not an appreciation of the subject itself: in general mathematics is just invisible if it can be 'done', it is 'just a tool', and little attention paid therefore to how best to introduce relevant mathematical expertise in science settings. I suggested one avenue that might usefully be explored in interdisciplinary teams is through modelling with joint design, planning and evaluation. But for this initiative to have any chance of success, teachers must have time and recognition for professional development.

I am Director of the National Centre for Excellence in the Teaching of Mathematics (NCETM). Earlier this year (2008), it was announced that in the latest Comprehensive Review of Government Spending, there would be £140m available over the next three years (2008- 2011) to improve mathematics and science teaching, an amount that includes continued funding for the NCETM.

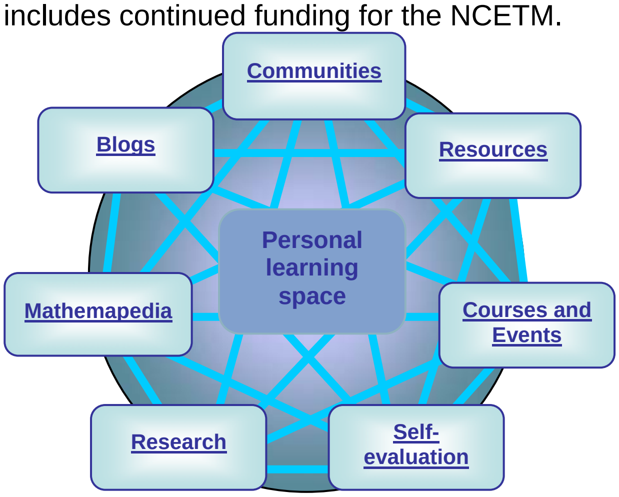


Figure 1: The NCETM's Professional Learning Framework

This long term funding is evidence of Government support for mathematics as at the heart of so much of education across all phases, and recognition of the importance of professional development for teachers of. mathematics The NCETM promotes a blended approach to continuing professional development (CPD) though face-face-face activities and through interaction on our portal www.ncetm.org.uk.
I showed and illustrated some of the parts of the NCETM's Professional Learning framework (see Fig 1) through which we are seeking to build a community of mathematics teachers across the country. And I ended with a plea that we together foster a European community around Mathematics in Science.

Innovations in Mathematics Education on European Level – A Systemic Approach

Volker Ulm, University of Augsburg

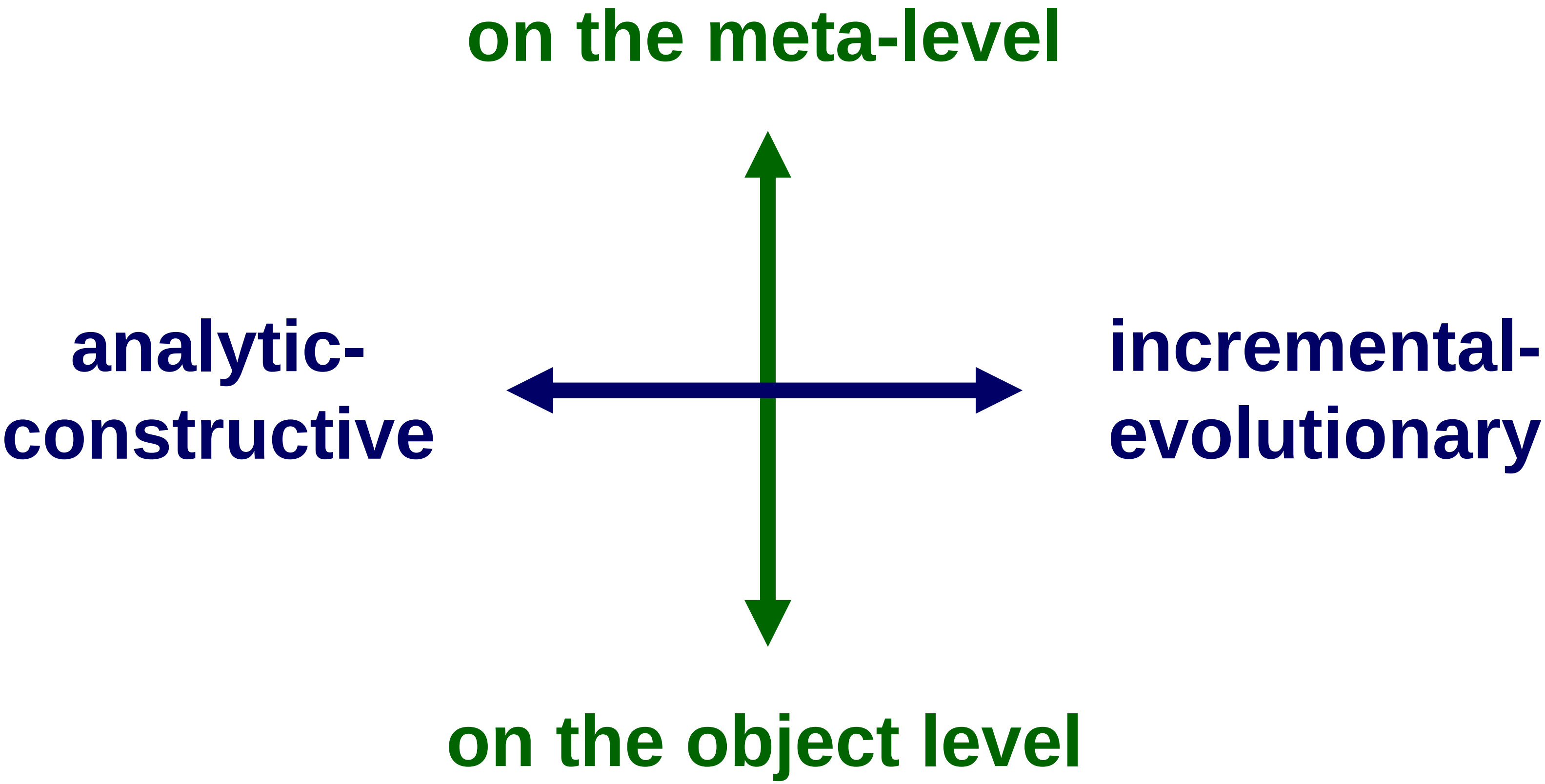
1. **Deficiencies**

2. **Innovation: Invention and Implementation**

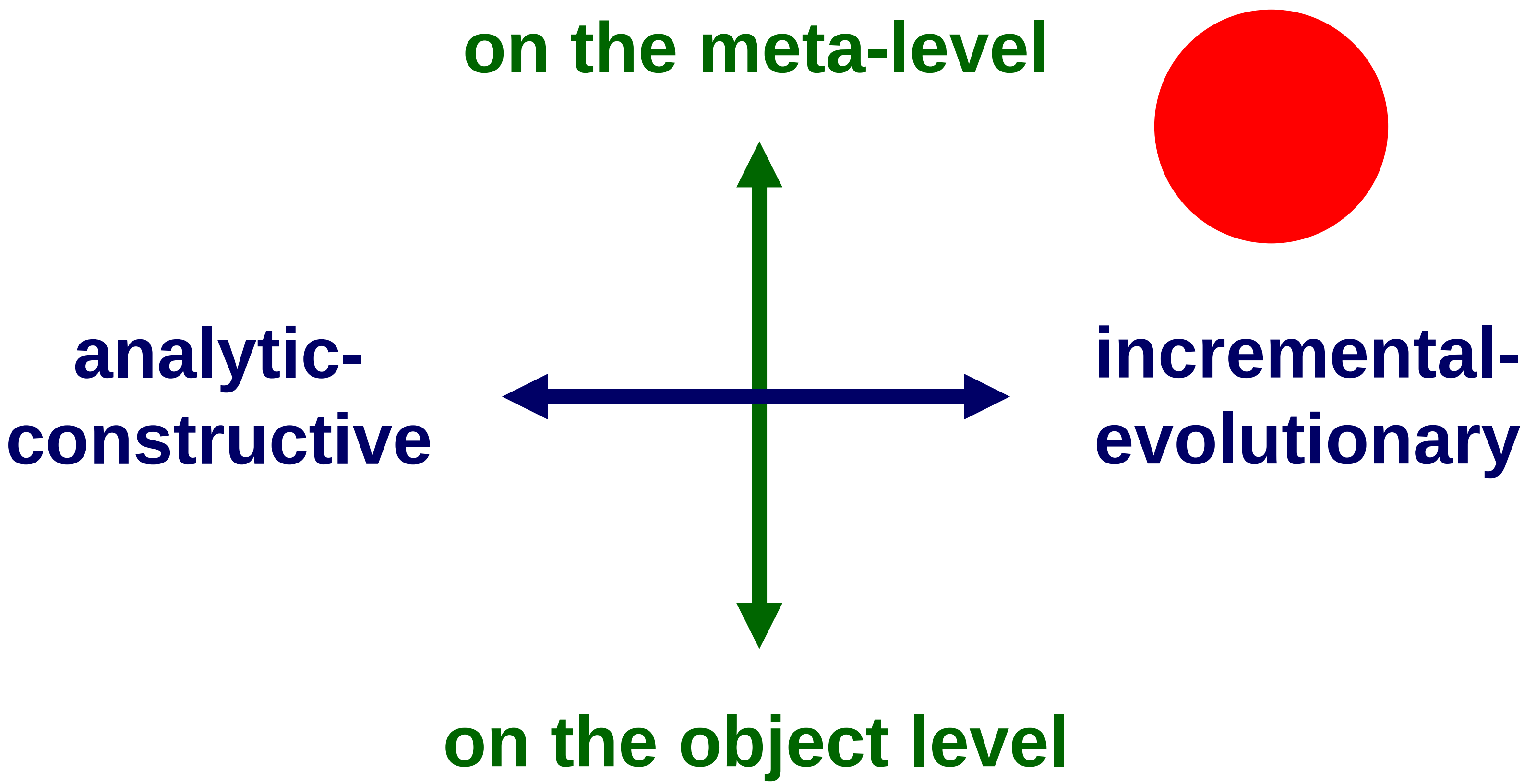
3. **How to change complex systems**

4. **Conclusion**

Steering complex systems



Innovations in complex systems



4. What should be done?

- aiming at teachers
- very large European programme
- main areas of activity
- aiming at the meta-level
- networks of teachers
- strong leading consortium
- processes take time

Innovations in Mathematics Education on European Level – A Systemic Approach

Conference "L'Apprentissage des Sciences dans l'Europe de la Connaissance"
Grenoble 08./09. October 2008

Prof. Dr. Volker Ulm
University of Augsburg, Chair of Didactics of Mathematics,
86135 Augsburg, Germany, ulm@math.uni-augsburg.de

1. Background: Deficiencies of Mathematics Education

International studies like TIMSS and PISA have revealed serious deficiencies of common mathematics education. Too many students lack in the ability to act on their own or to solve problems cooperatively. Their understanding for mathematics is rather superficial and their mathematical knowledge is quite incoherent. They fail in tackling mathematical situations that require creativity or thorough understanding of basic concepts. To some extent students are trained to imitate what they are shown by their teacher and are expected to memorize and apply given procedures. So innovations in mathematics education seem to be necessary.

2. Innovation as Invention and Implementation

The OECD defines an *innovation* as the implementation of a new or significantly improved product, process or method (OECD, Eurostat, 2005, p. 46). Thus an innovation requires both an *invention* and the *implementation* of the new idea.

In the educational system we are in a situation where lots of concepts, methods and tools have been developed for substantial improvements of teaching and learning. Three examples: Current pedagogical theories emphasize self-organised, individual and cooperative inquiry-based learning. There exist data bases and other collections of material for teaching and learning in a constructivist manner. A large variety of software and other tools is available for the integration of ICT in educational processes.

But for real innovations these promising theories and products have to be implemented in the educational system in Europe. Let's think at the three examples: Teachers should teach according to current pedagogical concepts. The proposed new task culture should become standard in everyday lessons. And ICT should be used as common tool for exploring mathematics.

So for substantial innovations we need changes in the notions of teaching and learning processes, in the attitudes towards mathematics and in the beliefs concerning educational processes in school. Hence the crucial question is: How can *substantial innovations in the complex system of mathematics education* be initiated and maintained successfully?

3. How to change complex systems

3.1 What is a complex system?

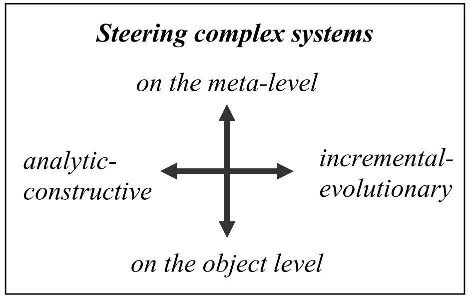
In theories of cybernetics a system is called *"complex"*, if it can potentially be in so many states that nobody can cognitively grasp all possible states of the system and all possible transitions between the states. Examples are the biosphere, a national park, the economic system or mathematics education in Europe (Malik 1992, Vester 1999).

Complex systems usually are networks of multiply connected components. One cannot change a component without influencing the character of the whole system. Furthermore real complex systems are in permanent exchange with their environment.

Maybe this characterization of complex systems seems a bit fuzzy. But, nevertheless, it is of considerable meaning. Let us regard the opposite: If a system is not complex, someone can overview all possible states of the system and all transitions between the states. So this person should be able to steer the system as an omnipotent monarch leading it to "good" states. In contrast, complex systems do not allow this way of steering.

3.2 Steering complex systems

The fundamental problem of mankind dealing with complex systems is how to manage the complexity, how to steer complex systems successfully and how to find ways to sound states.



With reference to theories of cybernetics two dimensions of steering complex systems can be distinguished (Malik 1992). The first one concerns the manner, the second one the target level of steering measures.

The method of *analytic-constructive* steering needs a controlling and governing authority that defines objectives for the system and determines ways for reaching the aims. Hierarchical-authoritarian systems are founded on this principle. However, fundamental problems are caused just by the complexity of the system. In complex systems no one has the chance to grasp all possible states of the system cognitively. So the analytic-constructive approach postulates the availability of information about the system that cannot be reached in reality.

In contrast *incremental-evolutionary* steering is based on the assumption that changes in complex systems result from natural growing and developing processes. The steering activities try to influence these systemic processes. They accept the fact that complex systems cannot be steered entirely in all details and they aim at incremental changes in promising directions. The focus on little steps is essential, since revolutionary changes can have unpredictable consequences which may endanger the soundness or even the existence of the whole system.

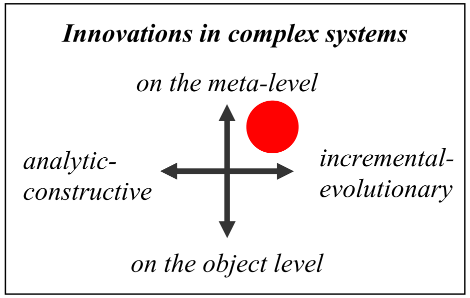
The second dimension distinguishes between the object and the meta-level. The *object level* consists of all concrete objects of the system. In the school system such objects are e. g. teachers, students, books, computers, buildings etc. Changes on the object level take place if new books are bought or if a new computer lab is fitted out. Of course such changes are superficial without reaching the substantial structures of the system.

The *meta-level* comprehends e. g. organizational structures, social relationships, notions of the tasks of system etc. In the school system e. g. notions of the nature of different subjects and beliefs concerning teaching and learning are included.

3.3 Innovations by incremental-evolutionary changes on the meta-level

How can substantial innovations in the complex system "mathematics education in Europe" be initiated successfully? The theory of cybernetics depicted in 3.2 gives useful hints:

- Attempts of analytic-constructive steering will fail in the long term, since they ignore the complexity immanent in the system.
- Changes on the object level do not necessarily cause structural changes of the system.



According to the theory of cybernetics it is much more promising to initiate *incremental-evolutionary changes on the meta-level*. They are in accord with the complexity of the system and do not endanger its existence. Nevertheless, they can cause substantial changes within the system by having effects on the meta-level, especially when they work cumulatively.

4. Conclusion: What should be done?

A short intermediate summary: We have seen that for substantial innovations in the educational system there is no lack of general ideas, pedagogical concepts or didactic tools. But there is a wide gap between theoretical knowledge and practice in school. So we have to develop strategies to bridge this gap. The theories of cybernetics give useful hints how that can be reached: Activities are most promising, if they aim at incremental-evolutionary changes on the meta-level of beliefs and attitudes of all persons related to the educational system – especially teachers and students.
How can this be done concretely? There is already experience e. g. from the European programme Pollen and the German programme SINUS.

(1) The key persons for innovations in school are the *teachers*. Their beliefs, motivation and abilities are crucial for everyday teaching and learning in school. One should set up a *very large European programme* which directly aims at teachers' work. In all countries in a first phase a critical mass of at least 8 % of all schools should be involved. In the long term one should reach at least 40 - 50 % of the schools.

(2) As developments should be incremental one should define *main areas of activitiy* like: Developing a task culture, autonomous learning, promoting student cooperation, cumulative learning and securing basic knowledge, learning from mistakes, interdisciplinary learning, promoting girls and boys, exploring mathematics with ICT.

Participating schools should first concentrate on one or a few areas. It is not promising to aim at total changes of mathematics education – because of the complexity of the system. However, such bounded fields of activity allow teachers to begin with substantial changes without the risk of losing their professional competence in class.

(3) Since developments on the *meta-level of beliefs and attitudes* are envisaged it is not sufficient only to distribute guidelines or material. Teachers should change theirs ways of teaching and behaving. For that teachers need

- regular and systematic teacher education offers,
- structures to work cooperatively with colleagues in regional networks,
- possibilities to exchange experiences with colleagues on national and international level and
- the freedom to try new ideas in their own school.

In recent projects like SINUS and Pollen *networks of teachers* on different levels have proven to be focal points of professional development. They can be regarded as *"learning environments"* for teachers. Teachers get acquainted with current pedagogical ideas, exchange experience and make steps towards systemic innovations cooperatively.
Moreover, networks of teachers and schools are essential means for dissemination processes (see 1). Experienced teachers coach colleagues from schools starting with innovation activities.

(4) Of course such far reaching efforts on European level need a strong *leading consortium* which combines the expertise from different stakeholders. In particular scientists have to carry and disseminate innovative ideas and provide theoretical background. Administrators should create links to the political level; they have to ensure the organizational functioning of all activities and their integration in the common educational system. Here we have to keep in mind that educational affairs are regulated on national or even regional levels. So from each (participating) European country several representatives have to be integrated in order to achieve acceptance and influence of the innovations in the different school systems.

(5) As deep systemic developments are evolutionary, all these *processes take time*. This seems to be rather trivial. But one cannot expect really substantial innovations in the European educational system within the usual project funding periods of 2 – 3 years. A more realistic time-frame covers 10 – 15 years. But for that we need prospective and foresighted political decisions to fund such long-term innovation programmes.

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Ján Figel'—Commissioner for Education, Training, Culture, and Youth

"L'apprentissage des sciences dans l'Europe de la connaissance"

French Presidency conference

9 October 2008 in Grenoble

Speech

(Acknowledge authorities in attendance)

Monsieur le Ministre,
Mesdames et Messieurs,
Chers amis,

Introduction (in French)

Je vous remercie de votre invitation à cet évènement dans cette belle ville de Grenoble. C'est avec un grand plaisir que je participe à cette conférence de la Présidence française. L'action de la France dans le domaine de l'éducation et de la formation est pour moi un encouragement et un signal très positif, qui nous invite à aller de l'avant.

Je crois que cette conférence représente une prise de conscience. Nous avons compris, aujourd'hui plus qu'hier, que la préparation des jeunes générations aux compétences scientifiques et technologiques est dans l'intérêt de la société dans son ensemble. Nous devons nous préparer à la "société de la connaissance" qui s'impose à nous chaque jour de manière plus évidente.

Nous ne partons pas de rien. En Europe, depuis des siècles, la science et la technologie font partie de notre patrimoine. Nos scientifiques, nos chercheurs, nos professeurs sont reconnus dans le monde entier. Je profite d'ailleurs de cette introduction pour saluer l'attribution des prix Nobel de médecine, ce lundi, à 3 médecins européens, dont deux Français. Je vois là un signe encourageant pour les jeunes scientifiques et chercheurs d'aujourd'hui, et ceux de demain.

Aujourd'hui, nous devons travailler dans deux directions. D'une part, former les scientifiques de demain. D'autre part, donner à tous les élèves la culture scientifique dont ils auront besoin pour réussir dans la vie.

The challenge

In a global world, Europe's most precious asset is its people – their skills and know-how, their ideas and innovation.

Quality education and training are indispensable, if Europe is to succeed – if we are to stay competitive, improve our standards of living, and keep our influence in the world.

And they are indispensable for our young people, who must be able to navigate a path securely and freely through the knowledge society.

Our children must leave school prepared for the world outside: ready and able to become active, engaged citizens; with the skills and attitudes to meet the demands and benefit from the opportunities of an ever-changing labour market; with the knowledge and creative capacity to shape our societies for the good of all.

Maths, science and technology education is a vital part of this palette of skills.

- Our schools and universities need to produce people who are capable of pushing back the boundaries of technology innovation. Technology doesn't just happen by itself. Technology is people – a whole chain of people who take the bright spark of invention and turn it into new products, new working methods, new ways of viewing the world.

But MST skills are not just for specialists. MST skills are <u>essential for all our citizens</u>.

- Increasingly, jobs need higher levels of skills. Already, **<u>more than half of all Europe's workers are using computers.</u>** The trend will intensify.

Our forecasts show a large increase in high and medium skilled jobs, and a sharp drop in jobs with little or no formal qualifications. As routine jobs die away, and creative tasks grow, people without basic MST skills will struggle to find satisfactory jobs.

- In addition, our daily environment is increasingly complex. We have to be able to grapple with difficult issues, whether this is a financial crisis or climate change. Without a measure of scientific and technological understanding, people may become frustrated and disengage from debate on ethical and social questions. MST skills are not just vital for jobs, they are part and parcel of being a citizen in today's world.

The context

But Europe is faced with a skills paradox in MST. Although the Union as a whole has done rather well by meeting, and even exceeding, the European target to increase the numbers of MST graduates by 15%, the picture is less encouraging than at first seems.

Growth rates vary between Member States and depending on the field of study – for example, a massive increase in computer science, almost zero growth in life sciences. Women continue to be under-represented.

And, despite the growth in numbers, we are simply not seeing this translated into MST jobs. There is a skills mismatch even on the relatively secure science & technology labour market.

Only a small number of MST graduates work in research – largely because we are still not spending enough on research in Europe. On the other hand, many companies find their hands tied when it comes to starting up new ventures because they can't find the MST skills they need.

In world terms, too, the picture for Europe is not encouraging. If we look westwards, there are significantly more researcher jobs in the US than in the EU, even though the EU has more MST graduates.

Looking east, China is producing more than twice as many MST graduates as the EU. And India is already the world's largest exporter of ICT services.

In schools, the PISA surveys show that Europe is not improving its performance in maths and science. Far too many of our young people are at serious risk of being left behind because they leave school without the basic maths, science and reading skills. We must redouble our efforts for these young people.

The European response

What has been our response in Europe? And how can we improve it?

- *Working with Member States*

First of all, there is genuine willingness to work together to find the right solutions. Member States are concerned – as shown by their agreement on setting a European target for MST.

The Commission has been supporting solid peer learning by the Member States, amassing a great deal of good practice and common understanding on how to improve science learning and teaching from school to university.

I am very pleased that this conference is closely linked to the work of the peer-learning group.

- *Rocard report*

I am also very pleased that yesterday you heard from Michel Rocard.

Two years ago, with my colleague Jan Potočnik, commissioner in charge of Research,I launched a High Level Group, chaired by M. Rocard, on combating declining interest and raising recruitment into science and technology studies.

Their report sent a strong message on the need to overhaul science education in schools, to move away from 'chalk and talk' towards inquiry-based teaching. Good news travels fast: Japan has just translated the Rocard report into Japanese...

The Commission has put 60 million euro from the 7th Research Framework Programme into projects that pioneer innovative teaching methods in MST.

- *Addressing perceptions, changing teaching*

In fact, I think M. Rocard and his peers have put their finger on the problem. We need to tackle the perceptions and the practices that give science a bad name, even among very bright pupils.

Science subjects are perceived by pupils – and often, by their parents - as difficult, abstract and dry.

We need to grab pupils' attention from the earliest age. As the research shows, pupils like practical work and linking school science with real-life. This, after all, is how science advances. And as we know, a 'hands-on' approach doesn't mean 'minds-off'. We'll never know if Archimedes really did take a bath..., or if Newton saw the apple fall..., but we do know that science advances by empirical observation, and this is the approach we should be fostering in our schools.

- *Schools for 21st century*

At the same time as we are re-thinking science teaching, we are reflecting on the role of schools in general. Can we equip our young people for the 21st century using methods that may not have changed much since the 19th?

Think of the amount of information a young woman or man from 100 years ago would have come across in the course of a week or a month. And compare it with how much our young people absorb from TV or the internet before they even leave for school in the morning...

We are producing and consuming knowledge far more intensively than in the past. This calls for new skills - to be creative and innovative, to adapt to change, to communicate well, to work in teams as well as individually.

We need to help our education systems to deal with this new world: to ensure that young people can develop their specific skills and talents, but also learn to work together, exchange ideas, enter into productive dialogue and cope with uncertainty.

It is therefore crucial to look in the round at the skills and attitudes that young people need.

One useful starting point is the set of key competences that Member States agree every young person should have leaving school. The key competences framework shows how skills overlap and interlock with each other. Learning in one area can strengthen skills in another, building up a set of interconnected skills so as to be creative and innovative in an interconnected world.

- *Partnership approach – involving business*

We need to connect up schools too, to support them through cooperation with other stakeholders – with universities, with the scientific professions, with business, to help foster innovation and a stimulating working environment.

The Commission will be unveiling a new initiative - New Skills for New Jobs - to help us predict the skills needed for the jobs of the future. By helping define the skills sets needed for jobs in scientific and technology fields, it will give these jobs a clearer, more attractive profile, and make it easier to match the skills young people learn and the skills they need for jobs.

I set up a University –Business forum earlier this year, where this is one of the issues on the table.

While respecting the competences of the Member States in the curricula of their schools systems, I believe that partnerships between companies and schools can help schools to impart the new skills needed – problem solving, planning and managing learning, for example - as well as providing role models to attract students towards jobs in the research or scientific fields, for example. This approach may also help close the gender gap in the MST area.

Conclusions

In conclusion, yes, there is work ahead. But it is not a question of 'too little too late'. Let me quote the Chinese proverb:

"The best time to plant a tree is twenty years ago; the second best time is today".

By acting swiftly, decisively, and in concert, we can put Europe on the right footing for the 21st century.

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Mesdames et messieurs, vous êtes à la mi-temps de vos travaux. Je sais que les tables rondes et réunions d'hier ont déjà produit des résultats substantiels et c'est avec grand intérêt que mes services et moi-même lirons le compte-rendu de ces deux jours de conférence.

Permettez-moi de féliciter de nouveau la Présidence française d'avoir organisé cet événement.

Je vous remercie.