

# Life of Science

LIFE OF SCIENCE

**Edited by  
Lykke Margot Richter and Robin Engelhardt**

White Book on Educational Initiatives in the  
Natural Sciences and Technology

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## ACKNOWLEDGEMENTS

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This book was published in connection with *Changes and Challenges*, a European Union conference held in Autumn 2002 at the Tycho Brahe Planetarium in Copenhagen, Denmark. EU member states and applicant countries were invited to submit examples of concrete strategies for improving learning, teaching and recruitment in the fields of science and technology. This, in turn, has enabled us to compile this broad collection of inspiring educational strategies.

After the initial deadline for this publication had passed we received several additional submissions from a number of countries. As we wished to make a printed volume available at the conference, we were not able to include submissions we received after the deadline in the conference version of the white book. However, we did decide to publish an extended version of the book later, so that these texts could also be included. The present volume is thus the final version of the white book that we have chosen to entitle *Life of Science*.

The publication of this white book was made possible thanks to support provided by the European Commission and the Danish Ministry of Education. The editors would like to thank Claus Christensen and Torben Christoffersen of the Danish Ministry of Education for their cooperation and the confidence they showed while the book was being produced.

Klaus Boberg Pedersen and Cheralyn Kaye Mealor are also highly deserving of thanks for their invaluable assistance in setting up and proof-reading the manuscript.

Last but not least, we wish to express our gratitude to the many contributors to this book. Without them it would have been impossible to present such a wide range of innovative approaches to education in science and technology in Europe.

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#### INVESTIGATING ONE'S OWN TEACHING

**Thomas Stern & Konrad Krainer, *University of Klagenfurt, Austria***

In her first "reflective paper" within the framework of the two-year professional development programme, PFL-science, a chemistry teacher analyzes the situation in a class of 17-18-year-olds (grade 11). And so a teacher tries to understand her students' learning difficulties.

#### WHAT MAKES A TEACHER A GOOD TEACHER?

**Cecilia Galvão, *University of Lisbon, Portugal***

Maria is a science teacher in a secondary school in Lisbon. Her youthfulness is no obstacle to the determination shown in her candid look. She combines a certain shyness, which she clearly seeks to overcome, with the confidence she reveals when talking about the content of what she teaches and the situations she has to control in order to feel well. There is an almost obsessive need in her to do everything perfectly, and she works as hard as possible to manage this.

#### EXPERIENCES FROM MERCURY PRIVATE COLLEGE

**Lydia Suchova, *Mercury Private College, Slovakia***

This is a first-hand Slovakian story from a physics teacher describing her experiences of teaching at Mercury Private College, where physics lessons are integrated with economics.

#### AUSTRIAN SCIENCE DIDACTICS LAB

**Jürgen Horschinegg and Christian Dorninger, *Bundesministerium für Bildung, Wissenschaft und Kultur, Austria***

The performance of Austrian students in upper secondary schools, age group 14 to 19, was less than satisfying in the third International Mathematics and Science Study. Especially problem solving and conceptual thinking, i.e. making use of basic scientific concepts for working on problem-oriented tasks, did not turn out to be a major strength of upper secondary school students in Austria.

#### WOMEN'S EDUCATION AND EMPLOYMENT IN SCIENCE AND TECHNOLOGIES

**Anne-Marie Bruyas and Alessandra Drioli, *Fondazione IDIS-Città della Scienza ONLUS, Naples, Italy***

Women's Education and Employment in Science and Technologies (WEEST) is a European project carried out in the context of the European initiative CONNECT. The project supported the realisation of a Web site that aims to "connect" the different aspects involved in the education of young people towards scientific careers: the influence of culture and society, school education, the world of science and research.

#### COPING WITH SCIENCE

**Lykke Margot Richter, *Research consortium Math and Science, Learning Lab Denmark***

What makes children think about scientific inventions? In this case it was watching the news and listening to parents conversation that made a 12-year old schoolboy write an essay on the theme: "The world would be a better place to live in if...!"

### LEARNING IN MOUSSAC

**Wolff-Michael Roth, *University of Victoria, Canada***

What I saw in Moussac was a school where the transition to out-of-school life in the community was much more transparent than in most other schools. The school has become part of village life. The close interaction between the school and the entire village of Moussac allows the children to participate in daily activities, that is, to develop into increasingly competent members of the community at large by actively participating from young ages.

### FINNISH LESSONS

**Robin Engelhardt, *Consortium Math and Science, Learning Lab Denmark***

Within the space of only one generation, Finland has made a successful transition from an agrarian society to a high-tech community with the highest educational level in Europe. But without having been able to combine the tradition of solidarity with the virtues of originality and discipline, the Finns would not have made it that far.

### CHILDREN EXPLORING THE WORLD OF MINERALS AND PLANKTON

**Lykke Margot Richter, *Research Consortium Math and Science, Learning Lab Denmark***

In Boulogne-sur-Mer, a leading fishing port in the north of France, there is a place where school children and families come to learn about the sea. This place is called Nausicaä just like the heroine in Homer's Odyssey.

### THE BEACH AS A SCIENCE LAB

**Teresa Oliveira, *University of Lisbon, Portugal***

"Ciência Viva" is a national program that aims to increase scientific knowledge, develop experimental work and improve scientific culture. A Portuguese science education team in Lisbon supported by the Minister of Science, developed the project from 1996 to 2000.

### VITEN.NO

**Doris Jorde, *University of Oslo, Norway***

The Norwegian educational system has strongly supported the use of ICT in schools at all levels and in all subjects. The Viten project was created to provide science teachers with the opportunity of using Web-based curriculum materials, free of charge, in their science classrooms. Viten is a research and development project located at the University of Oslo and the Norwegian University of Science and Technology in Trondheim.

#### THE HOUSE OF EXPERIMENTS

**Miha Kos, Gorazd Planinšič, Ustanova Hiša eksperimentov and Ivo Verovnik, National Education Institute of Slovenia**

The House of Experiments is the first and only "hands-on" science centre in Slovenia. A hands-on science centre is an exhibition of the science, technology and ecology experiments, performed by the visitors themselves. By researching and performing the experiment each visitor obtains first-hand knowledge, and there is really no better way of learning.

#### THE ISLAND OF BERLENGA

**Isabel Chagas, University of Lisbon, Portugal**

The use of the Internet as an educational tool has been encouraged in Portugal since the mid-90s. Different governmental programs supporting schools, teachers and students in the use of this network have been launched throughout this period. However, in spite of the progressive improvement of both Internet accessibility in most K-12 schools and teachers' training in the use of the technology, its effective implementation in schools is still far from satisfactory at present.

#### WEB-BASED LEARNING ENVIRONMENTS IN SCIENCE TEACHING

**Tago Sarapuu and Margus Pedaste, Science Didactics Department, University of Tartu, Estonia**

How easy is it really to implement e-learning in schools? This article from Estonia explores some of the main issues that Estonian schools have been dealing with.

#### INNOVATIONS IN MATHEMATICS, SCIENCE AND TECHNOLOGY TEACHING (IMST<sup>2</sup>).

**Ulrike Unterbruner, University of Salzburg, Austria**

IMST<sup>2</sup> is an Austrian initiative involving subjects such as biology environmental education, chemistry, mathematics and physics. The purpose is to create new teaching and learning styles supported by new media and technology.

#### MIKSIKE, AN OPEN SOURCE MOVEMENT

**Mihkel Põlv, Miksike Learning Environment, Estonia**

From a "schoolhouse based" educational model to "network based" education. Miksike Learning Environment works for K-12 and homeschoolers. Miksike gives away more than 25 000 worksheets in HTML eWorksheets, which are aligned according to state educational standards, and offers a set of collaborative learning services to facilitate learners in constructing their knowledge.



#### JOINING FORCES

**Nina Tange, *Research Consortium Tools for the Knowledge-based Organisation, Learning Lab Denmark***

The Internet technologies used in the Linux landscape makes it possible to connect people with similar interests, problems and needs. Joining forces on mailing lists is making it possible to collaborate on exploring problems from different angles.

#### BRIDGING THE DIGITAL DIVIDE

**Lisbeth Frølund, *Research Consortium Play and Learning, Learning Lab Denmark***

There is growing awareness about the digital divide. At the MIT Media Lab, researchers have come up with an idea for what to do about it. The idea is called Computer Clubhouses, and Learning Lab Denmark's research consortium Play and Learning is now working on bringing the Computer Clubhouse model to Denmark.

#### MATHEMATICAL TALENT OF YOUNG CHILDREN

***La Real Academia de Ciencias Exactas, Físicas y Naturales, Spain***

The detection and stimulation of children's mathematical talent is an educational project of the Spanish Royal Academy of Sciences. The aim is to show children what mathematic really means.

#### MY MOTHER WANTED ME TO BE A DOCTOR

**Marek Lešičko, *Student at the Faculty of Natural Sciences, Comenius University, Slovakia***

"Hello friends, my name is Marek and I want to tell you the story of my life." This is the story of Marek from Slovakia remembering his schooldays and in particular one specific event, a competition in biology, that made him a big fan of competitions as a means of increasing motivation.

#### SUMMER SCHOOLS FOR YOUNG CHEMISTS

**Marta Sališová, *Faculty of Natural Sciences, Comenius University, Slovakia***

Chemical Secondary School in the small town of Humenné in East Slovakia welcomed In July 2002 more than 50 grammar school students, whose hobby is chemistry.

#### OPENING THE COLSET OF NATURAL SCIENCE

**Lone Bruun, *LBformidling, Denmark***

"Videnskabet" is a Danish multimedia learning programme for physics, chemistry and biology in secondary schools. The project began 3 years ago. Here, the project manager shares her experiences from this project with us.

#### BIOSCIENCE COMMUNICATION "ON THE ROAD"

**Andreas Jungbluth and Doris Pischitz, *Flad & Flad Communication Group, Germany***

A mobile genetic laboratory provides information for German high school students, the media and the general public about modern biotechnology and genetics.

#### PLANET EARTH – THE YEAR OF GEOSCIENCE 2002

**Stefan Leonards, *Project Coordinator of "Year of Geoscience 2002", Berlin, Germany***

With the aim of popularising science in Germany, the "Year of Geosciences 2002" followed two other campaigns, the "Year of Physics" in 2000 and the "Year of Life Sciences" in 2001. Together, these make up the core of the initiative "Wissenschaft im Dialog".

#### SCIENTIFIC WEEK OF MADRID

***La Consejería de Educación de la Comunidad Autónoma de Madrid, Spain***

The scientific week of Madrid was an initiative in 2002 that aimed to bring citizens together and to inform about initiatives and increase interest in science and technology.

#### REFLECTIONS ON CHILDREN, ROOKS AND SCIENCE

**Erik Jørgensen, *Danish Museum of Electricity***

Project 'Green Touch' was a part of the long-term plan of Aarhus municipality's school authority to create a green school system, where teachers and students are aware of what is good for nature, and on such a basis to equip the citizens of the future with environmentally sound habits.

#### HENDERSON CREEK

**Wolff-Michael Roth, *University of Victoria, Canada***

I have taught science to several seventh-grade classes at Oceanside Middle School, where students generated knowledge, which they contributed to the community, through their exhibits at an open house event organized by environmental activists. The environmental group and students learn science by focusing on stream and watershed health, and the sometimes severe problems with the quantity and quality of water that threatens Oceanside.

#### LIVING SCIENCE

**Giuseppe Marucci, *Ministry of Education, Italy* and Ernesta Di Masi, *Liceo Scientifico "Genoino", Cava de' Tirreni (SA), Italy***

The Italian education system is currently undergoing great changes, and "Vivere la scienza" is one of the Science and Technology Education projects, an initiative that aims to lead the way towards the autonomy of schools. The project won the competition held by the Ministero dell'Istruzione, dell'Università e della Ricerca 2000.

#### OLIN COLLEGE

**Martin Burcharth, *US correspondent, Dagbladet Information, Denmark***

They're two young women who recently graduated from high school with a very high score. I met them at the newly inaugurated engineering school, Franklin W. Olin College of Engineering, in Needham, 20 miles west of Boston, on a recent visit.

#### A SCHOOL FOR THE FUTURE

**Robin Engelhardt, *Research Consortium Math and Science, Learning Lab Denmark***

Can you imagine a school without classrooms, without timetables, without school bells, without school bags, and without a teacher's desk? If not, you must visit *Futurum* in Sweden; a radically new school that combines creative architecture with modern learning and teaching methods.

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## FOREWORD

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It is with great pleasure that I present *Life of Science*, a white book prepared in connection with the EU presidency conference *Changes and Challenges - Facing Science and Technology Education*, which was held in November 2002 at the Tycho Brahe Planetarium in Copenhagen, Denmark.

The conference was initiated by the Danish Minister of Education, Ulla Tørnæs, who also lent her generous support to the creation of this white book and the conference Web site. Ms Tørnæs demonstrated her own considerable interest in the field of Science and Technology Education by opening the conference herself. A preliminary version of this white book was presented at the conference.

The Danish Ministry of Education wishes to express its sincere gratitude to the European Commission for the generous financial support it provided in connection with the conference, and to thank Learning Lab Denmark for its assistance during the preparation stage and in the production of the white book.

The aim of this white book is to present some of the most inspiring examples of Science and Technology Education in Europe, and I sincerely hope that this aim has been achieved in full.

In creating the white book, we chose to present the different cases as personal stories — each reflecting on educational practice and the context within which this practice was carried out. We hope that this approach will prove to be fruitful. Every one of the cases presented reveals the vast dimensions involved,

the changes that have occurred, and the challenges we currently face in Science and Technology Education. We extend our deepest gratitude to all who contributed to the volume.

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## INTRODUCTION

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Many European countries are recognising a growing need for young people to embark on a career in the field of science and technology. At the same time, the attention of policy-makers is being drawn to the public image and understanding of the natural sciences. Decisions concerning the way in which our societies are organised would be poorly founded indeed if there were no knowledge of their scientific and technological aspect. It is appropriate, then, that scientific literacy is now recognised as an increasingly important condition for a well-informed European public and for democratic decision-making in general.

Insufficient scientific literacy among the general public is just one of several problems facing the natural sciences today. Other problems include a declining interest in the study of science, disjointed political legislation, confused ethical standards, and seemingly incoherent risk assessments as regards new technologies – not to mention outdated methods of learning and teaching in schools. On the whole, these problems raise questions regarding the traditional position of science in society. Such questions can naturally contribute to healthy development, but they also present a significant challenge with respect to the positive transformation of traditional policies and educational institutions that concern scientific and technological issues.

A large number of recuperative initiatives have already been implemented at both national and international levels. Many of these initiatives represent genuinely innovative and forward-thinking approaches to science – and have the capacity to bring about significant change with the educational systems in which they are implemented. Bringing these initiatives together and subjecting them to serious discussion is an important step towards understanding the changes and

challenges facing science and technology today. Through the open exchange of new ideas and concepts – where inspiration from the outside is sought and cultural differences are acknowledged – we believe that we can achieve genuine improvements in science education in Europe.

### **About this book**

This book is a small step towards creating such an exchange. The various articles are diverse in scope and subject matter, but they are all united by a common purpose: to communicate positive experiences. The articles were written in order to share new thoughts concerning the teaching of science, and to demonstrate new ways of constructing meaningful learning environments – environments that inspire students and make people feel involved in science and technology. We made an effort to present articles that deal with specific “cases”, i.e. with concrete experiences from schools, science centres, projects, communities, and other science-related initiatives. The emphasis is on first-hand experience, and on reflection upon effective practice. The style is generally non-academic and personal.

There are many lessons to be learned from the cases presented. Most authors agree that traditional science education needs to be re-thought in light of changes that have taken place in our lives, in our societies and the way in which they are organised, and in science itself. We need to make learning and teaching natural science meaningful in relation to the new social functions that knowledge has taken on. The main educational focus is on the ability to *create* scientific knowledge – not to simply assimilate knowledge and apply it to specific circumstances.

The willingness to change must be based on a proper recognition of the challenges we face. Experiments in teaching conducted for the sake of experimenting alone are not enough to generate sustainable improvements in education. As demonstrated in Robin Engelhardt’s article, traditional approaches to teaching science in schools have obvious merits, and can be more fruitful than most other approaches if organised properly. It is therefore important to formulate a coherent vision of *why* and *how* you wish to change methods of teaching and learning science and technology in school. It is equally important to consider the conditions and contexts that exist within local communities if innovations in science education are to have lasting effects.

The subsequent articles by Thomas Stern and Konrad Krainer from Austria and by Cecília Galvão from Portugal analyse in detail what good teaching practice is, and what this practice means to the development of the teaching



profession. Their conclusions emphasise that teachers must be able to understand their students, and should know how to transform different learning styles into appropriate teaching styles – as well as promoting the students' autonomy and ability to reflect. The article by Lydia Suchova from Slovakia is a suitable follow-up that provides us with a first-hand account of how physics is integrated with economic at Mercury Private College.

The issue of how women and children are included in – and excluded from – the predominantly male career of science and technology is addressed in the following three articles by Jürgen Horschinegg and Christian Dorninger from Austria, Anne-Marie Bruyas and Alessandra Drioli from Italy, and Lykke Margot Richter from Denmark. These authors call to attention the importance of stimulating all the senses of those engaged in science, and of using acquired scientific knowledge to conduct socially worthwhile activities.

One problem with current educational practices is that they do not resemble the practices used in the fields in which they intend to prepare people to work. According to Wolff-Michael Roth and his studies of the French village school in Moussac, we need to re-think science education as collective “praxis”. At this school an attempt has been made to create an environment where teachers are oriented towards the object that characterises the scientific practice, rather than being occupied with influencing, constraining, and controlling students.

This article is followed by Robin Engelhardt's reflections on the long-established school system in Finland, which was the best-performing country in Europe in the PISA-2000 study. One of the main conclusions of this article is that cultural and societal aspects can have an overriding importance for the status of science and technology education, as well as for the degree of scientific literacy in society.

Shifting from an analytical perspective towards the practical realisations of science and technology in everyday society, the next group of texts present some of the most significant informal learning environments found in Europe today – environments such as the Nausicaä aquarium in southern France, described by Lykke Margot Richter. Following the upbeat story of Nausicaä is an article by Teresa Oliveira from Portugal describing a laboratory that is right in front of us, namely the beach. By actually applying scientific models to everyday life, children see that dealing with science does not involve stepping into another world: they are already in the world of science.

The article by Doris Jorde from Norway about the ITC-project Viten presents an example of how teachers' accessibility to Web-based materials can strengthen their motivation to use technology in class. By working in actual

classroom settings with teachers and their students, they are able to see first-hand how curriculum materials are implemented.

The Island of Berlenga depicted by Isabel Chagas is a Portuguese case, where the Internet is used in the classroom to stimulate informal approaches to scientific learning. Here, the playful nature of surfing the Internet and building a Web site create a virtual meeting-room for chatting about the teaching and the learning process involved in science subjects without any performance pressure.

However, cultural differences in school systems between countries are sometimes highly visible. In Tago Sarapuu and Margus Pedaste's article, we hear the story of the many problems Estonian schools have faced when implementing e-learning. The Austrians have also experimented with innovative teaching methods supported by new technology. Ulrike Unterbruner elaborates on such an initiative that gathers experiences within chemistry, mathematics, and technology.

The "open source" movement, as manifested in the rapid development of the Linux operating system, has become a paradigmatic example of the successful self-organisation of new learning communities. After Nina Tange's detailed discussion of the mechanisms by which the Open Source and Linux community operates through mailing lists and knowledge building, we turn to an article by Mihkel Pilv from Estonia about *Miksike*. This article deals with another kind of open source movement – one that provides learning materials. The article points out significant problems involved in implementing new technology in educational systems when old-fashioned teaching styles are not compatible with new forms of network-based learning.

Informal learning environments have become increasingly important sources for obtaining knowledge about science and technology, and they reflect a more social understanding of learning as an integrated part of our ways of life, as well as a means for the constant re-construction of "the social" and indeed the re-construction of ourselves. It is a central part of what it is to be human. Thus, the last few of articles in this book deal – on a systemic level – with the opening up of classrooms to the local community, and the integration of informal learning environments into the formal school system.

As shown in an article by Lisbeth Frølund from Denmark, bridging "the digital divide" through the establishment of off-school computer clubhouses in the United States is one way to benefit from the use of informal learning environments. However, formal learning environments can also prove to be successful. An article by The Academy of Natural Sciences in Spain deals with a successful example of formal learning: a programme specially designed to increase the mathematical talent of young children.

Where are the students in all this? In the article from Slovakia, Marek Lešičko tells the story of how he became interested in studying the natural sciences at the university. Creating a network of common interest is important for young people working to improve their skills, but the social aspect is also important in science subjects. In Marta Sališová's article, we learn about such an initiative – summer schools for young chemists.

Lone Bruun's article deals with opening up the closet of the natural sciences. A project entitled *Videnskabet* (The Science Closet) is an initiative that seeks to make it fun for children to learn about subjects such as physics and chemistry via a computer game and a CD-ROM that include six biographies of different scientists. "Hard work", said the project manager. Next, we are on the road again with Flad & Flad Communication Group: smashed tomatoes through a coffee filter to show the genetic material of a tomato. Andreas Jungbluth and Doris Pischitz's article is one example of how simple this can be done – showing children in a fun way what bioscience is about.

European countries sometimes dedicate a year to a life science, and in Germany 2002 was dedicated to geoscience. Stefan Leonards writes about previous experiences with these science years, and about this year's campaign in Germany. He gives us Planet Earth, so what more can a human being ask for? This article is followed by a discussion of the Scientific Week of Madrid 2002.

Project-based schoolwork extending into the local community – as presented in Erik Jørgensen's article about project "Green Touch" in the Danish town of Aarhus and in Wolff-Michael Roth's article about environmental activism at Oceanside Middle School in Canada – is another means by which one can break free of traditional teaching habits in classrooms. The macro level of national policies can also give greater autonomy to schools, as demonstrated by the last three examples from Italy, the United States and Sweden, where the experiences have all been very positive.

What will our future schools look like? What kinds of teaching and learning will take place in them? Will they lay the foundations for lifelong learning for all and not just for the lucky few? These are crucial questions addressed in this book. Whether the school of tomorrow will be characterised by Catholic discipline, by virtual schools on the Internet, or by network-inspired schools made of bricks and stones, we politicians, schoolteachers, scientists and schoolchildren still have a lot to learn before judging one vision to be better than another within a given context. Policy-making – as well as students, teachers and schools – must be willing to enter a state of constant learning.

Perhaps the best initiatives are the best because they daringly admit that they are not perfect, but willing to learn and change. One thing is certain: despite

cultural differences in upbringing, views on human nature, family patterns, and socio-economic structures, we can be inspired by examples such as an aquarium for schoolchildren in France, or a frustrated schoolteacher in Portugal. Or we can look north to Sweden and gain insight from attempts there to build a school that cuts the chain to traditional concepts of what a school is. The case stories in this book are a heterogeneous lot, and yet they point at the importance of parents, of the local community and of real life situations in boosting children's interest in studying science and technology. Combined, these contributions form a highly interesting picture of educational initiatives in science and technology at the outset of the twenty-first century.

Lykke Margot Richter and Robin Engelhardt, Copenhagen, 2 January 2003

## A SCHOOL DAY IS A SCHOOL DAY

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Robin Engelhardt, *Research Consortium Math and Science,  
Learning Lab Denmark*

**The Sint-Jozef-Klein-Seminarie in the Flemish town of Sint-Niklaas reveals a school system distinguished by hard work, solicitude and tradition.**

Departing from Brussels by train and heading north for about half an hour, you would expect to arrive at a nice middle-class town with small houses, neatly dressed shop windows, and perfectly clean streets. As I step off the train and look around from the exit of the main railway station, this does indeed seem to be the case. The white churches and windows decorated with flowers seem to match the blue sky perfectly. The name of the town is Sint-Niklaas. It lies in the Flemish part of Belgium.

I have an appointment with Walter Roggeman, the headmaster of Sint-Jozef Klein-Seminarie, a Catholic school for twelve to eighteen-year-olds. The remarkable thing about this school, and the reason why I wanted to visit it, is that student performance here was consistently at the highest level in all domains of the PISA-2000 study, as well as in the TIMMS study from 1995. Although Belgium's score in the PISA study cannot be said to have been very high overall, as the country only ranked eleventh in reading literacy, ninth on the mathematical literacy scale, and a mediocre seventeenth on the scientific literacy scale, Belgium still had the widest within-country variation of all thirty-two countries participating. In the PISA-study, the main reason for this variation was explained, at least partially, by huge differences in performance between the Flemish and French communities.

The Flemish results are among the best in the world. In reading literacy, Flanders is third after Finland and Canada. In mathematical literacy, Flanders is third after Japan and Korea – which, in fact, would make them the European champions. In scientific literacy Flanders ranked eighth, which is comparable to the Austrian performance and still a lot better than most other European countries. In order to understand the level of performance at Sint-Jozef Klein-Seminarie, one also has to consider the variation in the quality of schools in Flanders itself. Because of an indiscretion that was passed on by the German newspaper, *Die Zeit*, I had become aware that the school I was about to visit showed the best results in all disciplines when compared to all other schools in Flanders. It was simply the best.

#### **A combination of hard work and tradition**

In order to understand why this school did better than all the others in these comparative tests, I ask the headmaster all sorts of questions about the French and Flemish educational systems, and about the social, political and cultural circumstances that could explain such differences. Is it the thirty-two hours each student has to spend in school every week, and the many hours of homework they have to do in the evenings, I ask? Or is it the five Latin lessons each week? And why do you need to learn Latin anyway?

The headmaster looks at me with forbearance and begins telling me about the long-held traditions in this part of the country.

“More than seven hundred years ago, the town was just a small soggy village close to the sea,” he says. “The name of the area, Land van Waas, literally means “soggy land”. But as the land grew out of the water and moved to the west, more people settled in the area. Many religious houses and seminaries were built in the sixteenth and seventeenth centuries. A part of our school is also a seminary. We also have a monastery that was built in 1696 by followers of Saint Francis of Assisi. After the French Revolution, many Catholic monks fled to Holland, and the seminary was bought by wealthy men. In 1808, the Bishop of Ghent started a school on these premises, and the school was combined with the seminary until 1950.”

Latin, I learn, is very popular. It is regarded as an analytical language, which helps the development of intelligence and rational thought. So it doesn't matter that people do not speak it anymore. French and math also have a high priority in the school. Every child learns two or more foreign languages as well as math, physics, chemistry and biology. And they are tested often and thoroughly. Moreover, the students are differentiated on the basis of how they

perform. At the age of fourteen, it is decided whether a student can continue at a general, technical, or vocational level. When asked whether this early differentiation might comprise an irreversible selection process and result in social stigmatisation, the headmaster shakes his head: "We are trying to avoid wrong decisions by providing parents with good, solid advice. Nobody is perfect, but we prefer this "early" differentiation to postponing the choice between a general and technical level, because in our opinion, our system is better for student motivation. Being in an educational system that corresponds better with their interests improves their performance. So what we do is in the children's best interest."

### **Taking care of them all**

Compared with the French communities, where many children have to repeat a year if they fail the tests, the children in the Flemish communities get a lot of help if they risk failing. In the beginning of the first school year, the students can

"They need to learn to know *what* they read."

do their homework in the school together with their own classes and class teachers. The teachers are mainly concerned with the students learning how to organise their homework better. "It is not enough

just to be able to read," the headmaster explains to me, "They need to learn to know *what* they read, and they need to learn *what and how* they have to learn. It is not an oppressive system, but one of definite rules, which you have to follow."

If performance problems persist, students are given extra lessons, and problematic children are put into smaller classes, so that the teachers can better focus on their needs. In addition, a staff of "green teachers" pledged to secrecy talk to students who have personal or social problems. As many teachers will know, parents sometimes need as much help as their children. At Sint-Jozef-Klein-Seminarie, it has become a highly valued practice to involve parents in the students' work as soon and as much as possible. Before the beginning of the new school year, parents are invited to the school to talk about the coming year's program. They are given general information about the school, they exchange telephone numbers, and they receive a magazine. In the third week of September, the parents attend optional meetings with the teachers about how to help their children with homework, or they can obtain information about higher education. "We have very good cooperation with the parents," says the headmaster, "and we try to get them more and more involved in the school."

**The art of combining disparate parts into a prosperous whole**

Although Belgium lacks a systematic and formal teachers' education system – short-term practical training is all the system offers in terms of education, apart from the normal university Bachelor's or Master's degrees – the teachers' own efforts to further their professional status through engagement and social recognition seem to be very strong. This becomes evident to me, as the headmaster talks proudly about his teachers, who have been teaching at the school for ten, fifteen or even more years. They seem to take great pride in their jobs, and they also seem to have a lifelong commitment to their cause. "It is the art of combining disparate parts into a prosperous whole," he says. "We believe in a combination of tradition and the integration of new elements where the tradition doesn't work anymore. And the best is step-by-step innovation to which all members of the community agree."

It would be difficult to pin down just one factor that explains the differences between the French and Flemish schools. "But I guess it is a combination of many things," says the headmaster. "In this part of the country, three out of four schools are Catholic, whereas in the south it is only one out of four. Our basis is effective teamwork between the headmaster, the teachers, the parents, and their children. You also have to remember that we are not centralized like the schools in the south. Many of our teachers have worked here for many years, and they know what to do when things are not working. Our local infrastructure emerged in accordance with our own decisions, and it was therefore our own responsibility. The local community supports our financial and pedagogical autonomy. We are *not* being organised from a desk in Brussels."

Another important aspect of the Flemish success might be the long reign of the Flemish Minister of Education, Luc van den Bossche. Having read about his motto several times before, it does not come as a surprise to me to hear the headmaster reiterating it: "A school day is a school day," he says, "there are no excuses for not attending school, whether it is the beginning of January or before the tests in June." This motto has not only taken root in the heart of the Flemish community. It is also very popular among the Dutch in the border regions. They frequently send their children to Flanders away from what they feel is a wretched state of affairs in the Netherlands.

While I walk around this odd combination of an ordinary middle school and a former seminary, I wonder: is success Catholic? I have a good look at the old church that is connected to the school. Its vaults extend into parts of the school corridor and even make up the ceiling of the dining hall. Everything looks as if it is organically integrated into a functioning whole. No signs of carelessness. No



signs of excess. Just the kind of school you would expect to read about in old-fashioned memoirs telling stories about a time not yet out of sync.

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## INVESTIGATING ONE'S OWN TEACHING

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Thomas Stern & Konrad Krainer, *University of Klagenfurt, Austria*

**In her first “reflective paper” within the framework of the two-year professional development programme, PFL-science<sup>1</sup>, a chemistry teacher analyzes the situation in a class of seventeen to eighteen-year-olds (grade eleven). And so a teacher tries to understand her students’ learning difficulties.**

**W**hy were many of her students so reluctant to learn about the fundamentals of chemistry at the beginning of the year? Why did they hardly collaborate during the lessons? Many of them just seemed to wait for the first tests, and only after they had failed were they ready to take pains. But then it turned out to be too difficult for many of them to cope with what they had already missed. The teacher invited several colleagues and her PFL-mentor into her school and asked them to observe one of her lessons and to

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<sup>1</sup> PFL means “Pedagogy and subject-specific methodology for teachers”. The courses are funded mainly by the Ministry for Education, Science and Culture in Austria, the participants themselves pay a small fee. The programme is organized by the IFF/University of Klagenfurt. PFL-science is for teachers of biology, chemistry and physics. In addition, the IFF offers the following programmes: PFL-mathematics, PFF-ArtHist (art, music, history, German language), PFL-EAA (for teachers from schools where English is used as a working language for some or even all subjects), PFL-Primary school, and a MAS-programme on “Teaching and School Development”.

interview the students about their impressions and opinions. Afterwards the teacher asked the students to fill out a questionnaire about their opinions. The teacher's résumé in her first case study was:

*"The majority of the students stated that the lesson was interesting, but only few enjoyed it. The contents were new for them. Sixty per cent maintained that they had understood the explanations well. Nearly all of them thought that they could get answers to their questions, and two thirds of the students found they had sufficient opportunity to learn actively. Most of them felt comfortable during the lesson."*

So what was going wrong and what made the teacher feel uneasy and dissatisfied? Some of the interview results revealed deeper insights. Several students said that they found her teaching good, but on much too high a level. Many of them found that chemistry was dry, abstract, rather boring, difficult and unrewarding, and that her assessment was far too rigorous. In her first discussion with her PFL-group, the teacher appeared rather disappointed about these

"Many of them found that chemistry was dry, abstract, rather boring, difficult and unrewarding."

results. They seemed to confirm her conviction that students had negative attitudes towards learning and were biased against sciences. But a closer look at the transcripts of the interviews changed her view. She started to understand her students and to reflect on how she could give them better

support when they tried to grasp difficult concepts. As a consequence, she decided to change her teaching and to put more emphasis on chemistry-related issues relevant to daily life and ecological concerns.

She writes:

*"I must abolish the usual lecturing about the fundamentals (atomic structure, chemical bonds). It makes the students lose their interest. The first few months should be especially thrilling, even for the students who are prejudiced against this subject. It should be made clear that chemistry is very important for our very lives. "*

More experiments and hands-on learning, and changes in her assessment practice are also on the teacher's agenda. The analysis of the critical attitudes of her students, and the classroom discussions about the results, led not only to some innovative ideas about teaching, but also to a better mutual understanding. The teacher became more thoughtful, and the students ready to rethink their motivation. The whole atmosphere in the laboratory room changed.

This example of a teacher's research illustrates the importance of reflection as a dimension of professional work. Self-critical and systematic reflection can be very helpful in further developing the quality of actions.

### **Background of the Project: Promoting Action, Reflection, Autonomy and Networking**

PFL is a two-year university programme for teachers of all grades in Austria, with a strong orientation towards action research (see e.g., Altrichter et al. 1993). It supports teachers in developing their teaching skills, in addition to updating their knowledge of the subject they teach. The participants systematically reflect on their professional work and write (on average two) case studies about innovations in their schools, which they evaluate carefully. This includes critical investigations of the effects of their teaching activities by examining the results from different perspectives, paying particular attention to the students' opinions. Since the first courses started in 1982, more than five hundred participants received their university certificates. In 2003-05 four new courses will be held, each for up to thirty-two participants. The PFL-programmes are interdisciplinary and connect pedagogical, didactic and subject-specific aspects. They are planned and implemented by interdisciplinary teams of four to five members (educationalists, subject-matter specialists, practitioners). They include three one-week seminars, five meetings of small regional groups, plus the individual teachers' research at school. A main feature of PFL is stable "professional communities" of team members and participants, who engage in intensive theoretical and practical work and publish the results.

### **Main Goals and Principles**

Efforts to improve teaching at the class level can only be successful if the practitioners are motivated and interested in actively developing their professional expertise. A central idea of PFL-courses is the appreciation of teachers' work and their knowledge in the field of pedagogy. Their practical experience and their individual strengths are the starting point for further quality development. PFL aims at:

- Encouraging teachers to design and carry out innovations at their schools,

- Supporting teachers who conduct research relating to their own practice, thus gaining knowledge that can enhance the effectiveness of teaching and learning,
- Broadening their autonomous scope and their professional knowledge, thus improving their individual satisfaction,
- Giving teachers the opportunity to systematically exchange ideas and practical experiences with each other and with scientists, publish their professional accomplishments and organize professional development courses for themselves and others.

Teachers are regarded as professionals who try to further develop their capability *“to generate knowledge which is appropriate to the situation, ... a capacity for autonomous self-development through systematic self-study, through the study of other teachers and through the testing of ideas by classroom research procedures”* (Stenhouse 1975, p. 144). As “reflective practitioners” they constantly transform “tacit knowledge” (knowledge-in-action) into “reflection-about-action” (Schön 1983). Communication and collaboration between teachers is an important element in this process. It usually occurs incidentally and is felt to be unsatisfactory. In order to make the countless good ideas in teachers’ minds accessible to others, it is a main intention of PFL to provide opportunities for intensive discussions about different aspects of the teachers’ work. Thus, the regional groups become small “professional communities”, in which mutual understanding and constructive criticism are fostered. The participation of university researchers makes it possible for different perspectives to be included, and a continuous discourse between theory and practice can take place. The planning and realization of the seminars and meetings are partially being taken over by these groups, who increasingly take charge of their own education within (and, later, outside) the course.

Analysing a large number of PFL case studies, Altrichter & Krainer (1996, p. 34) considered four dimensions of professional practice:

- Attitude towards and competence in experimental, constructive and goal-directed work (action).
- Attitude towards and competence in reflective, (self)-critical and systematically based work (reflection).
- Attitude towards, and competence in, autonomous, self-initiative and self-determined work (autonomy).

- Attitude towards and competence in communicative and cooperative work with increasing public relevance (networking).

Teachers are used to making autonomous decisions and to taking spontaneous and efficient actions in order to inspire their students, satisfy their different needs, find solutions to learning problems and cope with unexpected situations in the classroom. Teaching primarily means to work by oneself. PFL aims to strengthen the teachers' competencies in all of the four dimensions, which means to shift the attention towards reflection and networking. The following descriptions of a PFL study illustrate how this can be achieved by a teacher in the course of her two years of research work.

#### **Autonomy and Networking: Research into the learning effects of laboratory work**

In her second case study, the chemistry teacher (Steininger 2002) investigated the second year of an innovation implemented at her school. Once a week, groups of eighth-grade students (thirteen to fourteen years old) worked in the laboratory for two units (100 minutes) in the afternoon: chemistry for half the class, biological experiments for the other half. This required about nine additional hours outside the lessons for both herself and her partner, the biology teacher, to design the lessons and prepare and remove the experimental materials. The question was whether all this work really paid off, i.e. how much the students profited. Since she was personally involved in this project, she had to be careful not to blindfold herself, but to be critical of her findings. She therefore used several research methods in order to look for contradictions in the findings.

First, she had all the students in her class fill out a questionnaire. She asked them what they considered interesting about the practical work, and if they thought that it helped them to gain understanding and to memorize. Most answers were positive:

*"I liked working with the gas burner and with the acids!" ... "The experiments about smoking were most interesting because it has something to do with real life, and it was important to know how dangerous cigarette smoke is."*

There was also some criticism, especially concerning record-keeping, and some suggestions.

She then interviewed those students who repeated the class and had attended no laboratory lessons the previous year, and students from the next class, who had attended laboratory lessons the previous year. The answers hardly differed from those on the questionnaire.

Finally, she compiled a science test with items of the TIMMS-study and gave it to a ninth-grade class in order to compare the results of students who had attended laboratory lessons the previous year with those who had not (Stern 2002). She found that the results of the first group were significantly better than those of the second.

All these findings were in favour of the laboratory lessons. Nevertheless, there were doubts whether this innovation should be institutionalized, because it meant a lot of additional unpaid labour. For a fourth data collection, the author asked a friend to interview a colleague who teaches biology. She was also very proud of their success:

*"I see that the students are enthusiastic. For them, a lung they can blow up is great fun, also the experiments with cigarette smoke, and how we killed the water fleas with extracted nicotine."*

Nevertheless, she was sceptical as to whether this kind of teaching could be continued and applied in higher grades. Without additional resources, the laboratory work could not be maintained. The final conclusion was that the science classes needed extra funding, because experimental work with students is extremely time-consuming.

This case study is an example of how reflection on a teacher's work can be of importance outside her classroom, and can create an opportunity for professional communication. The results were discussed intensely within PFL, then among the teachers at the school. Some of them were critical and opposed any shift of school resources to the sciences. But the data-based arguments impressed them. She started to exchange ideas with other schools. In her own school, she took it upon herself to formulate a "school programme" together with a group of colleagues.

Many PFL "teacher researchers" start by investigating their own teaching, e.g., situations in which they are accustomed to act autonomously. Collaboration with others and professional communication can lead to a considerable improvement in the quality of work. Written records such as the case studies play an important part in communicating one's ideas. Autonomy and networking proved to be complementary dimensions of professional practice.



Many PFL case studies are published by the IFF and are used in Austrian schools. Another significant result of the courses is their contribution to the professional development of the participants. The evaluations (based on questionnaires and interviews) show that many of them are encouraged to experiment with new forms of teaching and learning, that many have changed their attitude and now find their work more satisfying and rewarding, and that they are more interested in collaborating with other teachers. Most of them use their methodological knowledge for school development and promote innovations in their schools, and some also outside their schools, by getting involved in self-organized professional development activities for other teachers.

### **Summary and outlook**

The PFL-programme aims to promote teachers' action, reflection, autonomy and networking. It specifically supports the participants in increasing self-awareness when reflecting on their activities, and in deepening their communication and collaboration with their colleagues. PFL regards teachers not as receivers of prefabricated knowledge and solutions, but as reflective practitioners who develop their own knowledge and solutions and adapt them to the context in which they work (Krainer 1999). By investigating their own work and making the results accessible to a wider community, they acquire the ability to collaborate on all kinds of projects at their own schools or in school-networks, and to become partners in educational research. Their professional development could be the subject for further studies.

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## WHAT MAKES A TEACHER A GOOD TEACHER?

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**Maria is a science teacher at a secondary school in Lisbon. Her youthfulness is no obstacle to the determination she expresses. She combines a certain shyness, which she clearly seeks to overcome, with the confidence she reveals when talking about the content of what she teaches and the situations she has to control in order to feel good about her work. There is an almost obsessive need in her to do everything perfectly, and she works as hard as possible to manage this.**

I met Maria during her fourth year at university when she was a student in one of the classes I taught within the biology teacher education course. Maria stood out because of her capacity to reflect, which was demonstrated by the way she participated in class. She was always discreet and a little shy, but the things she said were very rich in content. Our contact continued throughout her practical training period at a school – she was the trainee and I was her university supervisor for the educational aspect of her training. Her whole performance during this time kept revealing her perfectionism, both in her work with students and in the varied professional skills she had to develop at the school. Already then, Maria had begun to reveal the professional she is today – responsible, reflective, and with good relations to students and colleagues alike.

We talked a few times and I treasure many of the stories she told about her work, such as the following one:

*We think we have the class prepared and, suddenly it becomes the opposite of what we had planned. The other day, in the experimental determination of soil humidity, something strange happened. The students weighed the Petri dishes, and then they put the soil inside and put them in the oven. After a couple of days, they weighed the dishes containing the soil, and did the same eight days later. The results were totally unexpected, because the dishes were supposed to be lighter but they turned out to be heavier than before.*

*The students and I were frustrated, because we thought we would have predictable results, and now we had the opposite to deal with.*

*We wrote down the results on the board and tried to interpret them. I told the students: "This was unexpected, I'm just as frustrated as you are, but this is what happens sometimes to scientists. In science, things are not as simple as you probably thought. Now we have to try to find explanations for what happened." So we tried to find these explanations.*

*One of the hypotheses was an error in weighing, but it was strange that all the student groups had made the same mistake. We checked in school and found that the oven had been disconnected during the night and weekends. We also found some material other classes had put inside to dry, and because of that our own dishes had taken in the humidity of the other material. They realised this could be the explanation and repeated the experiment, this time controlling the oven.*

*Now the results were as we expected, except for one of the groups, where the calculations were wrong. For me, it was a great experience as a*

*"Everything was so correct that it wasn't much fun."*

*teacher. The results were wrong but we actually thought together and discussed what was happening. In another class, everything was so correct that it wasn't much fun. That discussion in the first class was fantastic, and the students benefited from it. Revising their notion that, in*

*science, everything is right and simple was important for them as students. What disturbed me most was their question after the wrong results: "Why did we do this experiment if the results are wrong?" In their minds we only do scientific experiments to confirm what we already know.*

*After this episode, I feel they think differently about science.*

The story reveals this teacher's concept of science, which is that theories are built upon scientists' hard work, sometimes producing contradictory results. She

explores the error as a means of developing students' thinking. This situation demonstrates the teacher's capacity to create learning strategies based on an unsuccessful experiment. After having overcome the frustration of the initial results she felt disappointed with the correct results in another class. An immediate evaluation describes these feelings and, at the same time, the reflection takes us from what had been planned to the need to alter the experiment and the way the class had been thinking. The result follows a research strategy: the formulation of an explanatory hypothesis for the facts, the repetition of the experiment to try to test the new data, taking the interpretation of the unexpected results into account. Further evaluation shows the teacher's line of thought concerning her scientific concepts and her role as a science teacher, which is to contribute to the students' scientific literacy and improve their abilities in critical problem-solving.

Reflection about her work includes questioning the causes of events, such as attempting to discover why students who are considered to be very weak in nearly all subjects manage to achieve good results with a certain teacher. Faced with the need to justify her students' achievements, Maria looks for elements to help her ground these results in group meetings. She refers to the students, to comparisons with colleagues and retrospectively analyses her evaluation methods. The story she has to tell in this respect sheds light on her way of reflecting upon events:

*In my group meeting I have to justify how they all have good marks in science while in other subjects their performance has been disappointing. The group analyses the marks in science and then checks to see whether there's some sort of discrepancy between these and the other subjects. And in this class there is. I asked my students: "Tell me, why do you have good marks in science and flunk in other subjects?" (...) They told me that I explained things well and provided notes, that my evaluations weren't based only on the tests, that I taught a certain topic and then tested them in it, as opposed to other teachers who included lots of topics on a single test. I evaluate homework, reports, and tests. And I also evaluate their participation – when the class is small, it's easy to see who participates and who doesn't. Then I consider their notebooks, behaviour, whether or not they bring all the material. (...) I proceed at a much slower pace and teach topics in a much calmer manner than my colleagues. (...) It's funny, they said: "Here we learn much better." (...) Yesterday one told me: "I don't even study science, because I learn everything in the lessons". And everyone participates. I can make them pass.*

Maria could have found a plausible explanation for the discrepancy between the students' marks in her subject and in those taught by her colleagues in the nature of the subjects themselves, as certain subjects could well mean more to some students, or in her use of different forms of evaluation, which help the students to achieve good marks. Instead, Maria turns to the students themselves to help her reflect on the reasons for their good results. On the one hand, the way subject is taught is emphasised: a slow pace, in accordance with the students' conceptual demands (the students said that the contents were easy), interactive classes (Maria says everyone participates) during which the teacher summarises her points and the students write these summaries down in their notebooks (the students say that the teacher provides notes). The student who replies that he doesn't study because he learns in class is interesting. On the other hand, the teacher's evaluation methods are such that they provide her with better knowledge of her students. The latter are the first to remark that Maria gives tests on small content units, while the other teachers' tests cover much more information. All this analysis constitutes a general evaluation made by the students regarding the teacher's classes.

However, Maria also presents other hypotheses that explain the facts to her colleagues and to herself. As she told me, she compares percentages of tests and marks given by other teachers to see if she's being too generous – she concludes that the explanation lies instead in her strategies, the attention she pays to her students and their difficulties, and in valuing their work. Perhaps the phrase *I can make them pass* summarises the set of explanations for the success of these students in the natural sciences.

Besides the elements revealed in her story, however, Maria recounts other aspects that help provide an answer to the initial question she raised – aspects that comprise stages of the research she intended to carry out. She also analysed tests, the type of questions, and their level of difficulty and clarity. She asked colleagues to analyse her tests and compare them to theirs. With this comparison, Maria adds another explanation to her students' success: the care she takes in formulating the test questions, which must be sufficiently clear to be understood and therefore provide elements concerning the learning of contents.

She has also developed remarkable work with students in the science club and brought some students to scientific learning:

*I think this was important with the eighth-grade kids, because if they didn't pay attention in the classroom (they didn't study much either), what they learned was there in the club, I think. Take Alexandre, for example – that plump kid. He's a difficult boy, I'd force him to write, the teachers complained he did*

*nothing with them and with me he did. (...) Oh, and he's a kid who also organised the exhibition at the club and was standing by the aquarium. So teachers would come over, and he'd say: "What would you like to know?" "OK, explain this". The French teacher went there and told me: "Oh, this one doesn't know a thing", and I told her: "Wait a minute, hey Alexandre, explain it", and he goes: "This fish is so and so, this one's so and so ..." I've no idea about those things, he knows because he has an aquarium at home, and she was amazed! I didn't flunk anyone in the eighth grade in science.*

Maria described this case with pride. She managed to prove she was right without having to provide further explanations to her colleague. Giving this student an important role in monitoring the exhibition was the best solution to show the teacher's trust, and the best way for the student to reveal his abilities to the other teachers. The club allowed Alexandre to show interest in a topic that would otherwise have been hard to discover. The school valued this knowledge. For this teacher, Alexandre is the paradigm of saving a student by means of an unusual activity. It also confirms that a relationship based on co-operation, friendship and encouragement nourishes learning and will not ruin discipline. Therefore, the club gives her reasons to run risks and propose alternative ways of carrying out classroom tasks.

This narrative highlights certain elements of professional knowledge that guide the work of some teachers. Reflecting upon this knowledge – namely pedagogical content knowledge, content knowledge, curriculum knowledge, and the knowledge of how students learn – may help us as teacher educators to better understand our school and why certain students achieve good results.





## EXPERIENCES FROM MERCURY PRIVATE COLLEGE

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Lydia Suchova, *Mercury Private College, Slovakia*

**This is a first-hand Slovakian story from a physics teacher describing her experience teaching at Mercury Private College, where physics lessons are integrated with economics.**

**A**mong the general public, there is a prevailing opinion that exceptionally good results in a certain field are mostly achieved in schools (we are considering primary and secondary schools) that focus on the respective field. Even I was once a long-time firm believer in this idea; and this is why I was afraid when, as an enthusiastic physics teacher, I was given the opportunity to work in an economics-oriented secondary school. I was afraid that the low number of hours allotted to natural science subjects would prevent my students from being interested in physics, and from ever achieving good results.

**“If your will is strong, your dreams come true”**

It was sufficient to deal with the problem in a way that was a little untraditional and, above all, by having the willpower to do something. The school management’s approach to the natural sciences involves three basic aspects:

- Ensure high-quality, general scientific education for all students.
- Provide an individual approach for students who are particularly interested in the natural sciences.
- Initiate natural science activities that stimulate students at many schools - in the town, region and the whole republic.

### **Olympiads**

In spite of the fact that our students have fewer classes in biology, physics, and chemistry than their peers in other schools, they achieve excellent results in the highest rounds of the Olympiads. Many people are surprised by this fact. However, it is no miracle. We devote ourselves to them at various clubs in the afternoon. With these small groups of children, brought together by their interest in the respective subjects, we can deal step-by-step and thoroughly with various themes. After a year's work, they are so well prepared that they win competitions. But more importantly, they become very involved in their subjects and usually continue their preparation in the next school year.

### **Physics in Pictures**

I think that everyone will agree with me if I say that physics is considered to be one of the most difficult subjects in school (and this often makes it the least popular subject). It is probably the calculations that are the most difficult thing, and that keep many students from taking or enjoying the subject.

This is why we decided to organize a competition in physics in an untraditional way. We wanted children who do not feel drawn to formulas and calculations to be able to not only participate, but also to achieve success. Painted Physics is a competition in which children draw pictures on the sidewalk. It proceeds in several rounds. The winners in the school round advance to a district round. The students work in groups of three and they draw pictures on a surface measuring approximately 3 x 3 m. The theme of each year's competition is set in advance, so the children can prepare thoroughly. For example, one of the themes was "Physics is everywhere around me". The jury that evaluates the pictures is comprised of artists and physicists. The fine arts specialists evaluate the artistic aspect and the science specialists ask students questions concerning physics. All the adults who take part in these competitions every year are simply astonished at how much physics children are able to include in one picture.

The competition is well-liked among the students because it combines the possibility of artistic expression with logical thinking in the wonderful environment of the Bratislava parks.

### **Student Science Conference**

Each teacher knows the feeling that there is a student in his or her class who, regardless of age, is an expert in a given field, and whose knowledge is greater than the teacher's. These children are keen on a particular subject and spend most of their free time studying it.

The problem is that they usually do not have any opportunities to demonstrate their knowledge or compare it to the knowledge of their peers. And this is the reason why our school organized the Student Science Conference for students from the whole of Slovakia. Because such an event is unique not only in Slovakia but also abroad, we were worried about what the response to it might be. At the beginning of the school year we contacted every school in Slovakia to invite students between twelve and fifteen to take part in a student science competition. They could choose their preferred field: astronomy, ecology, botany, zoology, chemistry, experimental physics, theoretical physics, geology, etc. All these categories were divided into several groups according to the age of the students. Students worked on a given topic under the guidance of their teacher, and summarized their results in a research paper. They described theoretical knowledge and experiment results, interpreted their results and drew their own conclusions. The jury that evaluated the papers consisted of university teachers and other experts. Finally, participants from the whole of Slovakia were invited to Bratislava to spend two days there and to present their work in front of the jury and audience. Many participants brought some experimental equipment relating to their research paper.

It was great to see how excited the students were about their papers and their insight into the subject. For most of them, it was the first chance to make a presentation in front of an audience, to prepare a speech and answer questions from experts. The whole event was highly prized both by students and teachers, as well as by the experts. For many university teachers it was the first opportunity to work with such young students. Finally, we have followed the progress of some students who took part in the Student Science Conference. We can see that this was the first research paper that led them off in a new direction.

I would like to remind everyone that it is not the type of school that is the decisive factor: willingness and initiative are more important.

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## AUSTRIAN SCIENCE DIDACTICS LAB

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**The performance of Austrian students in upper secondary schools (ages fourteen to nineteen) in the third International Mathematics and Science Study was less than satisfactory. In particular, problem solving and conceptual thinking, i.e. making use of basic scientific concepts to work on problem-oriented tasks, did not turn out to be a major strength of upper secondary school students in Austria.**

**T**he Austrian school system is highly diversified, which means that at upper secondary level there is a great variety of schools providing academic and vocational education and training that leads to different levels of certificates (from apprenticeship to university entrance, as well as double qualifications – VET and university entrance). Therefore, the conditions for science teaching and the role of teachers is challenging in at least two respects:

- The number of teaching hours varies from, for example, one hour of chemistry or physics in VET colleges for tourism, to eleven hours plus two optional hours of science teaching in academic schools with a special focus on science.
- The amount of science teaching is a criterion for the selection of schools by students, and clearly shows gender preferences.

In reaction to the dissatisfying results of TIMSS Pop3, the Federal Ministry of Education launched a series of in-depth didactical analysis activities to

discover reasons behind the students' performance in TIMSS. This led to the start of a large-scale project: Innovations in Mathematics, Science and Technology Teaching (IMST<sup>2</sup>)<sup>2</sup> with a time frame extending from 2000 to 2004. IMST<sup>2</sup> targets are to formulate a concept of basic science education for upper secondary level (*naturwissenschaftliche Grundbildung*), initiate reform processes in pilot schools, develop proposals for teacher training and teacher-in-service training, and also stimulate science teaching methods in the community of Austrian universities.

### **The Science Didactics Lab**

In January 2002, the idea of a Science Didactics Lab was born. This additional activity, closely connected to IMST<sup>2</sup>, has a clear focus on the hands-on practice of science teaching in upper secondary schools, with an emphasis on the needs of VET schools. The special target group is students who do not favour (or try to avoid) science.

The conceptual basis is an understanding of science teaching that does not follow the logic and systematisation of scientific disciplines such as chemistry, physics and biology as these are manifested at university, but focuses on:

- Networking along shared boundaries of the disciplines,
- Science as the basis of technology,
- A close connection to the world in which the students live,
- The use of basic concepts to generate an overview,
- Mathematics only as a tool and support,
- Using a case study approach.

Behind this is the assumption that it is essential for everybody to have a certain understanding of basic concepts of science for everyday life in a world dominated by technology. Only this will ensure the ability of future generations to participate in the political processes in democratic societies where decisions on technological developments and projects are publicly discussed and made (i.e. use of mechanisms of direct democracy), and have long-lasting impacts on life on this planet.

Such an understanding can be achieved if students are confronted with problems and questions that affect them in everyday life, such as the following:

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<sup>2</sup> More information: <http://imst.uni-klu.ac.at>

- Material, distinctive features and handling,
- Electricity, electronics, how do electronic devices work?
- Construction, design and architecture,
- Nutrition, health, metabolism,
- Ecological circuits,
- Reproduction in nature and among human beings,
- Mind and understanding,
- “Life is biochemistry”,
- “Driving license”: transport, traffic, mechanical principles.

Equally important, however, is that students open up their horizon to science as a way of thinking and of interpreting nature and life. Therefore, subjects of a more philosophical nature should be included in contemporary science teaching as well:

- Scales in science (time, space, mass, energy ...),
- Life and the environment (anthropic principle ...),
- Matter, light, radiation and their biological reception,
- Climate, weather phenomena and effects,
- Simplicity and complexity in science,
- Safety and risks in scientific and technological development,
- Science, esotericism and magic,
- “Dialogue with Nature” (equilibrium, quantum phenomena, ...).

At the Science Didactics Lab, a group of innovative practitioners, under the guidance of an educational specialist from the university, works on cases of “good practice” to show how the above-mentioned ideas and principles can be implemented in actual school life.

A wide variety of pedagogical methods and approaches should be used to organize fruitful and interesting learning conditions (focusing on self-organized learning and the individualization of learning).

The tasks of the Science Didactics Lab include:

- Cooperating with the IMST project on the development of a “new pedagogy for science”,
- Promoting young educational experts,
- Organizing a “survey” for examples of good practice at schools and universities,
- Developing content for e-learning and multimedia use,

- Organizing in-service teacher training and congress events,
- Participating in curricula development.

The point of departure was a Start-Up Conference on 7 October 2002 in Vienna, where the concept of the “Science Didactics Lab” and some interesting pilot projects were presented to a group of about 140 Austrian science teachers. A sense of going beyond “new frontiers” arose among the participants, and a lot of new ideas, plans for projects, initial results and interesting insights into science education were developed.

The next step will be to share experiences in life sciences such as biotechnology and gene technology. The coordinators will arrange a half-day programme where experts from universities, companies and research institutes (there are some biotechnology clusters around Vienna and in Tyrol) will visit schools and teacher training institutes.

In addition, examples of good practice in subjects such as biology, chemistry, physics, and even interdisciplinary studies at twelve upper-secondary schools will be presented throughout the current school year. The results and experiences from the projects will be disseminated in the spring and will provide the basis for the next year’s work.



## WOMEN'S EDUCATION AND EMPLOYMENT IN SCIENCE AND TECHNOLOGIES

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Anne-Marie Bruyas and Alessandra Drioli, *Fondazione IDIS-Città della Scienza ONLUS, Naples, Italy*

**Women's Education and Employment in Science and Technologies (WEEST) is a European project carried out in the context of the European initiative CONNECT. The project supported the creation of a Web site that aims to "connect" the different aspects involved in the education of young people towards scientific careers: the influence of culture and society, school education, the world of science and research.**

**T**he WEEST project partnership brings together the competencies of different types of institutions in France, Spain and Italy. CNIDFF – *Centre de Documentation e d'Information des Femmes et de la Famille* – is a national network in France that promotes equal opportunities. IRENE is an Italian association working in the field of vocational training with the specific objective of increasing women's participation in scientific careers. IPSIA Bernini is a secondary school in Naples. *ARENOTECH* and *GEA 21* are Spanish and French organisations developing different initiatives to encourage the participation of women in social and cultural issues. *Pax Mediterranea* is a Spanish agency for the propagation of innovation and technology. Finally, *Cité des Sciences et de l'Industrie* (CSI) and *Città della Scienza* are two important science centres in Europe engaged in the dissemination of scientific culture and education.

The Web site mainly addresses students, teachers and others working in the field of education, training and vocational guidance. The products and materials collected by the partnership have been organised in the Web site into four main sections:

- Exhibition,
- Meeting women scientists,
- Education and training,
- Employment.

### **Exhibition**

In 1995, in a discussion with women scientists who were producing a video, Julia Goodfellow, a professor of biomolecular sciences at the University of London, showed us the results of a study on career selection in England. The image of science that women had was very negative. Girls were less interested in the technical and physical sciences. One of the reasons for this was an image of science linked to old stereotypes: *“It’s about wearing white coats and being stuck in laboratories”*. Another image pertained to science itself, not the scientist: *“Science is often perceived as something which runs counter to society, rather than trying to improve the quality of our lives”*. This unattractive image still exists today as far as girls are concerned. This is the reason why we decided to set up a small exhibition with fifteen posters, which can be easily reproduced and distributed throughout Europe. The first part of the exhibition examines the role of women in the history of science from the beginning of civilization (eight posters), the second part explains the themes of the current discussion of women’s views about science and technology (two posters). The last part underlines the weak presence of women and the difficulties they encounter in their careers (three posters). The poster exhibition is available on the Web in all European languages.

### **Meeting women scientists**

In order to improve the image of science, it is necessary to establish personal contact with scientists, particularly, in this case, with women scientists. This is the aim of the women’s portraits presented by WEEST. Women working in various scientific fields were interviewed, and portraits of them were published. These sixteen portraits present women who practise scientific careers today. Tiphaine Bichot, for example, Product Marketing Manager at Alcatel said:

*"I think it's incredibly exciting to work with various careers, and trying to make progress in one of them is not a question of focusing on technique as far as I am concerned, but about helping other people employed in the high-tech business to formulate new approaches. Engineers, for example, work on technology not simply at the request of others but for themselves. They also need to consider the issue of how to market their discoveries. That's the idea of collaboration as far as I am concerned:*

*"You don't have to be a pure scientist to work in a technological sphere today."*

*products have to be thought out and created for users, and users have to feel that their interests shape the process. My job might be scientific but I have a very human job, a very specific job, where the*

*way in which I work differs considerably from day to day. In my job I meet all sorts of scientists, product engineers, artistic designers, publicists, etc. You don't have to be a pure scientist to work in a technological sphere today. All types of knowledge can be integrated very successfully."*

The same objective was proposed for the three "chat sessions", organised as an on-line debate between secondary school students and women scientists. It was great to see how women can communicate their enthusiasm and sometimes justify the tricky choices they have to make. It seems easier for women to communicate their passion and the reasons that have informed their decisions.

### **Education and Training**

The work implemented in this field is based on two premises: first of all, training is a vital thing for the actual building of human personality; secondly, school is not the only place where one can learn.

In the context of WEEST, a specific list of tools for activities to conduct in class have been collected throughout Europe: questionnaires, teaching activities, and publications designed to help create modules for experimenting with educational programmes that are sensitive to gender differences. Also, best practices in the field of education and training for the involvement of women in scientific careers have been identified and reported here on the Web site.

School is still, of course, the principal location of primary and secondary education for young people. It is in this very area that the old stereotypes are often inculcated. The role of teachers, therefore, is vitally important, but we have not yet managed to convince all of them to teach in a way that respects all of their students. School textbooks in science and technological issues are often

far too male-biased. The question of equal opportunities at school is restricted to a number of activities and is not really fully integrated in school life. The education of teachers is often insufficient to enable them to carry out more personalised forms of teaching that take the differences between their students into account. We often hear about aptitude, but the idea that men and women might have different methods of learning is something that has not yet been grasped.

The activities carried out in science courses should attempt as much as possible to diversify and use all possible methods of learning, stimulate all the senses, get people involved hands-on, get them involved in team work, move from a global to an analytical approach, stimulate the curiosity and imagination of the students, and use the scientific knowledge gained to carry out socially worthwhile activities, etc.

### **The entrance into professional life**

Choice of profession is a key element in the lives of young people. This decision, whether taken under pressures from school or other influences, is vitally important. Those who help young people to make these choices should help them fulfil their own desires by putting together a personal project that is well thought-out and is not simply influenced by the stereotypes and standards put forward by society or the opinions of their peers. It is vitally important in this very sensitive stage of life to make people aware of women who have successfully entered into so-called male careers, and to show the broad range of possibilities that are available to young people today. Thanks to the contribution of all the partners, a portal now invites surfers to visit other sites showing scientific careers, examples of women in what are perceived as masculine careers, types of courses, and how to obtain scholarships for study abroad.

[www.cittadellascienza.it/weest](http://www.cittadellascienza.it/weest)

## COPING WITH SCIENCE

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Lykke Margot Richter, *Research consortium Math and Science, Learning Lab Denmark*

**What makes children think about scientific inventions? In this case, it was watching the news and listening to parents' conversation that made a twelve-year-old schoolboy write an essay on the theme "The world would be a better place to live in if...!"**

Once upon a time a twelve-year-old schoolboy wrote an essay on the theme "The world would be a better place to live in if...!" Accept for including this sentence the theme was optional, left to the imagination of the children in the fifth grade. A girl wrote about how her world would be a better one to live in if she could only afford to buy that lovely dress she had seen in the local shopping centre. Now, this essay theme was given at a time when it seemed that all hell was breaking loose. Terror attacks, war between the Palestinians and the Israelis, war in Afghanistan, the Bosnian rehabilitation, and much more. Every time you watched the news on television, a new sad story with bloody photographs and facts about people being killed or injured would appear. No later than later months after the terrorist attack on the World Trade Center, the schoolboy had come to a sad conclusion concerning the adult world.

### **An essay**

*"When watching TV, you always see and hear about war. Lately, we have heard about the war in Palestine. Before, it was the war in Afghanistan and now the*

*war against terror. War is a very insane thing! War destroys houses, buildings and cities. People get arms and legs blown off and some die, while others are seriously injured. And it is all because some people can't get enough power. Also, it is because of all the insane weapons invented over time. Some of them are even used in war. One of these insane weapons that has not been used in war is the Hydrogen Bomb. This invention is so dangerous that it takes an atomic bomb to trigger it off. A bomb like that would cause an explosion big enough to damage Denmark, Norway and Sweden!*

*The USA is a superpower, and through their presence they have made themselves unpopular by interfering in other countries' politics, which among other things was a reason for the terror attack of 11 September. Afghanistan is not big enough to declare war against the USA, and so they had to attack through terror. Once upon a time there were two superpowers: Russia and the USA, which meant that there was a balance of power. Today, the USA owns the most weapons and therefore it is the only superpower. The USA spends an unimaginable amount of money on the invention of new weapons.*

*I think the world would be better if people could live together in peace. Those enormous amounts of money spent on war and weapons should be spent on other things such as helping the poor countries, then the world would be a better place to live in."*

*(Victor, fifth grade 2002)*

### **Imaging Science**

When reading this essay I thought of how intelligent children are and how often we actually underestimate their understanding of science in everyday society. Children are fast learners. They very easily follow adult discussions on politics, nature and catastrophes – especially when such issues arouse people's emotions. And they love to learn from their parents. Now, this is not a discussion concerning whether or not children become psychopaths and murderers from watching the TV news. Personally, I have learned most of what I know about geography by playing the war game Risk, where the aim is to conquer countries – and I am no Napoleon, I am only a mosquito-killer. So, let the political debate rest for a while and let me pick up on the "most insane invention", the hydrogen bomb, and let us play a little game of physics.

Usually there are two scientific explanations to this phenomenon – one that focuses on the positive aspects, and another that focuses on the negative. Let me give you the scientific explanations starting with the positive one.

The positive scientific explanation:

The hydrogen bomb is a powerful type of atomic bomb based on nuclear fusion. Fusion occurs when two isotopes of hydrogen melt together. The melting process causes a temperature of up to a 100 million degrees Celsius. Fusion is the energy that fuels the sun and the stars and, needless to say, it is therefore a very lasting type of energy. Here on earth, such extremely high temperatures are not found, except in the hydrogen bomb. A hydrogen bomb is 100 to 1000 times more powerful than an atomic bomb. In order to reach the million-degree temperature that would trigger a hydrogen bomb, it is first necessary to explode an atomic bomb. Even though, here on earth, fusion is only achieved with the hydrogen bomb, it is an amazing form of energy. It is extremely powerful, with a lifetime of radioactive toxic of a few hundred years, instead of the many thousands of years of radiation from the nuclear power plants in existence today.

The negative scientific explanation:

The hydrogen bomb consists of an atom bomb with heavy isotopes of hydrogen. These undergo fusion when subjected to the immense heat and pressure generated by the explosion of a nuclear fission unit in the bomb. The fission bomb is first triggered allowing the temperature in the assembly to be raised to several million degrees.

In 1950 Niels Bohr wrote a letter to the UN in which, based on his scientific knowledge of nuclear power, he warned them about the extreme power of the hydrogen bomb and what it could lead to. Even a small hydrogen bomb that can be carried on a truck is powerful enough to cause an explosion bigger than the sum of all bombs ever exploded in the world. The bomb was tested in the South Pacific and in Siberia from 1952 to 1963. Castle Bravo was a hydrogen bomb and was tested at the Bikini Atoll in 1954. It yielded fifteen megatons and had a fireball 4 miles in diameter. This is how Marshall Rosenbluth, an American theoretical physicist who was part of the test crew, described it:

*“I was on a ship that was thirty miles away, and we had this horrible white stuff raining down on us. I got 10 rads [100 chest x-rays] of radiation from it. It was pretty frightening. There was a huge fireball with these turbulent rolls going in and out. The thing was glowing. It looked to me like a diseased brain up in the sky [...] It was a much more awesome sight than a puny little atomic bomb. It was a pretty sobering and shattering experience.”*

Typically, it is the first explanation that is emphasized in the classroom. There is a tendency in science to try to be as objective as possible, providing explanations based on facts, leaving out the personal experiences of the scientist, and also emotions. Explanation number two clearly shows us that the metaphorical description given by the testing crew actually tells us a lot about the hydrogen bomb. The that image of a diseased brain up in the sky symbolises emotions, and gives a strong image of the scientist's experience of an experiment that was so insane it was beyond belief. My point is that the second explanation includes the emotion, felt during the actual experience of a scientific experiment, and it thereby speaks to the heart in a common language. Concerning the essay, it is obvious it was his emotional response after watching the news that caused

*“ What will happen to us  
if Barsebäck blew up in  
the air? ”*

Victor to write down those reflections. Also, I came across some letters written by schoolchildren from Frederiksberg Gymnasium in Denmark. Here the class had been working with the theme of nuclear power in physics:

*Dear Natural Science editor,  
We always read your mailbox and think highly of your answers. We would like to know what a hydrogen bomb is and what causes the radioactive radiation?  
Waiting for your reply, D, C, M and H*

And,

*Dear Mailbox editor,  
Perhaps you can help us to answer these profound questions:  
How does one die from an atomic bomb? When using nuclear power, how often does fission succeed in a reactor? What exactly does an atomic bomb consist of, and what happens when it hits a target?  
Regards, C, J, H, D and R*

These are questions about physics that the class had to prepare for each other. The questions were written down in an informal way, so that the students were forced to think about what they would actually like to know, and also to make sure the replies would be given in an informal way. Unfortunately, I do not have the students' own answers. However, this does not make my point less relevant.



Everyday children are exposed to the media. It is as much a part of their life as ours. What adults talk about is interesting and exciting, even when it comes to discussing the more negative impacts of scientific inventions, as in the case of insane inventions such as the hydrogen bomb. So, instead of being so romantic about science, let us place all the facts and emotions on the table, especially the ones that are linked to social consequences.

In other words, let me find inspiration in Victor's essay and ask you the question: What could you do to make the world of natural science a better place?



## LEARNING IN MOUSSAC

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Wolff-Michael Roth, *University of Victoria, Canada*

**What I saw in Moussac was a school where the transition to out-of-school life in the community was much more transparent than in most other schools. The school has become part of village life. The close interaction between the school and the entire village of Moussac allows the children to participate in daily activities, that is, to develop into increasingly competent members of the community at large by actively participating from young ages.**

**I**t is morning in Moussac. Through the viewpoint of a camera, we see children walk towards their one-class elementary school as they explain that they arrive at school when they want to in the morning. In fact, their teacher Bernard Collot does not want all of them to turn up at the same time. Once at school, the children show the visitors around. There are computers where children publish their own newspaper and write letters to pen pals all over the world. The children explain the function of the music room, with its homemade percussion instruments and a tape recorder, the discussion room containing long table, the classroom for the little ones (roughly K-3), and that for the older ones (roughly grades four to six). Then there is the blackboard where the children record their daily “curriculum,” which they establish themselves through collective efforts.

Journalist: So, if I understand well, the children in this class do what they want?

- Teacher: Not entirely, not entirely. It's not what they want, but what the collective activity of the class, what the events globally bring about. So what I try is to order these events somewhat.
- Journalist: Because I get the impression that they, by and large, get by without you?
- Teacher: Yes, they do well without me. My own problem is to make this group function as a community.

Throughout the school day, one can see five-year-olds preparing a puppet show or gathering for one of their collective meetings around the discussion table with Jean, their current, but weekly-changing chairperson. In these discussions, the teacher Bernard is but one of the members, and waits for his speaking turn as any other member of the community. There is the chess lady who comes every Wednesday, and who emphasizes that because the children are free, they also make her free. The teacher explains, "If I am really glad about her presence, it is not for the chess but for her presence as a person. It is because she has a relationship with the children, there are extraordinary things that happen while she is here."

Later, a couple of older kids bring letters that they have written to their pen pals in other countries to the post office, where the official indicates that the children's posting of letters two or three times a week has become part of everyday village life. The post office manager says that it was strange initially to see the children come from school just like this, in the middle of the school day, but it makes for a revival of the village in the school. In the school's shop room, children work on their own projects, sculpting and hammering while Bernard watches the youngest ones, but without interfering. He explains that it is only when people get nervous about failure and accidents that failure and accidents come about. Viewers can see a parent who comes to garden with the children; some children in the music room experiment with the percussion instruments; a boy sits in the corner by himself and listens to music using headphones; in another corner, a boy writes a letter while others read with a group of smaller children.

- Journalist: Don't you have this fear weighing over you, "I have to teach them to read, teach them to write, and teach them to count"?
- Teacher: No, I don't have this fear at all, absolutely not at all. For slowly I learned that when the children are part of a group that really exists as community, when there is a real setting, when the interactions with this setting, with other children and adults, when this context really exists, at that point, all children without exception learn to read. How? Now, this is another matter. But it isn't really my problem. The gardener's problem is not how

plants grow tall, strong, and well. His problem is to put them at their right spot, to plant them somewhere, to recognize that this might not be the right place, and to replant them somewhere else, and so on. And I have this gardener's job. And when the garden, the community is like a garden, when it really works, children inevitably learn to read. It's like with their teeth, they will inevitably come. But although the children's mothers know about it, they still worry. So here, it's about the same thing. One has the responsibility of not preventing children from learning how to read.

In the end, Bernard talks about failure experienced by students in schools other than his own. It is not the children who fail, but teachers, schools, and the school system who fail the children. Learning is natural, and emerges from participation in the collective activities of a community. Learning and participation cannot be separated, but are inextricably bound up with each other.

### **School and Community**

In this village, children learn through engaging in real activities, activities that are meaningful to them, over which they feel ownership, and that they plan on their own. They publish a newspaper, they communicate with peers in other parts of France and the world, they keep journals to write about the contents of their reveries and reflect on their learning. Younger children learn as they participate in legitimate peripheral ways in the activities of older children. There are meetings of the collectivity, times when older students read to and with younger children; at other times, adults from the community interact and make available their competence as resources to the members of the school community.

An important aspect of the community in the school of Moussac is that children have a sense of self-determination and control over their activities, and with it, over their own learning. But the activities of individual children are not independent of each other, not an odd collection of individual activities disconnected from those in which other children engage. Rather, the activities of individual children are in part determined by the "sum total" of the collective activity; they are concrete realizations of the possibilities that exist at the level of the group. Individual interests and those of the community influence each other in a reciprocal way: they are mutually constitutive and always bound up with the object of the activity. This makes it unnecessary for the teacher to motivate children, that is, to make them do on their own what others want them to – such a form of motivation is a voluntary acceptance of an external control. Coming to school at their own time, going to the post office, or determining

their daily curriculum are but a few of the outward signs of the children's ownership over their learning contexts. In such a community, teachers' activities change from those they traditionally performed. Here, teachers have to be centrally concerned with setting up the community, keeping it going, and not interfering with the children's propensity for learning. They do not have to disseminate information, but only help to order emerging collective activity. Bernard's comment that children will inevitably learn when the community really exists resonates with Lave's (1993) assertion that we do not need to force children to learn. Learning occurs inevitably, as part of our being-in-the-world and participating in collective activities with everyone else. Nonlearning or mislearning "occur when embarrassment is too great or result from anxiety, from the social delegitimation of learning or the learner, and from the retarding effects of denying learners access to connections between immediate appearances and broader, deeper social forces or to concrete interrelations within and across situations" (p. 16).

Once the community exists, it develops its own history. From year to year, only a small number of students leave and an approximately equal number of students join, so that the community builds its own memory. This community memory (for how things are done, past accomplishments, "heroic" stories) does not stay constant but enriches itself from year to year. The students are as much, or even more than the teacher, carriers of this history. This means that the teacher no longer has to work with the children at the beginning of each year to establish sets of rules and *modus operandi*. Once the community exists, it maintains and reproduces itself year after year because of the stability that comes from a stable membership.

In Moussac, the interaction between school and community goes even further in the sense that it offers opportunities for others, adolescents and adults, to acquaint themselves with new information technologies or to borrow a book or document. Students, from middle school to university, come to use the computers to write their essays, research papers, and other forms of homework. Adults in search of work come and type their curriculum vitae using appropriate software that has been made available to them. It is also here at the school that the association "Une École Un Village" holds its monthly meetings for organizing school life, village theatre, and festivals. The local paper is published at the school, the village choir practices here. Initiated by Bernard Collot, the idea of the village-school integration was subsequently supported by the parents and elected officials. Over the years, he supported intense local activity around the concept of continuing education, that is, the readiness of an entire village population as an instrument of proximal learning.

When I talk to teachers about the documentary and other information I obtained about the school, I inevitably hear lists of reasons why this is an idyllic situation and cannot be transported elsewhere. However, I have repeatedly observed and documented classrooms that had striking similarities with the school in Moussac (Roth 1995, 1998). For example, during my last three years as a schoolteacher and head of science department, I taught eleventh and twelfth-grade physics. I turned the physics laboratory into an open place where people, students and teachers, could come whenever they wanted and work at whatever they wanted. There was a community in which older students helped younger ones in grappling with intractable problems in their physics experiments. Mathematics teachers came to do their work on the available computers (when all computers were used, teachers did something else first, and came back later rather than claiming their “rights”). Other science teachers came to work with students on experiments, to observe and participate. But in this physics laboratory, it was not just the physics students who learned, and it was not just physics that was learned. Students came after school and in the evening to work on mathematics projects, write their religion and geography essays, and produce graphs for their economics class. Again, there was interaction between students at various levels of competencies, interacting with each other and with the teachers present. I was often sitting in an adjoining office with the door ajar, doing my own work. Like the teacher at Moussac, I saw my job as keeping the community going, creating an environment in which members learn, inevitably, and because they want to.

How can we design such communities that support learning, communities in which participants learn school-related things although they pursue projects that they have designed on their own?

### **Motivation: A Social Psychological Perspective**

Psychologists and educators often wonder how to motivate students. Here motivation is equivalent to making students do voluntarily what someone else wants them to do – this question is the motivational formulation of external determination (locus of control). The teacher’s question “How do I motivate students?” therefore inherently contributes to the external locus of control rather than to the situation where motivation is inherent in the object of the activity chosen by students on the basis of meaningful grounds. Historically, we can understand motivation to arise from a projection whereby individual needs could be satisfied by participating in the satisfaction of collective needs (Holzkamp 1983). Let us take the famous example of collective hunting activity in which

beater actions (frightening the game) and hunter actions (killing game) are coordinated (Leont'ev 1978). In this case, individual and collective motives coincide. That is, the individual who recognizes that the contribution to the collective activity also opens up a control over and improvement of the individual situation, is inherently motivated. Truly collective activities are always characterized by the coincidence of individual and collective motivation – this is most clearly evident in competitive team sports. When individual and collective motivations do not coincide in the course of collective activity, there exists a contradiction, entailing different coping mechanisms that sustain or remove the contradiction (the shortsighted solution to school violence is the removal of individuals rather than the making of changes to society as a whole).

We can generalize that learning is motivated when the subject of learning anticipates that learning will lead to greater control over his or her conditions or quality of life, that is, to an increase in his or her possibilities. Learning, motivated in this way, is inherently *expansive* (Holzkamp 1993). Learning for the sole purpose of avoiding a diminishing control or quality of life is *defensive*. It is associated with an external locus of control focused on avoiding or coping with menacing situations.

“They begin to read and write when they are ready.”

*Expansive* learning is generally associated with situations in which individuals form collectives to deal with problematic circumstances in order to capitalize on the greater control they have as a collective (Engeström 1987).

*Expansive* learning, in addition to being mediated by the collective, orients itself according to the needs of the problematic situation. Motivation is therefore tied to the object (necessarily as viewed from the individual subject). That is, students who choose their goals are inherently motivated to achieve them – even in the case where they desperately want to go to the bathroom to avoid a physics lesson.

The students in the Moussac village school are not made to learn to read and write; they begin to read and write when they are ready for reading and writing. They are not made to learn musical notes, they learn to play because they play in a context where, now that the “community really exists,” others always and already play. In a context where cultural practices include reading and writing, where older children read to younger ones and where children are engaged in writing e-mail messages or sending letters, participation in cultural practices is coextensive with learning to read and write. Motivation to learn is built into the cultural practices and the objects towards which they are directed:



children learn to read and write not because their motive is to learn, to read and write, but because they participate in the practice of writing letters to pen pals or in the practice of reading to the younger group members. Similarly, the direction of learning is produced and reproduced in practice. As an individual begins to participate in a legitimate peripheral way in an ongoing practice in a process to master the practice at some point, the motivation to learn is built into the process. How it is achieved depends on the particular needs of the individual, and happens just in time and as needed. The exact moment of time when learning is needed depends on the trajectory that the particular individual takes, for every future moment on the trajectory depends on where the individual is at the moment, which itself depends on the prior history of the trajectory; that is, during learning, the trajectory integrates its own history.

After the early development of the child into society, he or she later becomes a member of this or that community of practice. For example, a child might decide to play soccer; in the context of a club or sponsored team, under the guidance of the coach and other club and team members, and with the support of parents who drive him or her to training and games, the child gradually becomes a soccer player. Later in life, he or she may decide to earn money by working for a fast-food restaurant as a dishwasher, short-order cook, or sales person. Again, in the context of an existing community, the individual participates, and through this participation is exposed to a particular material and social world. Finally, the individual may decide to become a physicist or ecologist. Again, from the interaction with others and the material world, for example, during their fieldwork experience, scientists develop dispositions for looking at and interpreting the formal representations (e.g., graphs) characteristic of their field (Roth and Bowen 2001). By becoming competent, the individual also incorporates the tacit assumptions that underlie the particular community of practice, whether this concerns particular ways of dealing with dirty dishes, the do's and don'ts of preparing food, or patterns of how to interact with clients. Learning can be thought of as changing participation in the ongoing but changing collective praxis.

### ***Communities and Responsibilities***

In the light of the foregoing comments, let us take another look at the village of Moussac, its students, teacher, parents, officials, and the village at large.

In Moussac, there exists a collective responsibility taken by the community as a whole, that is, the responsibility for learning is distributed across the community, students, teacher, parents, elected officials, and others. I understand

“distributed” not in terms of being divided up, each individual or group taking a little bit of responsibility. Rather, distributed means that the community takes collective responsibility, which is a generalized referent for action. Individual and collective responsibilities are therefore related in the same way as individual and collective possibilities for action, individual and collective motivation, or individual and collective dispositions. That is, individual responsibility then is the concrete realization of the generalized responsibility. At the same time that the teacher and the rest of the village take responsibility for learning, each child takes individual responsibility for his or her actions, beginning the day with the outline for the daily program. These actions and projects are not designed willy-nilly but are in part determined, as Bernard Collot said, by the sum total of the collective activity in the class. Thus, we have again the mutually constitutive interaction between individual and collective actions, and between individual and collective responsibility for the context in which children learn. Closest to the children during the day, Bernard enacts his own part of the responsibility, which concretely consists in “regularizing what is going on to make the group really function as a community.” Parents and other adults (like the chess lady who comes from another village), and village officials, too, take their respective parts, each enacting a concrete realization of the generalized responsibility.

Production and reproduction of practice are always part of practice. The hardest part, as Bernard Collot said, may be to bring the group about initially. Once the collective exists, the number of individuals joining or leaving the group is relatively small compared to the entire group. As pointed out above, this delimits the amount of effort any teacher has to spend at the beginning of each school year to socialize students into particular patterns of social interaction. Even more interesting, the Moussac experience continues although Bernard Collot has retired from teaching and another teacher has taken his place. That is, just as in the “natural” communities of practice studied by social scientists, such groups provide newcomers with an existing, relatively stable social structure into which they can be socialized without any effort on the part of the teacher. An important aspect of schooling in Moussac is the heterogeneity that comes with the composition of a one-class school and with the interpenetration of school and village life. That is, the heterogeneity that seems to be at the core of the success of the Moussac experience, challenges common assumptions about the homogeneity of school classes as a prerequisite for efficient teaching and learning. The well-known social anthropologist Jean Lave, also challenges the assumption underlying much of education that actors, goals, motives, activities, participants, culture, and meanings of events have to be homogeneous for learning to occur. Her description of situated learning

appears to fit well with what happens in Moussac, while constituting an antidote to what counts as knowing and learning in the majority of educational systems.

Once the group exists, goals and motives are embodied in the objects of activity; by participating with their older classmates in the ongoing practices, the younger children also take on board the inherent goals, motives, responsibilities, and dispositions. In the process, they experience the need to learn to read, write, and do arithmetic, even though the teacher never has to motivate them (or worse, force them). Once the group interacts with children in other schools in their district, their country, or countries around the world, newcomers to the classroom experience from their first day “writing to pen pals” as a common everyday practice. In Moussac, students take an active role in learning. Rather than merely responding to fixed external conditions, like cultural dopes who blindly follow rules, doing and saying what the teacher tells them to, the students contribute to producing and reproducing the conditions necessary for expansive learning to occur. In the first place, they reproduce the group characterized by particular practices. In collective activity, individual possibilities of action are viewed as the concrete realization of generalized (collective) possibilities. Because they are cultural agents rather than cultural dopes, the teacher and students have the capacity to change the conditions that frame their activity. However, this agency and therefore control over the context is not unlimited. Objectively experienced structures in the village constrain what the teacher and students can do. There are always social and material determinants of action. The teacher and students learn and their group develops, as they increase their control over the events in the classroom.

We can think of learning in the community of Moussac in terms of the notion of the zone of proximal development (Vygotsky 1978), which is often used for theorizing activity and learning when a less able individual (student) achieves at a higher level because more able individuals “scaffold” engagement in a task. The zone of proximal development is then the distance between achievements when an individual works alone, on the one hand, and when he or she works with the more able person, on the other. However, the zone of proximal development can also be understood in a wider sense. It can be understood as the distance between the everyday actions of individuals and the historically new and culturally more advanced activity that can be collectively generated (Engeström 1987). In Moussac, the village as a whole constitutes the community that engages in the activity of learning in the course of daily praxis. The community allows for learning not only as adults come to school to provide support or children go into the community (such as to the post office), but also the adolescents and adults come to the school to access resources (books,

Internet) or engage in collective activities (meetings, choir practice) that provide contexts for their own learning. School and village life more generally interpenetrate one another.

### **Implications for policy**

I think that it would be worthwhile to rethink science education in terms of collective praxis, which may require us to uncouple the formation of scientists and engineers from the broader goal of allowing each individual to learn and develop into a democratic citizen, who contributes to the overall project of maintaining collective life in the society.

Here, I am not advocating that all schools become like that in Moussac or that all children engage in environmentalism. Rather, Moussac and other case studies that I have constructed as part of my research are examples for rethinking (science) education as collective praxis and for drawing implications from such an approach. I know that the practices of Moussac cannot be copied exactly as they are into other settings, for they are historically situated practices, deeply interconnected with other practices that bind the village of Moussac into French society. Nevertheless, we can learn some lessons from the experience in Moussac.

In true learning communities such as Moussac, teachers are oriented towards both (a) the maintenance of the community and (b) the object that characterizes the practice, rather than towards influencing, constraining, and controlling students. Concerning the first point, the village school in Moussac provided an example that shows that such an orientation allows learning to occur because it is inherent in the practices of the community. As part of the second orientation, a teacher engages or talks about problems with the object rather than talking about it. The problem with current schooling practices is that they do not resemble the practices of the fields that they are intended to teach. Rather than doing science, mathematics, or history, teachers do questioning, controlling, preparing tests and marking, and students do responding, submitting to control, getting ready for tests, and ask “What’d I get?” As long as science, mathematics, or history is not the activity being engaged in, by teachers and students alike, expansive learning cannot occur.

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## FINNISH LESSONS

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Robin Engelhardt, *Consortium Math and Science, Learning Lab Denmark*

**Within the space of only one generation, Finland has made a successful transition from an agrarian society to a high-tech community with the highest educational level in Europe. But without having been able to combine their tradition of solidarity with the virtues of originality and discipline, the Finns would not have made it this far.**

**F**inland is now a country many politicians look upon with envy, due to its being ranked as the best performing European country in the PISA-2000 study. Since the results were made public, politicians and educational experts have flocked to schools in Finland to discover the secret behind such outstanding performance. And so did I. Because of a tip I got from a PISA researcher, I decided to visit one of the best performing schools in Finland, the Voionmaa secondary school in Jyväskylä.

### **Counting on education for all**

The first thing you discover when visiting Finland in the late summer is your own shadow. As you walk along, your shadow follows you on the other side of the road as if it were a grotesquely distorted extension of yourself. It is the effect of a sun that always hangs low, shining yellow and bright on the horizon. Also, it is not unlikely that you will meet cross-country skiing Finns in the streets with

ski poles in their hands and traditional wool caps on their heads. The only problem is that there is no snow and they do not use skis. They use rollerblades.

The new headmaster of the Voionmaa school in Jyväskylä is Ismo Falck. He is a young biologist who got the job temporarily after the previous head teacher, Tamara Eloranta, retired last summer. He shows me the school. At first glance it does not appear to be the wonderful place of educational excellence it is said to be. The grey buildings clearly need to be renovated. The long naked corridors are painted in poisonous green colours, and the classrooms are quite small. But there is no graffiti. Lots of students between fourteen and seventeen walk quietly up and down the corridors or sit on the small benches reading.

“We have no national tests, something which gives us a lot of freedom,” says Ismo Falck. “And we do not control what the teachers are teaching. We only look for teachers who are willing to get involved in the students’ learning and are able to support the weak as well as the strong students. The atmosphere among the teachers is very good at this school.”

In Jyväskylä, Finnish and foreign students can study English from grades one to six in the neighboring Cygnaeus school and from grades seven to nine in the Voionmaa school. Those foreign students who are not taught in English are given one year of preparatory tutorials for comprehensive school, after which they move to a support school. These schools have language assistants for the largest language groups and teaching materials for foreign students. There is also an option to be taught in your mother tongue. In addition to this broad range of opportunities, every teacher in the primary and secondary schools has a minimum of a Master’s degree. This means that the subjects taught are up to date, and it adds positively to the professional depth and development at the schools. At the Voionmaa school, up to seventy-five percent of the students will later attend the upper secondary school. The national average is only sixty percent.

### **Not that outstanding!**

I decide to attend a physics lecture. The subject is electricity. The teacher is a bit worried as she walks towards the classroom because the students “are all ninth-graders and know each other well”, meaning that they talk a lot and might turn out to be a little more difficult to handle than other classes. The classroom is organized quite traditionally. Tables and chairs are aligned in rows and face the blackboard in front. The students sit in pairs. Girls at the front, boys at the back. The teacher shows overheads with batteries in series, batteries in parallel, bulbs in series, and bulbs in parallel. We learn that serial arrangements make the bulbs



glow dimly and parallel arrangements make them glow brightly. The students write everything down in their notebooks. They are quiet and prepared to work hard even if they are not very interested.

After the theoretical readings, each table is handed an experimental box containing batteries, flexible cords, an ammeter and voltmeter. The point is to convert theory into practice. The teacher is the one to pose the questions and the students answer by putting up their hands. Pedagogically speaking, this is not the best way for students to be taught, of course. They will get the impression that practising physics is a matter of following a recipe, and being tested on whether they are bright enough to assemble wires quickly and correctly. But it is probably hard to blame the mistake on the teacher. She has been taught this way, as have her teachers before her. Moreover, the amount of time, space, and materials available in the school does not leave much room for the implementation of more modern learning principles. Forty-five minutes twice a week is the time the physics teacher has to work with, and it is naturally also necessary for the teacher to make sure the students learn everything stated in the school's examination requirements.

But then again, since the beginning of the 1990s the Ministry of Education has dropped the detailed national curriculum. The current national guidelines only include the most general principles, for instance, the number of hours a subject has to be taught. The previous head teacher of the Voionmaa school, Tamara Eloranta, rebuilt the whole curriculum. The school now mixes the classes so that seventh-graders sit together with ninth-graders. This reduces teasing and makes older students take responsibility for those who are younger.

### **Sticking together**

The school has also developed some strong mechanisms for working together with parents. After the physics lesson, Ismo Falck shows me a document that is a written agreement between the teachers, the students, and their parents. They all have to sign this agreement before the students begin in the Voionmaa school. The agreement states some general principles concerning how one should behave and cooperate as a parent. It says for instance:

“We listen and talk to the children.

We try to see the good things in the children.

We guide them in learning right from wrong and help them develop responsibility.

We do not accept any teasing.

We interfere with improper behaviour, also among other children.

Curfew is 9 PM Monday to Friday and 10 PM during weekends, if their homework is done.

Kids inform their parents where they are and parents inform the kids where *they* are.”

“This written statement,” says Ismo Falk, “is becoming normal in Finland, because parents do not realize that they have to say no sometimes. We try to support parents to do their job as parents.”

The demographic statistics support his claim. More than half of the children in Finland are children of divorced parents. Unemployment in Jyväskylä is 15 per cent, but it has actually been much worse. Twelve years ago Finland had a huge financial crisis. The economic collapse of the Soviet Union and of the other socialist countries virtually eliminated Finland’s export markets. Just one year after the collapse, the national income had fallen by 6.3 per cent. Unemployment rose to 20 per cent.

There is one thing that characterizes the Finnish people very well. It’s the notion of “*sisu*”. When people mention their *sisu*, they talk mainly about sport. *Sisu* stands for the determination to win and for the endurance and toughness that is needed in order to reach a goal. In Finland there is a lot of *sisu*. Within twelve years, the Finns have collectively managed to become a rich country with the highest educational level in Europe. The schools and universities are free of charge and the government has a detailed program for the financial support of women with children who wish to study and start a working life. Finland has a mantra, a kind of national saying, which every teacher repeats to visitors. Sirkka-Liisa Kuorikoski, the chemistry teacher at the Voionmaa school, puts it this way: “We are only five million people. We cannot afford to lose anyone. Wherever there is talent, it will be supported.”

### **The well-behaved children**

The last lecture I decide to attend takes place in the forest near the city. The new biology teacher, Elina Nurmenniemi, has prepared a list of names and printed images of leaves and flowers on paper, and the students must now find samples of the leaves and flowers in the forest. Even though it is the first time that Elina Nurmenniemi has taught this particular class, there is no trouble from the students. They listen carefully and organize themselves into small groups in order to retrieve the samples. It is quite late in the afternoon and the students work quickly. They find the samples and deliver them in a polite manner to the teacher. Then they head off for the bus stop.

As we wait for the bus back to town strange things happen. One of the girls from the class offers her seat to Elina Nurmenniemi and myself. Baffled by this politeness, which is uncommon to me, I reject the offer instantaneously and start to wonder what is going on with these Finns. No shouting, no teasing, no jumping, no nothing. The competitive mingling and constant struggling for social acceptance, which is so normal for Danish teenagers, seems to be unimportant to them. They just talk quietly and they even seem to be happy when they sit alone in order to read a book. No wonder they are the best readers in the world.

From the hill comes yet another rollerblading Finn. Doubled up with his ski poles at his sides, he quickly tears down the road and out of sight. This scene, I speculate, might be a good metaphor for the story of Finland: “the combination of modern equipment with traditional supporting tools mixed harmoniously together into a fast moving body”. After the first, yet another man comes down the road. But this time it is a heavy drinker who walks towards us slalom-style. He tries to grope the girls but is sent away by the teacher. Then the bus arrives and we all go home.

### Waiting for the magic mill

It is as if Finns still have an animistic heritage. Nature is still endowed with spirit, just as it is in the *Kalevala*, Finland’s national epic. Every school child reads and learns the *Kalevala*. It is about the struggle and reconciliation of animals and the woodland spirits with the witches and the humans. The heroes

“ If I were a politician, I  
wouldn’t envy Finland because  
of its educational system. I  
would envy Finland its enduring  
people.”

of the epic promise to return one day with the “*Sampo*”, the magic mill. The mill will then once again grind gold and flour and salt, and it will bring another *Kantele* – a wing-shaped zither – that will enchant all life with its magic music. This epic is as different from the epic of the slaughtering

Vikings as the Finnish children are different from the restless children in Danish schools.

If I were a politician, I wouldn’t envy Finland because of its educational system. I would envy Finland its enduring people. Finland’s success is a fairy tale about an agrarian society that has skated into the hi-tech world of the Internet and mobile phones. The Finnish people have made many sacrifices in

order to be where they are today. So far, the tale seems to have a happy ending, as the Finns have survived as a community. But thinking about the larger context, it's also a worrying story. In 1990 the share of wages among salaried employees and wage-earners amounted to fifty-five per cent of the country's total earnings. In 2000, it dropped to forty-five percent. In the same time span, business earnings rose from fourteen to twenty-eight per cent. Ismo Falk barely earns €2,100 a month before taxes. A teacher for grades one to six earns only €1,700. Along with the decline in wages, workers had to accept the erosion of the social welfare system. From 1992 to 2000, social expenses were cut from thirty-four to twenty-five per cent. And since 2000, things have become worse. Finland's largest company, Nokia, continues to cut expenses and eliminate jobs. It is very likely that social tensions will increase as the recession in the IT industry persists, making inequalities in income more visible.

But then again; maybe Finland's prospects are not really that bleak. As long as the Finnish people continue to combine new discoveries with traditional virtues, such as when they combine IT, solidarity and "*sisu*", or when they combine rollerblades with ski poles, nothing should be able to prevent Finland from having a flourishing society in the twenty-first century.

The city of Jyväskylä has a population of 80,000 and is situated almost in the centre of Finland, about 250 kilometres north of Helsinki. Jyväskylä's nickname "The Athens of Finland" derives from the city's long tradition of education and culture. The educational level of the citizens is high: sixty-one per cent of all citizens over fifteen years of age have graduated from educational institutions. Moreover, the city's thirty-year-olds are the best educated in Finland. The University of Jyväskylä is home to Finland's first Faculty of Information Technology, the only Faculty of Sport and Health Sciences, a strong Faculty of Natural Sciences, and a highly extensive range of study programmes in the Humanities, Economics and Social Sciences.

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## CHILDREN EXPLORING THE WORLD OF MINERALS AND PLANKTON

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Lykke Margot Richter, *Research Consortium Math and Science, Learning Lab Denmark*

**In Boulogne-sur-Mer, a leading fishing port in northern France, there is a place where school children and families come to learn about the sea. This place is called Nausicaä, just like the heroine in Homer's Odyssey.**

The former mayor, Guy Lengagne had a passion for the sea and the fishing industry, and was the driving force behind the redevelopment plans for Boulogne. His meeting with three oceanographers resulted in the idea of Nausicaä, a sea life centre that opened in May 1991. At least this is how the story goes. That was now ten years ago, but the vision of being more than just an aquarium is still strong. According to the description of Nausicaä:

*“Nausicaä is more than a successful tourist attraction. It is also a breeding establishment and nursery, a hospital where sick animals can be cared for, a cultural forum, and a research base with its own multi-media centre and team of experienced scientists. It also has an imaginative educational role. Nausicaä is dedicated to environmental concerns, raising public awareness about the need to act responsibly towards the world's seas if their resources and beauty are to be maintained” (press material 2002).*

With such promising words in mind, I set out to explore the real world, and on a summers day in late August I found myself at Nausicaä. My first impression was that the atmosphere was exciting. Modern architecture and “ocean adventure” music let my imagination lead me into an underwater city of

the future. The digitised voice of a guide welcomed me, and an escalator took me below sea level. Here, I first encountered an aquarium filled with jellyfish, swimming as if they were they performing *Swan Lake*. I caught sight of children, accompanied by adults, watching sea lions, sharks, sea horses and plankton. “Look mummy it’s plankton!” a little girl says. Quite amazed by such words coming from a little girl, I wondered how on earth she would know the characteristics of plankton? But it is neither the size nor the cuteness of an animal that necessarily attracts children’s attention. Moreover, I experienced that the more knowledge a child can impress their parents with, the more interested in learning the child becomes. Interestingly, it is not a real person that explains, in an authoritative, scientific manner, the food chain, the classification of species, and adaptation to nature. Rather, it is a mascot, a friendly tropical ray called Rayä. Rayä tells very educational stories about sea life in a language that appeals to even very small children. I observed that the children recognised the Rayä signs, which showed special activities for children, and that they actually acknowledged the information given.

### **To make children wonder**

It is all about making children wonder. Maybe curiosity killed the cat, but how dull life would be without having the desire to explore the world and accumulate knowledge. At Nausicaä it is also important to circulate knowledge, and resources have been spent on building a team responsible for the “education service”. I talked to Cville Delattre from this department about their strategy for educational programmes and his work with the school children:

“How dull life would be without having the desire to explore the world ...”

*“There is always a message about the sea to be given in an educational activity such as explaining the food chain: here, they have to be actors themselves and mime a fish. If some species disappear, we will see what happens to the chain. And the message is that even the smallest animals in the sea play an important role for the cycle of nature.”*

One activity for school children down to four years of age is “Clément gets a parcel”. It is the story of Clément, a boy who was supposed to go to the beach, but unfortunately came down with chicken pox and had to stay in bed. And as every child knows, it is rather boring to stay in bed compared to spending the day at the beach. The following day, Clément receives a parcel from his Uncle Martin and in this parcel he finds sand, shells, different types of water and more.

All these things are similar to the contents of the parcel the children open at the sea centre, which then enables activities such as finding out by tasting the water which one of the different types is the sea water, or differentiating between sand, shells, seaweed and stones.

For children between eight and twelve years old, activities such as finding out how to distinguish between different species provide insight into the important work and methods of scientists when classifying species. It is an understanding of biodiversity that the children have, without yet knowing the scientific language.

*“What are the characteristics of a fish? They’ve got mouths, fins, and breathe by gills. Then we ask the children to give examples of living creatures and things in the sea that are not fish. One workgroup will start by making drawings of what they see in the aquariums that are not fish, while another workgroup will start with a “touch tank”. So, we work with the shapes, colours and texture”.*

The next step for the children is then to link their acquired knowledge to everyday life, and in this connection I found the activity “The sea, a source of wealth” to be a good example of how simply it can be done: “Did you know that seaweed is used in jelly, and petrol in lipstick...?” Even a dead old horseshoe crab can be used to explain how its “juice” helps to analyse human blood.

Communication plays an important role in scientific work. To be able to pass on information is essential: “Species are being born and others are disappearing constantly...” Below we are watching a TV program made by the school children themselves. It is an activity that lets them become “Reporters on the world of the sea”, which allows children to be creative and to enjoy being in the limelight.



### Children evaluating

How do we as adults actually know whether the children are getting anything out of such learning activities at a sea centre or museum? In my opinion it is very important that the children feel welcome at a museum, and are not constantly reminded of how noisy, dirty, clumsy and uncultured they are. To create a stimulating learning environment for children, a visit to a museum should not be like a visit to an old aunt, where you are made to sit on a towel on the sofa and must not touch any of her bric-a-brac, as the mere thought of clumsy child fingers on the fine china would cause a heart attack. Children are stimulated only if they are both seen and heard, otherwise a visit to a museum will have quite the opposite effect. I don't have enough fingers to list the many bad and boring experiences I had at museums when I was a child. Everything smelled of dust and dead socks and the biggest impression did the many "do not touch" signs, rather than the things actually displayed.

It was a pleasure to find out that the educational department at Nausicaä had designed a special evaluation form for children. So, not only is it the teachers' professional opinions on the place, but also very much the children's own words that are interesting. On behalf of her French classmates, Michéle, aged nine, filled in the evaluation form on her visit to Nausicaä. Answering the question about "the new things I discovered" she wrote:

*"The many animals and the vegetable kingdom of the sea, plankton living in the sea, and that pollution is not only poisonous for fish, but also for people on the beach."*

Here, she also mentioned that she found the animal life, the microscope and all the aquariums in Nausicaä astonishing. And in response to the question on "things I didn't understand" she wrote:

*"Fishing, and why man doesn't do something about all the pollution."*

Furthermore, they were asked in the questionnaire what they would like to do for the sea:

*"Save the sea from pollution, respect the sea, and build water treatment plants."*

In my opinion this sea centre has a mission, which is to enlighten and spread knowledge about how to manage the sea. The centre is involved in networks with environmental organisations and research institutions and is placed right in the heart of the French fishing industry. Even though it was not initially planned as a tourist attraction, which it became due to financial circumstances, it has managed to become an example of best practice among science museums. The pedagogical efforts put into the educational programmes are of such great



interest that French schools subscribe to the centre – and children like Mich lle find it important enough to evaluate by taking responsibility for gathering the necessary information and handing in the evaluation forms.

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Web site: [www.nausicaa.fr](http://www.nausicaa.fr)  
References:

Interview with Cvrille Delattle 30 September 2002  
Visit by Lykke Richter in 30-31 August 2002  
Evaluation form from French schoolgirl Mich lle  
Press material from Naussica   
Sample of articles from French newspapers



## THE BEACH AS A SCIENCE LAB

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**“Ciência Viva“ is a national program that aims to increase scientific knowledge, develop experimental work and improve scientific culture. A Portuguese science education team in Lisbon, supported by the Ministry of Science, developed the project from 1996 to 2000.**

**T**hree friends, all university teachers working in two different science faculties, sitting on an esplanade in front of the Atlantic Ocean, talked about their personal and professional projects one warm evening. Suddenly, one of the teachers said: “Look, the beach is a science laboratory.” For fun, each teacher added a different content giving real meaning to what had been said. The brainstorming about water, the sand and rocks, the animals and plants, the sun and its reflection in the water, the tides, the wind, etc., was the starting point for a new educational project.

The project “the beach as a science laboratory” was organized around the following elements:

- The beach as a unifying theme for elementary and secondary science curricula,
- The communication of experiences and scientific knowledge among teachers and students of different levels,
- The creation of a community of learners (teachers and students) for understanding the natural world in a situated learning condition,
- The motivation for science learning,
- The development of competencies and scientific knowledge,

- The materials developed support experimental activities, adjusted and adapted for students at age/grade level, for use in the classroom laboratory and in the field. Materials include both hands-on and computer-based information and communication technologies.

Learning more and better about the beach and what it may bring to science classrooms was the main goal concerning scientific knowledge. Situated learning with the beach as the local environment was an effective way of developing competencies and of integrating practical and theoretical learning. It motivated young people to participate in scientific activities and learn science.

The development of social competencies such as responsibility, autonomy, self-esteem and confidence, tolerance and respect for others, communication and argumentation as well as the development of scientific skills, such as curiosity, rigor, observation, inference, the formulation of problems and hypotheses, and drawing conclusions were also crucial goals of the project.

An interdisciplinary approach was planned and developed in order to understand nature as a complex system, where the specific knowledge from different sciences such as biology, geology, physics, chemistry, and environmental sciences are interlinked. This approach to scientific learning meant good team building skills (particularly useful in breaking down disciplinary divisions).

### **Building a project is a hard job**

Several meetings took place in our own homes, where we discussed who could participate and agreed on the principles of the learning process. Learning was based on the principle of communities of practice. Social interaction was a critical component of situated learning – learners (teachers and students) became involved in a community of practice.

Teachers from elementary schools (three teachers), secondary schools (two teachers) and university teachers who co-ordinated the project (four teachers) and students from grades one to twelve built the community of practice involved in the project. More and more meetings took place in the different schools in order to motivate the participants, listen to the teachers and decide on the methodologies and activities to be implemented and the tools of evaluation. Teachers from different levels of schooling working together developed a research-action activity and an ongoing training programme. In informal talks, formal meetings (often at weekends), or in workshops, all the teachers shared

experiences and knowledge, solved problems, jointly planned the activities, and evaluated and redirected the actions.

Regular field trips to the beach were organized. Students and teachers, across all grade levels of schooling and from different curricular disciplines, investigated the ecology and animal behaviour of the marine coast and shared data to learn concepts of sampling, ecology, and interaction between the biotic and abiotic components of beaches. Furthermore, the problems that arise in the field were discussed at school, and appropriate research activities were implemented. This research included both experimental work, and library or computer research. Internet resources were used to share findings, ask questions and compare field sites. Learning by practical training has always been of importance, especially in science education. In this project, practical activities based on problem solving were highlighted.

The students taught other students, organizing the scientific concepts in their minds. They visited all the schools enrolled in the project, planned activities and built materials for the others. The students became teachers on the beach and in school. This was very important for the students because they developed an awareness of the importance of their own knowledge and competencies, as well as the importance of the knowledge and competencies of the other students, even if "the other" was a small child.

In each school, teachers and students planned, built materials for, and implemented interactive exhibitions open to the local community as well as the other participating schools. Each group of students was in charge of one small workshop. They had to explain, demonstrate, argue, and discuss scientific concepts, and motivate visitors to try hands-on activities. In the students' opinion:

*"Finally I can understand the reason why some people choose to be teachers" ... "To teach something to someone else is highly rewarding, because we learn more than in a formal classroom" ... "Not only the young students learned, but we did also as monitors".*

All the participants in the project evaluated it. The results of several intermediate and final evaluations were discussed. The results were very positive. In the secondary students' opinion:

*"The elementary school students surprised me. They wanted to know more about science, they paid attention to our explanations and they had carried out the proposed tasks with real enthusiasm" ... "I felt a deep happiness, because I was there to do something useful for those students" ... "This project developed my enthusiasm for scientific activity, created a feeling of solidarity among all the participants as a link between students and teachers, and I am more aware*

*of the importance of nature for our lives, and the need to protect it and the entire environment.”*

### **The project**

“The beach as a science laboratory” was an innovative project. It was innovative because it demonstrated the possibility of an alternative curriculum based on the development of competencies integrated in conceptual scientific learning. It also demonstrated that innovation is related to the importance of implementing adequate methodologies for scientific learning such as:

- Practical learning (laboratory simulations, field experiences, computer-based activities, Internet data exchanges, cross-grade exhibitions),
- Communities of practice,
- Peer learning/shared activities with other learners – students as teachers
- Interdisciplinary work – teachers from different scientific fields and teachers of different grades working together,
- Situated learning,
- The local environment as a motivational tool for science education,
- Provision of diverse teaching/learning materials,
- Awareness of the role of environmental study in the development of scientific culture.

Postmodern discourse is centred on the individual as subject of the learning process within a social context. Present-day society is characterised by deep social, cultural, technological and scientific challenges, accelerated scientific development, technological modernisation, facilities for accessing knowledge, life-long learning, globalisation, mobility, multiculturalism, recognition of cultural, social and personal diversity, and inclusive society. More and more is necessary to develop competencies to face new social and scientific challenges. This characterisation of present-day society implies challenges to science curricula, innovation, and research into training methods, and has led to a re-definition of the roles and functions of teachers and learners. opinion:.

The enthusiasm of the young students for scientific learning and of the science teachers for teaching in a new way served as a stimulus for investing more in finding educational alternatives towards scientific learning. And the friendship is stronger among the three university teachers, reinforced by the friendship of the other teachers, and the regular informal evening meetings near the ocean go on.

VITEN.NO

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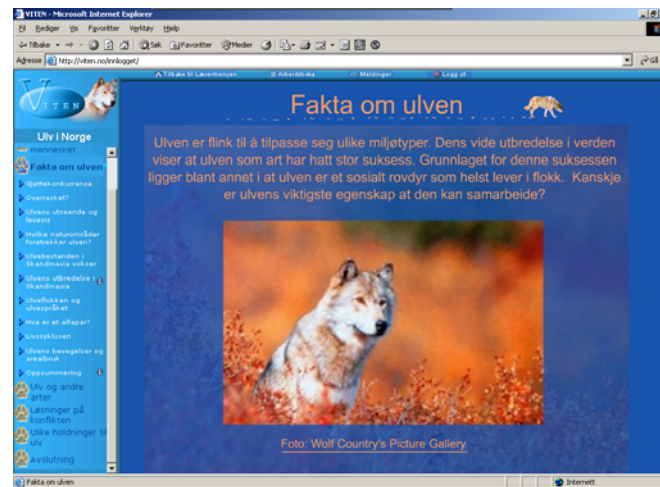
Doris Jorde, *University of Oslo, Norway*

**The Norwegian educational system has strongly supported the use of ICT in schools at all levels and in all subjects. The Viten project was created to provide science teachers with an opportunity to use Web-based curriculum materials free of charge in their science classrooms. Viten is a research and development project located at the University of Oslo and the Norwegian University of Science and Technology in Trondheim.**

Viten is the Norwegian version of the Web-based Inquiry Science Environment located at the University of California, Berkeley called WISE. Whereas WISE has a long history of research and development in the United States, Viten was started in 1999 as a parallel project. Researchers in both projects continue to conduct comparative classroom research on implementation studies of Viten and WISE in science classrooms.

The WISE/Viten learning environment was developed to scaffold students as they work with inquiry-based science projects. By encouraging learners to connect new ideas and perspectives to their existing ideas about the scientific phenomenon under investigation, the framework promotes cohesive understanding. Students compare, contrast, critique, sort out, and re-conceptualise their scientific ideas, incorporating new information, evaluating alternative accounts, and linking everyday life to scientific ideas. Our goal is to help students become lifelong learners of science, critics of information, and collaborators in argumentation.

The WISE and Viten learning environments, curriculum and assessments are all designed in accordance with the *Scaffolded Knowledge Integration* (SKI) framework<sup>3</sup>. This framework has been continuously refined through years of classroom trials, comparing different versions of technology tools, different approaches to guidance, and different designs for curriculum development.



The SKI-framework includes four major principles that guide the design of successful inquiry activities and technologies:

- **Make science accessible:** Inquiry curriculum requires an appropriate level of analysis for the scientific content so that students can restructure, rethink, compare, critique, and develop more cohesive ideas.
- **Make thinking visible:** Inquiry curriculum should challenge students to articulate what they know and think about scientific topics so that they are able to restructure their thinking when new ideas are presented.
- **Melp students learn from each other:** Inquiry curriculum should include opportunities for collaboration, discussion and debate, enabling students to articulate their own ideas for their peers, as well as to receive and exchange feedback.

<sup>3</sup> Linn and His (2000) Computers, Teachers, Peers. Science Learning Partners. Lawrence Erlbaum Associates.



- **Help students develop autonomous learning skills:** To help students become autonomous science learners, inquiry curricula can enable the development of lifelong learning skills such as critiquing evidence, debating arguments, or designing solutions to relevant problems.

Typical projects engage pairs of students in *designing* solutions to problems, such as designing a spaceship that allows astronauts to grow plants on board, *debating* contemporary science controversies such as “Should we have wolves in Norway?” or *critiquing* scientific claims found in Web sites, e.g. “Should we support vaccine or pesticide research for Malaria control?” As we design projects, we try to incorporate exciting roles for students to adopt as they work with the evidence. In the radioactivity project, students act as journalists writing an article about an accident involving radioactive material; in the malaria project, students act as consultants (biologists) to the government, advising on what international programs to support; in the plants in space project, students design a greenhouse for a spaceship travelling to Mars.

In all cases, we start with a sequence of motivational activities, also designed to survey what the students may already know about the topic. The next sequence of activities is designed to present the actual science needed to understand the challenges placed into the role. Finally, the projects move into a phase where students work on some form of final presentation of their role that may take the form of an online newspaper article, a classroom debate or even building a spaceship. The curriculum projects do not replace existing practices in science teaching; rather, they enhance them by providing a new means of presenting science.

The WISE/Viten servers deliver interactive Web pages and curriculum materials to schools, as well as managing and storing students’ project and assessment work. Students navigate through activity steps in the left-hand frame of their Web browser, called the “Inquiry Map”. WISE/Viten provides a number of student software tools, including a note-taking tool, a Web-based discussion tool, concept mapping and argument building tools, search pages, student/teacher-generated quizzes, Web-based newspapers and on-line assessment, including teacher feedback to students. Additionally, external tools and pages from the Internet are easily made to function within the software. As pairs of students work through the sequence of activities in the project, the teacher circulates in the classroom, interacting with one small group of students at a time, helping them interpret Web materials, reflect on the topic and interact with their peers.

Whereas the WISE server is located in Berkeley, California, the Viten server is located in Norway at NTNU, where platform development has taken a slightly different orientation. Both the WISE and the Viten projects allow free access and are available to all teachers and schools with Internet connections.

In the creation of a Web-based curriculum we are working across academic boundaries, as Science, Pedagogy and Technology together create an intricate “web” of interaction. It is not enough to have sound pedagogical ideas about how and what to teach in science, or to make intelligent electronic delivery systems for the collection and distribution of information. Web-based curriculum development involves teams of people with expertise in areas integrating technology with subject content, pedagogy with electronic delivery systems, and classroom research with ICT in schools.

Our research and design activities are based on a continuous improvement model that combines the development of materials with classroom evaluation. All curriculum projects are developed in teams consisting of teachers, science educators, IT technicians and experts from the academic discipline. Once themes have been constructed using the WISE/Viten software toolbox, they are sent to trials in the classroom, where we participate as classroom researchers. In order to understand the challenges faced by teachers and their students while implementing WISE/Viten projects, we must take into account the realities of everyday life in science classrooms and school systems. We include pre-testing and post-testing, as we are looking for conceptual growth. We videotape groups of students working, so that we can better understand the role of social discourse in learning concepts. We use responses collected in the software program for analysing conceptual growth while students work with the projects. We interview students before and after their introduction to our projects, trying to understand their views on the use of ICT and their knowledge about actual science topics in contextual settings.

By working with teachers and their students in actual classroom settings, we are able to see first-hand how curriculum materials are implemented. Classroom science teachers and their students have provided valuable input into the further development of Viten projects by making suggestions for improvement and by allowing us to follow the use of projects both in the classroom and through document analysis of student work. Our current library of Viten projects covers a wide variety of topics in both science and mathematics.

<b>Project title</b>	<b>Grade level</b>	<b>Description</b>
Cycles of Malaria	8–10	Biology, controversy, debate, life cycles, global science
Radioactivity	9–11	Physics, journalism, problem solving, radioactivity
Wolves in Norway	8–10 & 11–12	Biology, controversy, debate, ecology, animal behaviour
Earth Forms	8–10	Geology, land forms in Norway, history
Plants in Space	8–10	Photosynthesis, respiration, plant reproduction, technology, space travel
Sine (mathematics)	11–12	Waves, underwater waves, history, problem solving
The Nature of Science	11–13, higher	What is science? Anti-science

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For further information on Viten, please contact project leader Doris Jorde at:

[doris.jorde@ils.uio.no](mailto:doris.jorde@ils.uio.no)

<http://viten.no>

WISE:

<http://wise.berkeley.edu>



## THE HOUSE OF EXPERIMENTS

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Miha Kos, Gorazd Planinšič, *Ustanova Hiša eksperimentov*  
and Ivo Verovnik, *National Education Institute of Slovenia*

**The House of Experiments is the first and only “hands-on” science centre in Slovenia. A hands-on science centre is an exhibition of science, technology and ecology experiments performed by the visitors themselves. By researching and performing the experiment, each visitor acquires first-hand knowledge, and there is really no better way of learning.**

**T**he House of Experiments is the first and only “hands-on” science centre in Slovenia. A hands-on science centre is an exhibition of science, technology and ecology experiments performed by the visitors themselves. By researching and performing the experiment, each visitor acquires first-hand knowledge, and there is really no better way of learning. A Chinese proverb says, “Having heard, I have forgotten. Having seen, I have remembered. Having made it myself, I know.” The last part of this ancient wisdom is and will continue to be practiced in the centre.

The plan is to create a centre of science, a place that will bring together science, industry and the media. We plan to construct a collection of two to three hundred experiments. So far, thirty-six exhibits has been set up. Since May 2000, when The House of experiments moved into permanent facilities in the town centre, more than 50,000 people have visited us. The House of Experiments also organizes brief lectures full of illuminating experiments, specially designed for students, teachers and others with a thirst for knowledge. So far, ten lectures referred to as “Adventures in Science” have been completed

and are held regularly. We also constantly invite the public to contribute their own ideas for original experiments.

One of the main goals of the House of Experiments is to help build a more contemporary and richer society, a society open to the exchange of ideas (whether they be scientific discoveries, innovations in industry or personal insight), learning and the deepening of personal knowledge through individual experience and experiment, the observation of nature or works of art.

Education, science, industry and the arts are intertwined at the House of Experiments. Students and teachers get to know the experimental side of science. Industry contributes in the construction of the experiments and makes contact with scientists and HE representatives. The centre is also open to artists, who have their own way of experiencing nature and natural phenomena.

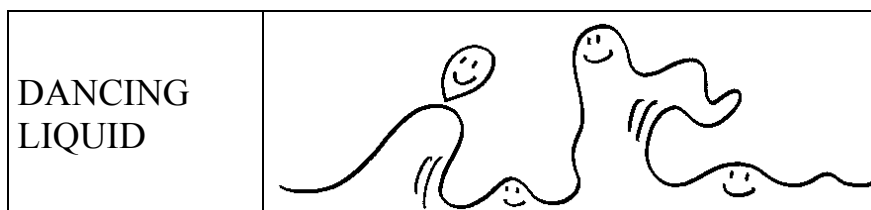
We would like to help in the formation of a society of inquisitive and open-minded people who are not afraid to admit to some ignorance and try to find the answers to their questions. The personal experience acquired through experimenting enriches an individual's knowledge, and the free exchange of ideas between individuals makes richer society. House of Experiments helps people gain personal experience and opens the flow of information.

### **Activities**

- The individual learning of scientific truths through direct personal experience is encouraged. Visitors are encouraged to pose questions and to try to find answers on their own, guessing the outcome of the experiment from previous experience, and repeating the experiment with changed parameters. Each experiment has instructions, a short overview, a thorough explanation of the phenomenon, and some interesting points of the "Did you know?" variety.
- The science centre is complementary to the established school programme, giving students an opportunity to participate in running the experiments. Single-topic shows with expert guidance are organized with elementary and high school teachers.
- Meetings with elementary and high school teachers are organized, where advice is given to teachers on how to prepare exciting experiments in schools. Summer schools will provide an excellent opportunity to plan and construct new experiments with teachers.
- Industry is invited to participate, and indeed does so as a partner in designing and preparing permanent as well as temporary experimental exhibits.

- The centre arranges popular lectures on natural phenomena, discoveries and findings in science, technology and the arts, by scientists from Slovenia and abroad. Certain days feature in-depth coverage of a particular topic, but the experiments will remain on permanent display.
- The science centre works with high schools and provides compulsory and non-compulsory activities for students. At first, students get to know the experiments. Later, they provide explanations for visitors and discuss details about “their” experiment. Because of their youthful enthusiasm and relaxed attitude, visitors feel more inclined to ask about aspects they might not understand.
- Once a year a competition is held to choose the best homemade or school-made experiment. The best experiments are awarded prizes and become part of the permanent display.

**An example of explanation of a “hands-on” exhibit:**



**Do and observe:**

Press on one of the green buttons on the left side of the control panel. Wait for a few moments and then listen to the music, while observing the liquid under the translucent cover. Repeat the experiment with other pieces of music. Slide the microphone cover to the left side. Say something or sing a song into the microphone, holding down the red button beside the microphone. If you wish to use the microphone without the background music, wait for the piece to come to an end.

**What’s going on?**

There is a magnetic liquid in the basin beneath the translucent cover. The liquid’s special property makes it drawn to a magnet. A magnetic field can be created by an electric current – this is called an electromagnet. There are twenty-five electromagnets beneath the basin,

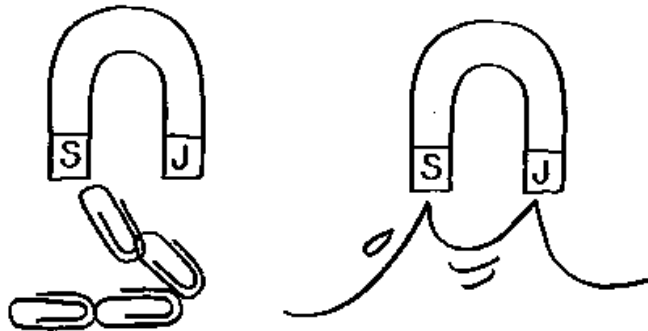
and these are switched on and off by the music you're listening to. An electronic circuit in the box makes some electromagnets respond more to higher tones and others more to lower tones. Thus, the music makes the liquid in the basin literally dance.

**Did you know?**

Magnetic liquids are used in special speakers as well as in liquid gaskets that stay in place because of the action of a magnetic field.

**More...**

The magnetic liquid is full of tiny particles of iron that are drawn to a magnet. To make sure that the particles do not stick to one another, every particle is surrounded by a protective layer. In this way, the liquid remains fully liquefied even when the particles are attracted to one another by a magnetic force.



**What we have learned so far:**

- The Hands-on Science centre can only operate with significant support from the public and the government. This is even more important in countries where current tax system does not encourage donations.
- Science and school systems in transition and post-transition countries were traditionally theory-oriented. For this reason, the establishment of hands-on science centres in these countries is of crucial importance.
- The interdisciplinary approach and commitment to searching for new forms and ideas require that hands-on science centres are independent institutions, and not “example” sections of existing museums .Of course, museums might have their own hands-on sections.

One of the most important goals of the hands-on science centre is to create an environment in which science, humanities and art can meet. Only this will



ensure that people from different social and intellectual circles visit the centre regularly.

<http://www.h-e.si>



## THE ISLAND OF BERLENGA

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Isabel Chagas, *University of Lisbon, Portugal*

**The use of the Internet as an educational tool has been encouraged in Portugal since the mid-1990s. Different governmental programs supporting schools, teachers and students in the use of this network have been launched throughout the period. However, in spite of the progressive improvement of both Internet accessibility in most K-12 schools and teachers' training in the use of the technology, its effective implementation in schools still remains far from satisfactory.**

**T**eachers point out several reasons linked to the nature of the Internet itself, such as the lack of Web sites in Portuguese with resources matching K-12 curriculum demands in a context that is familiar to the youngsters. Students also refer to difficulties in finding useful and reliable information on the Net for their school projects, as well as in integrating information from either online or offline sources.

With those remarks in mind, a group of teachers, university professors and multimedia specialists was formed in order to create a Web site that could serve:

- As a source of content for middle school science activities,
- As a platform for communication and collaboration involving teachers and students in different schools,
- As a starting point for a learning community involving many different people sharing a preference and the willingness to learn about science.

The group's first meetings took place during 1995. These meetings consisted mainly of brainstorming sessions, in which each member gave his or her opinion about the nature and characteristics of the Web site, in order to meet not only teachers' and students' needs but also to address contemporary perspectives about science education and the educational use of ICT. Many sessions included a discussion centred on a journal article chosen by a member according to his or her concerns and field of study. The project's theoretical framework emerged from these discussions. Its main assumptions were the following:

- The Internet is a meeting point of both formal and informal approaches to science education. This medium makes it possible to associate the playful, highly motivational climate generated by edutainment software or educational strategies developed by science centres with curriculum-oriented classroom activities.
- Developing Internet-based resources adapted to the scientific and pedagogical demands of school curricula implies a partnership of teachers, scientists, educational researchers, and multimedia communication specialists.
- Student participation is essential for the development of any educational resource. One advantage of a Web site is its unfinished nature, enabling continuous improvements based on its users' suggestions and recommendations.
- Science is better learned in context, where authentic problem solving as a collaborative enterprise is involved.
- A Web site with the potential to promote effective scientific learning is situated, dynamic, flexible, interactive and encourages collaboration.

In 1996, the group submitted a proposal of the project to the Institute of Educational Innovation in Portugal, and was awarded a small grant that enabled the design of the Web site's prototype. Later, the project was supported by the *Nónio Século XXI* programme, an initiative of the Ministry of Education aiming to support schools implementing Information and Communication Technologies (ICT).

Figure 1 shows the sketch of an imaginary island on the home page of the Web site called "*Explorações nas Berlengas*", meaning exploring the islands known as Berlengas, located about ninety km northwest of Lisbon. These islands constitute the Berlenga National Reservation because of the biological, geological and physical characteristics of their ecosystems, and are a popular destination for study trips.



Figure 1. Icons providing access to the different pages of the Web site

The sketch contains different icons corresponding to links enabling navigation through the pages that make up the Web site. These icons represent different metaphors that lend meaning to the following pages:

- The *fortress* contains role-playing activities about contemporary and meaningful environmental issues. These simulations imply the confrontation of ideas and feelings, as well as decision making. Students have the opportunity to solve problems, develop attitudes toward the topics under discussion, and train skills involving Internet-based communication.
- The *inhabitants* contains information and activities relating to the creatures that live on and around the islands.
- The *lighthouse* is an interactive encyclopaedia allowing students to ask questions of specialists in different scientific domains and to search for information using common search procedures. The information on this page is organised on a database with different entries.
- The *tent* provides access to several virtual study trips through the island Berlenga and the surrounding ocean. Following the trails, students have the opportunity to explore situations that demonstrate the delicate balance of these ecosystems.
- The *athena* is a portal that provides access to other sites on Web relating to these themes.
- The *boat* encourages students to relate what they have found on these islands to what exists in other locations on the coast or other islands around the world. Comparing the fauna and the flora of these different

locations enables students to explore aspects essential to an understanding of biological evolution and diversity.

This version of the Web site is part of a story that is just beginning. What we have learned so far is that the construction of a resource with these features is a long-term endeavour in which collaboration among different partners contributing with specific knowledge and experience is essential. The positive reactions conveyed by both teachers and students have assured us that merging formal approaches to scientific learning with informal ones, which are not usually implemented in classroom settings because of their playful nature, is a promising idea. This has led us to the next step of the project – which will be the integration of the Web site as a resource to be used in the process of teaching of science subjects. Collaboration will be even more important in this case, involving not only the application of this new resource, but also a continuous monitoring of the learning environment that it generates.

The Web site is presently available at:  
<http://redeciencia.educ.fc.ul.pt/berlenga>

## WEB-BASED LEARNING ENVIRONMENTS IN SCIENCE TEACHING

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Tago Sarapuu and Margus Pedaste, *Science Didactics Department,  
University of Tartu, Estonia*

**How easy is it really to implement e-learning in schools? This article from Estonia explores some of the main issues that Estonian schools have been dealing with.**

In most countries, it is comparatively easy to find software for teaching various subjects. But in Estonian schools, where English is the second language, educational software cannot be used in the learning process unless it is in Estonian. Some software can be translated from other languages, as there are a lot of common problems and themes in the curricula of all countries. However, in the case of natural sciences, especially in biology, each country must create its own. This is because of the fact that the natural environment of each country is unique, all the species of plants and animals exist in distinctive conditions with their own specific relations. Knowledge about local nature and its diversity, and also environmental problems, is acquired on the basis of local examples and facts. Therefore, the Science Didactics Department at the University of Tartu has developed two educational Web sites – “Estonian Vertebrates” and “Estonian Plants”.

### **The Estonian Web sites**

“Estonian Vertebrates” includes information about five groups of vertebrates – fish, amphibians, reptiles, birds and mammals. A database that includes about three hundred species of the most common Estonian vertebrates forms the main part of this Web site. Information about each species has been presented on two Web pages that take the different abilities and age of the students into account. The first page contains descriptions of particular species; their appearance, distribution, abundance, feeding, reproduction, development and endangerment. The topics are illustrated with colour photos and voices. It has only a few terms and simple vocabulary in order to be used in basic school science classes. On the second page, the information on each species is compiled in a table including some more scientific facts. This page is supposed to be used mainly by secondary school students.

The second educational site, “Estonian Plants” (<http://bio.edu.ee/taimed/>), follows the same principles of design as “Estonian Vertebrates”. The main part of the site consists of descriptions of the most widespread species of Estonian plants (c. 340) together with illustrative photos. There is general information, taxonomic specifications and local aspects given for five groups of plants – Algae, Bryophytes (mosses), Pteridophytes (ferns), Gymnosperms and Angiosperms (flowering plants). One can choose pages of herbs, plants under protection, poisonous and edible plants. Several figures illustrate the morphology and structure of different groups of plants. Symptoms of being poisoned and methods of first aid are briefly described in the case of poisonous plants. The pages on herbs explain which parts of the plants can be used, where they grow and what diseases they can cure. As far as edible plants are concerned, there is exact information on which parts can be eaten, and when and where they can be picked and used.

The educational Web sites “Estonian Vertebrates” and “Estonian Plants” are suggested for teaching various themes in integrated science, biology and environmental study following the Estonian State Curriculum. Both sites can be used in several out-of-class activities, for example, in writing and compiling student research papers, reports, essays, etc. Computerized educational tasks composed on the basis of “Estonian Vertebrates” and “Estonian Plants” enable students to learn the particular themes independently, to acquire scientific facts, to develop their memory and comprehension, and to apply the facts and check their knowledge. More attention was paid to systematic learning than to memorizing facts. Various electronic tests added to the package provide teachers with necessary feedback of the students’ knowledge and abilities. There are



opportunities to check your knowledge and the results of tasks in the software. On the other hand, it is impossible to create the computerized tasks in such a way that they satisfy all the teachers' aims and are adaptable to all the appropriate themes in the curriculum. Therefore, supplementary printed worksheets have been compiled for students. These can be used "as is", or they might serve as examples for teachers to prepare their own worksheets.

In order to get feedback on the applicability of both Web sites and the teaching method based on the supplementary printed worksheets, twenty-seven basic school students (aged fourteen–fifteen) and fifty-nine secondary school students (aged sixteen–seventeen) were asked to fill in a questionnaire. Forty-six per cent of the students who worked with "Estonian Vertebrates" said that they had learnt something useful for everyday life. The themes of Estonian nature and the protection of the environment are central themes in the Estonian State Curriculum. This area of study brings teaching natural sciences closer to everyday life and society. Another aim of both educational Web sites is to motivate students to become more interested in these areas. Thirty-five per cent of the students answered that the lesson on "Estonian Vertebrates" made them more interested in Estonian nature and the problems of protecting the environment; Twenty-five per cent of the students claimed that it made them more interested in school biology.

During the last three years, the Science Didactics Department has developed a new Web-based simulation environment, "Hiking Across Estonia". Theoretical principles published in scientific literature, the structure and design of analogous learning environments, and the curricula and other teaching materials used in Estonia and several developed countries were taken into consideration in creating the Web site. This simulation program is unique in its content, scope and technical solutions, both in Estonia and abroad. It comprises not only the learning environment, with educational tasks and supplementary materials, but also the administrative pages for developers and researchers of the simulation. Several features of JavaScript and EmbPerl have been used to make the simulation more authentic and effective.

### **The educational tasks**

Students become acquainted with five ecosystems during the virtual hike: heath forest, meadow, grove, waterside meadow and bog. All the communities are provided with informational windows containing supplementary texts and illustrations of about 198 species of plants, mushrooms and animals. The

information introduces the most common and interesting living things found in Estonia, but it also serves as source material for solving the educational tasks.

There are six different environmental tasks in each community (thirty in total) to be solved during the course of the virtual hike. All the tasks are presented and can be solved in the Web environment. Immediately after answering the questions and solving the problems, students receive feedback on their results – they can see the correct answers and study their own mistakes. A certain number of points are awarded for each task. This enables competitions to be organized between individuals or hiking teams.

The participants also have to face another problem during the hike – they must find edible food from different sources. Each team is allowed to take along a certain amount of food from the virtual home at the beginning of the simulation, but then the hikers must find their food in the communities. They have to decide whether the species of plants and mushrooms available in the simulation are edible or not.

The goal of the program is to help students develop their environmental literacy and promote higher-order thinking skills, especially their problem-solving and decision-making abilities. The main target group of the simulation “Hiking Across Estonia” is upper-compulsory and high school students.

The hikers start by examining their virtual community. They are provided with information concerning several aspects of it. Then, they can proceed to open a new window containing an educational task related to the respective community. Next, they must find additional information needed to solve the task. The information is usually available on the Web pages of the simulation program itself, on the Web sites listed on the links page, or in the articles contained in the learning environment. In some cases the needed facts must be looked up in different books.

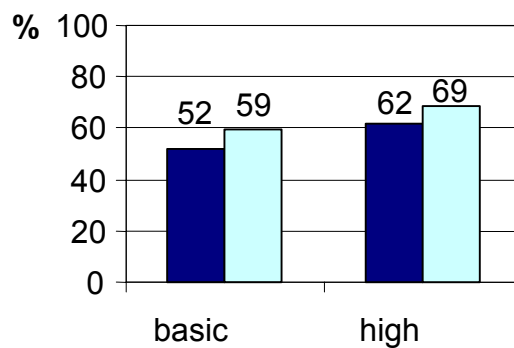
Educational tasks were composed on the basis of themes in school biology, environmental studies and health education, and are related to the themes in the Estonian school curricula and those of other developed countries. This ensures that the questions and problems provided in the simulation are not only connected with local Estonian problems, but might be understandable and applicable for students from other countries as well.

Students are required to analyse texts, drawings and graphs to solve the environmental tasks presented in the virtual communities. They can get up to thirty per cent of the total score of 1000 points on the basis of knowledge and comprehension of different facts shown in answering simple questions. About ten per cent of the score is related to the students’ ability to apply the information. The final sixty per cent is related to certain problem-solving tasks,

and can be achieved by analysing and synthesising presented materials and making decisions. Another aim of the simulation program is related to developing the students' teamwork skills, but it should also promote their interest in environmental problems. "Hiking Across Estonia" is applicable in different ways: individually or in groups consisting of three to five students, in computerized science classes or as an extracurricular activity.

Two nationwide Estonian competitions in virtual hiking have been organized between groups of Estonian schools – 143 teams with 605 students from 119 schools participated in the first competition in 2001, and 272 teams with 1103 students from 127 schools (about twenty-seven per cent of Estonian schools) participated in 2002.

All the activities carried out by the participants on the Web pages, including their answers, are saved on the server and can be analyzed by the organizers of the virtual hike. This makes it possible to find out how using the simulation develops students' problem-solving skills. The influence of the usage of the learning environment was also measured by the electronic pre-tests and post-tests. The results of this investigation demonstrated with statistical significance that the use of the simulation "Hiking Across Estonia" improved students' skills in solving ecological and environmental problems (Fig. 4).



**Figure 4.** The development of students' problem solving skills in basic and high school results in pre-tests (■) and post-tests (□)

The analysis of the simulation program's log files supported the evidence that the students' abilities in solving ecological and environmental problems were developed significantly by using "Hiking Across Estonia".

This asynchronous learning environment can be used not only for developing students' ecological and environmental problem-solving skills – it is comparatively easy to alter all the educational tasks and supplementary information contained in the program. Therefore, this Web site might serve as an exploratory environment for studying other themes in the curricula of different countries and languages.

*<http://bio.edu.ee/tour/front/eng/>*

*<http://bio.edu.ee/animals/>*

## INNOVATIONS IN MATHEMATICS, SCIENCE AND TECHNOLOGY TEACHING (IMST<sup>2</sup>).

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Ulrike Unterbruner, *University of Salzburg, Austria*

**IMST<sup>2</sup> is an Austrian initiative involving subjects such as biology, environmental education, chemistry, mathematics and physics. The purpose is to create new styles of teaching and learning, supported by new media and technology.**

**T**he book *Longitude* by Dava Sobel formed the starting point for an exciting teaching project involving the subjects of mathematics, physics, geography, and economics, as well as the German language. It describes how the problem of determining positions in navigation during the eighteenth century was solved and discusses its historical significance. It tells us the story of the peculiar clockmaker John Harrison, who gained advantage over England's elite astronomers after a contest lasting some decades, and thus received an enormous cash prize that had been offered by the British parliament. This story and the background information about the significance of scientific problem solving for future economic, political, and social development served as a "red thread" for the project.

This project presented tenth-grade students (aged fifteen to sixteen) at an upper secondary school in Vienna with complex issues:

- The importance of a precise measurement of positions on earth for navigation, the economy and world politics,

- The practical significance of mathematical problem solving (geodesy, survey),
- The understanding of scientific discoveries in a historical context (historical development of global survey and early map-making),
- The necessity of setting up a reference system of measurements and benchmarks such as meridians and time zones.

As regards basic education, students should not only gain knowledge of relevant facts and principles of surveying, but, most importantly, develop understanding and insight concerning:

- Why and how scientific work is carried out,
- Motives and interests underlying the process,
- Thoughts on culture and nature, now and then.

An interdisciplinary project seemed to be most effective means of achieving these ambitious goals. Classes designed to be both highly diverse and problem- and student-oriented were organised. Considerable emphasis was placed on collaborative, yet independent, work in groups.

At the beginning of the project, the fifteen to sixteen-year-olds read and discussed the book *Longitude* in their German classes. The analysis of literature (text analysis) was an unconventional starting point for scientific studies. Even though the students were not as enthusiastic about the book as their teachers, it triggered some curiosity and motivated them to get more involved. The students were subsequently introduced to surveys of land and the universe in their physics classes. An overall view of the development of surveying and cartography was provided in geography classes. And finally, during mathematics classes, students were equipped with the required know-how (trigonometry).

The students found themselves confronted with numerous demands, such as the phrasing of questions, the reading of subject-oriented literature, the graphical representation of structural connections, the compiling of mind maps, and the passing on of the acquired knowledge to classmates. The results of this several-week-long project were mind maps created by the students that presented an overview of the subject matter, folders on the geographical and physical aspects, and portfolios focusing on mathematics. In these portfolios, the students worked on problems they had posed themselves. Amongst other topics, they studied the history of astronomy, ancient surveying instruments, and spherical trigonometry. They even undertook specific activities, such as surveying their own schoolyard.

To quote one of the girls after completing the task: “*The calculations were not difficult, and all in all it was more fun than simply solving a problem out of a book. Carrying out a survey out in the cold by yourself may be more time consuming but it is definitely much more fun ...*”

A questionnaire completed by the students served as a means of evaluating the project. On the whole, the students expressed great contentment. Despite initial scepticism, most of the students developed some interest in at least one part or another. Many were astounded by the interconnections that were revealed to them by this historical illustration. The students were convinced that they would derive great benefit in the future from the experience they gained from this project. Some students, however, were overwhelmed by the complexity.

According to the students’ own assessment, more than half of the students were able to contribute to the project and were satisfied with their personal increase in knowledge. A greater majority wanted more projects of this kind, and asked to play a greater role in the planning of classes in the future.

This report on an educational innovation is based on a “reflective paper” by a team of teachers (Fertl, Salner-Gridling, Schaberreiter & Schröder, 2002) of the priority programme S1 “Basic education” of the Austrian initiative IMST<sup>2</sup>.

### **Goals and activities**

*IMST<sup>2</sup> – Innovations in Mathematics, Science and Technology Teaching* – is a long-term nationwide initiative involving the subjects of biology and environmental education, chemistry, mathematics and physics (see Krainer et al. 2002). The addition of “Technology” expresses the fundamental importance of technologies for mathematics and science teaching. The Federal Ministry of Education, Science and Culture is financing the four-year initiative, starting with a pilot project IMST<sup>2</sup> in the school year 2000-01.

The *long-term goals* of the IMST<sup>2</sup> initiative are:

- Better basic education – higher quality of understanding, problem solving, reasoning and reflection,
- Bigger variety of teaching and learning styles – creativity, independence, gender-sensitive teaching and learning, supported by new media and technology,
- More and better-designed forms of professional exchange of experiences among teachers, contributing also to the further development of the whole school,

- Setting up and further developing a network that supports carrying out and evaluating innovations, and for communicating these in various forms to a wider public,
- Improved “image” – more favourable perceptions and expectations with regard to mathematics and science in schools and society.

**Four priority programmes (S1–S4) have been established based on the following reasoning:**

*Basic education (S1): The unclear expectations concerning the qualifications and knowledge needed by students on leaving secondary school.* The four S1-teams (biology and environmental education, chemistry, mathematics and physics) support initiatives at schools that reflect such expectations, and they aim at working out (interdisciplinary, interconnected) concepts for basic education at the upper-secondary level for the four subjects. These concepts, which were intended to be generated by theoretical considerations and by practical experience from the collaboration with schools, and thus negotiated in a wider form – are expected to be a key element for a support system for mathematics and science teaching. It is assumed that the teachers’ clearer view on the importance of goals and content might raise the quality of learning and teaching.

*School development (S2): The relatively low status of the subjects of biology and environmental education, chemistry, mathematics and physics in schools, in comparison to their importance in society and for the economy, might lead, in times of greater autonomy for schools, to a situation where, in general, these subjects are left behind when schools change their profile.* The S2-team supports schools that focus on mathematics and science teaching, and tries to establish a network of such schools. Alongside this and drawing on practical experience, it aims at working out a concept that reflects the initiation, support and evaluation of school development processes that (partially) focus on the enhancement of mathematics and science teaching. This concept is also intended as an important element of a future support system. It is assumed that organizational development (often underestimated in subject-specific pedagogy) – when properly linked with classroom development – makes a crucial contribution to the quality of learning and teaching.

*Teaching and learning processes (S3): The dominance of relatively passive forms of learning that do not sufficiently take into account the individual needs of students in general, and the low interest and the poor results of Austrian girls on the TIMSS achievement test in particular.* The S3-team both supports



innovations at schools focusing on situation-appropriate teaching and learning processes, and aims at working out a concept for generating, analyzing and evaluating such processes. Such a concept, supplemented by material such as a CD with video-clips of real teaching that is intended to be used in pre-service and in-service teacher education, should support teachers' growth in planning and reflecting on their own teaching. It is assumed that increased competence of this kind will have a deep impact on teaching and learning processes.

*Practice-oriented research (S4): The lack of well-developed practice-relevant research and development in mathematics education and in science education in particular.* The S4-team initiates, finances and supports teams of schoolteachers or university teacher educators (or mixed teams) who carry out research on their own teaching (action research) or undertake traditional research projects. Following the analyses of a preceding research project (IMST), the promotion of students' independent learning is seen as a major goal, hence the project's focus on this issue. The team also aims at working out a concept for the promotion of subject-specific educational research and culture. Through raising teachers' and teacher educators' interest and competence in practice-relevant research, the network of researchers in mathematics and science education is expected to grow, both in quality and quantity. A stronger mathematics and science education, where theoreticians and practitioners collaborate more intensively, is expected to form a fundamental part of a support system for school practice.

This shows that each of the four priority programme teams has two important and closely interconnected tasks: first, to support innovations at schools (and in S4 also in teachers' education) and secondly, to work out concepts that help to plan, describe and understand such innovations. In the school years 2000/01, 2001/02 and 2002/03, altogether more than one hundred innovations have been (or are) supported by the IMST<sup>2</sup>-team.

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Descriptions of these innovations can be found at  
<http://imst.uni-klu.ac.at>

## MIKSIKE, AN OPEN SOURCE MOVEMENT

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Mihkel Pilv, *Miksike Learning Environment, Estonia*

**From a “schoolhouse-based” educational model to “network-based” education. Miksike Learning Environment works for K-12 and home-schoolers. Miksike gives away more than 25,000 worksheets in HTML eWorksheets, which are aligned according to state educational standards, and offers a set of collaborative learning services to facilitate learners in constructing their knowledge.**

**T**he amount of information available to us is increasing very rapidly, and our brains are not growing any larger. In the seventeenth century, people received as much information in a whole lifetime as is packed into the Sunday edition of the New York Times. In the past, one could compare the educational process with reading a book and consuming information written by others. The Information Age is different: too much information is available, things change too often and too fundamentally. If we rely entirely on old-fashioned learning – memorizing facts, filling in the blanks in worksheets – we won’t be able to live fruitful and productive lives in the information age. Thus learning should not be equated with consuming information in the sequence created by high-end educational professionals. Learning is instead a creative process. Learning is about creating our very own unique understanding of the world we live in. Properly implemented, the educational learning environment helps to keep the learning process systematic. Flexibility and creativity are the keys to future learning.

Educational publishers of the “paper age” provided students and teachers with resources that were “written in stone”. For largely technical reasons, it is difficult to change content already printed on the paper. All modifications of learning material to meet the needs of students and teachers were subject to copyright law. Learners were pushed into the role of acquiring facts, following the topic in the way it was presented by the book and filling in the blanks on workbooks.

Putting the student at the centre of an information-rich learning process fundamentally alters the roles in the educational processes from those we have inherited from the era of paper. The educational publishers who used to sell books/workbooks to schools will become more like information brokers and community management facilitators. Their roles will be to help learners (teachers/students) to construct their knowledge.

Basic educational content will reach the classroom in electronic formats and will be available free of charge, with copyright policies that allow users to modify the original content. This means that learning materials are more in the form of “drafts” given to learners, and that enable students – with the help of teachers and those in their online communities – to write their own books, thus creating their own unique understanding of the world they live in.

Miksike is successfully moving towards this model. Miksike Learning Environment works for K-12 and homeschoolers. Miksike gives away more than 25,000 worksheets in the form of HTML eWorksheets, which are aligned according to state educational standards, as well as offering a set of collaborative learning services to facilitate learners in constructing their knowledge.

### **Using technology**

The Miksike motto is: “The educational vision comes first, then technology follows”. Nevertheless, Miksike provides all necessary ITC support to make this flexible “network-based” learning model work.

There are four main reasons to visit Miksike Learning Environment:

1. Free eWorksheets

a) “Semi-traditional” – teachers/parents choose what they need or prefer from the database of eWorksheets and print them out on paper. Before printing eWorksheets, changes can be made by teachers or virtual teacher assistants to make them better suited for use in the concrete situation.

b) “New way” – each student has his or her own account on the Miksike server, and eWorksheets are used as a draft, while students write and compile their own “story” and workbook in collaboration with teachers. Alternatively, VTA’s. Miksike allows the possibility of creating a “My Miksike” type of folder with e-mail and discussion board options.

2. Miksike Support centre services. Learners and teachers receive online support from this centre in the form of practical learning/teaching tips. This system is built on discussion-board software. Virtual teacher assistants and the volunteer community provide the answers. If needed, professionals in their own field are invited to contribute with answers.

3. By making use of interactive exercises with the code name “Modern repetition”, learners can engage in interactive educational exercises and combine learning with fun independently.

4. Collaborative learning events such as quizzes, collaborative story writing, and math contests. Different people and organizations all over Estonia manage most of these activities. Miksike is just a “common roof” over a number of projects. Project organizers are from very different groups – students, teachers or parents, and enthusiasts who do not have a direct link to the formal education system. For different projects, different tech solutions are used. It depends on the preferences of the user.

### **The last will be the first**

The main problem with using IT is how to fit it sensibly into K-12 classrooms. We may compare IT to a super modern jet engine, but our schooling model can be compared to the biplane, which was used in the middle of the last century. If we attach the jet engine to the biplane it will not fly. What we really need to do now is to modify the old biplanes so that the jet engine suits them.

Miksike is fortunate to be located in Estonia, where Internet based strategies are highly developed (the Internet is available to nearly every school in Estonia), and where society is still young and open to change. After the collapse of the Soviet Union, Estonia got an opportunity to jump into a new era, the Information Age. Developed countries are often stuck in well-organized systems that were designed to serve yesterday’s needs. The need for change is more evident in Estonia.

Estonian institutions that supplied schools with educational material during the era of paper books never reached the same level of proficiency as their equivalents in the West, so Estonia had the opportunity to take a giant step directly into the electronic age. Miksike does not know any other initiative in the world that manages to give away free systematized educational content for grades one to nine, and that has anywhere near the same intensive user base. Miksike's special focus during the last three years is helping more than one hundred smaller schools in rural areas. Thanks to this type of communication, rural schools that use Miksike have equal access to critical information, which gives them an equal or better position than schools in bigger centres. This enables them to keep educational quality higher, and it definitely revitalizes education in such areas.

Besides the passion and the will to help small villages, there are other reasons behind this, mainly linked development. Schools in rural areas have a greater need for change. They face a shortage of both students and teachers. They cannot continue to provide education in the old-fashioned way, with a schoolhouse, an administrator, many teachers and so on, because it is too expensive and clumsy. And classroom size is smaller there, which enables them to implement a student-centred learning model much more easily than in bigger schools. So, rural schools with talented teachers are the first ones to adopt the "network-based" learning model. Subsequently the big and famous "elite" schools learn from these experiences. As it is sometimes said: "The last will be the first". Although the needs of rural schools were the driving force behind implementing the Miksike Learning Environment vision, this vision can be applied to all educational levels and locations.

Miksike has managed to create a sustainable environment and receives no basic funding from state or other donor organizations. When people need to visit the Miksike real-world office and do not know where the office is located, they search for a big building and expect 40 people to be working there. But all they find is 2 small rooms filled with computers in a garage-style environment. Yet Miksike is alive, happy and sustainable.

### **Negative or unintended consequences**

Three main issues should be pointed out. The first two are connected with the educational aspect and one is connected to the economic side of the story.

1. The greatest problem with IT innovation is to keep innovative solutions compatible with the existing educational system. There is a conflict between the

new network-style learning and old schoolhouse-based learning. In several cases, students in the classroom use network-based learning elements, while in these same classrooms teachers provide lessons in the old-fashioned schoolhouse way of learning.

Many educators teaching a wide variety of subjects are used to teaching the class in exactly the same way, year after year. For example, a teacher who teaches literature in grade eight each year in October gives students a homework assignment to write a paper with the title “The Tragedy of Hamlet”. In the paper age, this system worked well, because students had to write the paper on their own. Students today may find easier ways to do homework, and may find a paper with exactly the same title from a huge database of learning resources at Miksike.ee Web site.

We are aware of this, and are addressing this problem concerning the old-fashioned teacher. In fact, it is critical to introduce new electronic strategies that combine the best aspects of previous educational environments with the potential of the new.

Solutions:

Explaining to users that although Miksike learning resources are freeware and we allow users to change the content, copyright law still exists. When students use Miksike materials for their papers, they have to add the source from which the information is taken. Presenting a paper written by others under your name (just changing the name of the author and making slight modifications) is considered fraudulent.

It is important to respect the skills and accumulated knowledge of teachers, while helping them adapt to more innovative ways of encouraging students to think about the subject than they may be accustomed to. The online Miksike support centre provides free advice and ideas. We also acknowledge the pitfalls inherent in new learning models. If needed, for example, Miksike helps teachers figure out whether a particular paper by a student is original or simply copied from somewhere on the Web.

**2.** The “Open source” movement means free services for the user, but also that the quality has to be certified. The “basic” Miksike eWorksheets are tested and approved by Ministry of Education specialists. New supplementary materials, submitted by students, teachers and parents may contain errors. To deal with this problem, Miksike has run a project called “Washingday” for the past three years. The project involves users “washing mistakes out of Miksike eWorksheets” and winning points/prizes in return. Hundreds of volunteers have participated in the

Washingday contest, and at the moment we can be quite sure that materials at Miksike are correct.

**3.** The way Miksike distributes educational content is a problem for current educational publishers. The Miksike concept is based on giving away its products (eWorksheets and study material), which is the main income of the publishers. As a result, traditional educational publishers may feel that Miksike is reducing the market for worksheets. In fact, we suspect that they are right. Miksike predicts that in the next three years, sales of paper workbooks will fall by at least a third. Instead of workbooks, schools will buy printers, toner and paper, and use free educational content over the Internet to meet their needs for learning content. In ten years, paper workbook publishing as we know it today will become the alternative method of the past. The need for thoughtful, well-edited books and illustrative materials will continue unabated. We expect that this competition will only increase the pressure on “traditional” publishers to produce better and more useful materials.

So, the Information Age towards which we are moving is not a paradise where all the problems are solved automatically.

<http://www.miksike.com>



## JOINING FORCES

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Nina Tange, *Research Consortium Tools for the Knowledge-based Organisation, Learning Lab Denmark*

**The Internet technologies used in the Linux landscape makes it possible to connect people with similar interests, problems and needs. Joining forces on mailing lists is making it possible to collaborate on exploring problems from different angles.**

Once upon a time, Linus Torvalds, a 21-year old computer science student at the University of Helsinki in Finland, was playing with writing a kernel<sup>4</sup>. During the summer of 1991, he announced this to a newsgroup:

*“Hello everybody out there using minix - I’m doing a (free) operating system (just a hobby, won’t be big and professional like gnu) for 386(486) AT clones. This has been brewing since April, and is starting to get ready. I’d like any feedback on things people like/dislike in minix[...] I’d like to know what features most people would want. Any suggestions are welcome, but I won’t promise I’ll implement them”.*

Linus (torvalds@kruuna.helsinki.fi)

Torvalds released the entire source code for free download to anyone who was interested in using and modifying the system, and he volunteered to add

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<sup>4</sup> The kernel is the central module of the operating system – the part of the operating system that loads first, remains in the main memory of the system, and controls memory management, process and task management, and disk management.

functions written by others, as long as they were also freely distributable. Torvalds quickly found help, support, and feedback from many other enthusiastic programmers, who sent back bug fixes, code improvements, and new features and functions. By the end of the year more than a hundred people worldwide had joined the Linux newsgroup and mailing list. Updates to the kernel were made on a daily and weekly basis throughout its development. Torvalds released 90 additional versions, culminating in 1994, with the first official release of version 1.0. Since then, updates have continued to be released on a daily or weekly basis.

Linux is Open Source software, which basically means that you may copy and distribute the software as you like, provided you do not inhibit others from doing the same. While traditional software licenses protect copyright, Open Source licenses guarantee “copyleft”, where any changes or improvements to the source code is required to be made available to the public.

This article examines how the use of Open Source and Internet technologies has made it possible to organize communities around the development of knowledge, and how this organization leads to learning for those participating.

### **Creating Knowledge via Mailing Lists**

*“The formulation of a problem is far more essential than its solution. To raise new questions, new possibilities, to regard old problems from a new angle requires creative imagination and marks real advance in science.”*  
(Darsø, 2000).

In the Linux communities, interaction and communication is mediated by Internet technologies. Therefore, communication differs from normal face-to-face communication, as it takes place via mailing lists, is asynchronous, is written, and is many-to-many. Even though you can always simply subscribe to the mailing list and monitor what other people are writing, you do not really participate in the interaction until you make yourself visible through actually posting to the mailing list. And when you write, you are not sure who actually sees and reads your writing, as everything is sent to all the people who subscribe to the mailing list.

The mailing lists link people who otherwise have no connection to each other around their interests. Therefore, the communication on these lists is mostly about the sharing of perspectives within the given areas of interest: people ask and answer questions, share and clarify perspectives, discuss back and forth, post suggestions, and discuss the best way of doing things. So peers

on the mailing list are constantly reviewing each other's perspectives. The result is a cacophony of practice-related perspectives about different problem areas.

With software, as with a lot of other things, problems and solutions are often negotiable and, in many instances, there are no isolated problems to which you can search for a single correct solution. Rather, there are problems that have complex interrelationships with other problems, and solutions are often invented simultaneously with the problems themselves. This is exactly what the interaction on mailing lists is about. People discuss what is and isn't important, what considerations should be taken before doing different things, which tools should be used and for what, which strategy should be chosen, and for what reasons, and what the concrete context is and how this specific praxis relates to these questions.

*“Knowledge building occurs as students explore issues, examine one another's arguments, agree, disagree, and question positions... and new ways of understanding the material emerge as a result of contact with new or different perspectives”.*

(Harasim, 1989).

The interaction on the mailing lists can thus be seen as journeys from unarticulated, or not yet well-defined problems, towards a wide range of negotiations of meaning that places the problems within contexts. The divergent perspectives and competing ideas from the people on the mailing list lead to multiple framings of the problems. The people who participate hereby collaborate and contribute to the creative and difficult work of framing the problem and constructing the data. Rational problem-solving theories often ignore this activity of formulating the problem. But the Linux communities do the opposite. They acknowledge that the process of formulating the problem is essential, and accept that problems are open-ended, having potentially many different solutions, depending on the context of the user. In these communities, knowledge is explicitly viewed as something that is produced socially in the process – leading to old problems being regarded from new angles and new possibilities being seen. Knowledge is thus created, challenged, probed, and validated through the constant criss-cross peer review.

The process of validating the information is placed in an open social forum where multiple views meet and discussions are visible. In this way, information is negotiated and challenged, turning it into situated valid knowledge for the

“ People use the mailing list  
as a room for reflection.”

people working with it. As the  
production of knowledge occurs in  
the “context of using”, the focus is  
on application in practice – making it

highly relevant and useful for those involved. Apart from using the mailing lists for problem exploration, peer review, and validating of information, people also use it as a room for reflection. They ask themselves: What is this? Why does it work like this? What can I do to make it work? – and they ask their peers on the mailing list about it. The written communication on the mailing lists thus makes reflection visible. The replies, which are the results of other people's reflections and knowledge, frame and conceptualise the original questions and thereby further the reflection. This reflection opens up to new understandings and interpretations, and new actions are thought out and tested through experimenting, as people try out in practice what they have discussed on the mailing list. The experiments lead to new concrete experiences with software, computers, etc., which again lead to new reflections and conceptualizations on the mailing list, leading to new experiments – and so forth. Experience, reflection and experimentation are thus part of the process of problem framing and problem solving<sup>5</sup>.

So far I have discussed the mailing list as a tool for participation and active involvement in a social practice. However, it is also a tool for reification, as all discussions are archived in “threads” related to the themes being discussed. This archived reification of the discussions includes all the interaction in the community; all the stories, symbols, actions, ways of doing things, etc., which are created over the lifespan of the community on the mailing list. The archive thus encompasses the history of the on-line community, simultaneously showing how the knowledge was produced. This design of a simultaneous reification of the participation creates a very important sense of continuity in the on-line communities, which are often in considerable flux. This continuity consists even though old members leave and new arrive. The reified process also reflects the shared experiences of the community – anchoring the negotiated meanings, and creating a shared repertoire for the community to build from in future discussions. In this way it is ensured that you do not invent the wheel twice.

The software programs and code developed in the communities also function as reified knowledge. Software programs consist of algorithms, which are abstract math symbols used in a concrete setting to get the computer to do a specific thing. For the Linux communities, these “code-symbols” give form to the experiences and negotiations of meaning among the people discussing the code via the mailing lists. The programs become the object of communication and interaction as they focus the participants' attention on specific things, and provide people with opportunities to engage in conversations linked closely to

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<sup>5</sup> Inspired by David A. Kolb, *Experiential Learning* (1984)

concrete experiments with the programs. Information thus resides in the programs, and this information is made into useful knowledge as people are continuously working with them, altering them for their own use, etc. So, by looking at other people's code you can discover how they have solved different problems.

### **What to learn from this community?**

I have pointed out how the mailing lists connect people across time and space in communities of shared interests and practices. I have explored how these communities create knowledge through peer-reviewed processes of exploring problem areas. We have seen how these social processes of knowledge creation are automatically reified in archives along with the product (mostly software) of the knowledge creation. I have argued that the archive and software programs function both as shared knowledge bases, supporting the continuity needed in on-line communities of constant flux, and as objects used for reflection and learning among the participants.

As both the participating discussions and reified knowledge are open and accessible, anyone is free to explore a problem from whatever angle they want. In this way, the combination of Internet tools and Open Source's "copyleft" enables massive knowledge sharing by significantly increasing the scale and the number of developers involved in development, and thereby allowing a much greater exploration of a problem. This exploration is not dictated or directed by any managers or teachers, who tell you what to do. Instead, newcomers learn from more experienced peers:

*"The people who have been on the mailing list for a while are familiar with each other, and have developed respect for each other's opinions; newcomers are generally greeted with reticence until they have established a bit of a presence and the long-term residents feel comfortable with them. This makes it sound as though new contributors aren't welcome, but that's actually very far from the truth. The project is always glad to get more help – but would-be contributors need to show that they're there for the course before they'll be taken seriously. That means proving themselves by showing awareness of current and past discussions (through lurking for awhile and reviewing the mail archives), technical ability, perseverance, and the courage to stand up for their opinions."* (A core member of SSLUG).

Unlike normal schools, the participants in the landscape are not on the same learning trajectories, learning the same things. They join different mailing lists and learn different things, depending on the interest and focus of the individual.

In schools, where the course of learning is mostly specified beforehand, and mandated by teachers and curricula, learning is directed, in certain ways limiting some learning possibilities. So if we apply the interaction, organization and tools of these Open Source communities to the context of schools, many new possibilities open up.

Allowing children to pursue their interests, being motivated by authentic activity, exploring real problem areas, solving authentic problems, and doing genuine work in a community of practice, might solve the problem of motivation. Instead of the curriculum being the structuring principle of school practice, interest groups at different levels would make up the guiding structure. Instead of one teacher trying to teach thirty students exactly the same thing, the teacher's role would change to being a facilitator and resource person within a field of knowledge. Using the principles of Open Source and IT as a tool for supporting both participation and reification, these interest groups would be able to create learning for the people involved.

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## BRIDGING THE DIGITAL DIVIDE

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Lisbeth Frølunde, *Research Consortium Play and Learning, Learning Lab Denmark*

**There is growing awareness of the digital divide (Johnson et al. 2002). At the MIT Media Lab, researchers have come up with an idea for what to do about it. The idea is called Computer Clubhouses, and Learning Lab Denmark's research consortium Play and Learning is now working on bringing the Computer Clubhouse model to Denmark.**

**A**s I walk down the west side of Harlem, New York City, I think about how abstract our discussions concerning the transition to the knowledge society seem. It is generally agreed that a key challenge is to reduce what is known as the “digital divide” – the gap between those who are fluent, active producers using the new digital tools and those who are merely passive consumers. The problem is that new technologies seem to have accentuated previously existing social divisions. This has been pointed out time and again by organizations such as the OECD and UNESCO.

Nevertheless, instructive as discussions about the digital divide might be, it is easy for those of us with a background on the “privileged” side of the divide to forget what it actually looks like on the other side. Not unless we visit places such as Harlem, are we able to see the size of the digital divide. Here, all sorts of social factors converge and reinforce each other.

### **Computer Clubhouses**

So, what to do about all this? Well, this is what I am in Harlem to find out. Among these run-down city blocks, I am looking for what might be the learning environment of the future: Computer Clubhouses. Established in cooperation between the MIT Media Lab and local partners and corporate sponsors, now with Intel Corporation as the major sponsor, the Computer Clubhouse is an informal learning environment. Here, young people between ten and eighteen can come for free to experiment and express themselves using digital media and physical toys and tools. The young members are guided by volunteer mentors in producing music, artwork, games and Web sites. The motto is “do it yourself”. This is where children from underserved communities are being prepared to participate in a future society, where learning, communicating and creating are key words.

### **Media literacy**

A basic idea behind the Computer Clubhouses is that of “media literacy”, or “technological fluency”. Media literacy is a term that builds on literacy in the broadest sense, not just the ability to read and write, but also the capacity to think abstractly and to communicate own ideas and thoughts orally and in writing. In media literacy, these abilities include expressing own ideas visually, and presenting them with the aid of media authoring tools.

As described by Mitch Resnick, Professor at the MIT Media Lab, a person is considered to be technologically fluent (Resnick et al, 1998) when he or she is able to not only use technological tools for general purposes but can use these tools for specific purposes as well. In the transition to the knowledge society, these forms of fluency are increasingly a prerequisite for meaningful participation in society. An active and critical understanding of media is becoming increasingly relevant for both political and economic citizenship, and crucial in our media-saturated world.

### **How mentors help out**

I am visiting this Computer Clubhouse in Harlem and other locations to observe the model in practice, and see if and how we at Learning Lab Denmark can facilitate the establishment of one or more Computer Clubhouses in Denmark.

In Harlem, I meet with Ouida Washington, Clubhouse Coordinator, and Shawn Chin-Chance, Assistant Clubhouse Coordinator. It is inside a Boys &



Girls Club, which fills much of the ground floor and basement of a residential high rise. The clubhouse receives funding jointly from Intel and a host organization, in this case the local NGO, the Boys & Girls Club.

This Computer Clubhouse has only been open a few months, and Ouida tells me about the start-up issues. She has struggled hard to not replicate typical school and authority problems, where kids have to keep their guards up and act cool and tough. This is a neighbourhood, where schools have security guards checking for guns. Ouida tries to draw on older peers from the neighbourhood to be junior mentors and serve as role models for younger members, to show that it is cool to be involved with projects at the Computer Clubhouses. So far it seems to work.

Ouida has a background as a filmmaker and producer of music videos. But she grew tired of the industry and wanted to do something meaningful, to contribute to expanding the horizons of young people in Harlem. She tells of plans for summer outings to art galleries and museums in midtown Manhattan and Soho. It shocked her to realize that so few of the young members had visited these areas or ever been inside a gallery. Striking when they live in a city that is an art centre, and where it takes fifteen minutes by subway to get downtown. Yet it is completely foreign territory to them.

### **Building on the motivation to learn**

Maybe part of the explanation for the success of the Computer Clubhouses is that they build on young people's interest in digital media, yet inspire them to

“... the computer is an ideal learning tool, “the children's machine.”

try out new types of activities. Having helped to establish the first Computer Clubhouse, Professor Mitch Resnick and colleagues from the MIT Media Lab quickly realized that the approach was a hit with young people who often had little interest and success in school, yet were

eager to join in these creative, IT-related activities.

The pedagogical approach is founded by the Lifelong Kindergarten group and other researchers at the MIT Media Lab and is referred to as “constructionism”, meaning that learning works best when students construct personally meaningful projects. The fundamental idea is to get away from traditional “instructionist” teaching, where students passively receive knowledge defined by the teacher. Instead, the learning initiative and the enjoyment of

learning are given back to students. To this end, the computer is an ideal learning tool, “the children’s machine”.

In recent years, Computer Clubhouses have grown quite dramatically in number. Earlier this year, Mitch Resnick visited Learning Lab Denmark in Copenhagen to discuss how to implement the idea of Computer Clubhouses in Denmark. He elaborated on the growth of a network of Computer Clubhouses around the world, going from one Computer Clubhouse in Boston in 1993 to more than 70 around the globe in 2002. With Intel as a major sponsor, the aim is to establish a network of 100 Computer Clubhouses over the next few years.

### **On-going development**

Evaluation of the Computer Clubhouse model for learning is currently in the second year of a three-year period of assessment and development, run by educational researchers at the Centre for Children and Technology in New York City. They are looking at organizational aspects such as the phases of maturity in clubhouses, and proposing values that show how the learning model evolves over time. Making the implicit practices of the mature clubhouses more explicit can benefit the new clubhouses. A goal of the research is to develop a common understanding of the learning process by defining the Computer Clubhouse universe and describing how the mentors are scaffolding learning. As the Computer Clubhouse network grows, there are more efforts to share experiences and knowledge, so that there is a common base of understanding and clear measures of success.

The Computer Clubhouse model increasingly attracts attention from academic researchers. The flagship Computer Clubhouse in Boston is a model for this, due to the on-going collaboration with the Lifelong Kindergarten group from the MIT Media Lab. Research and development areas currently include:

- Workshops for democracy,
- International and intercultural understanding,
- Outreach to families and the local communities,
- Inspirational activities aimed at girls,
- Documenting the learning processes,
- Identity and integration issues,
- Inter-generational exchange through mentoring,
- “Clubhouse to careers” networking and assistance with career planning.

The people involved with the Computer Clubhouse agree on what is essential for a start-up to succeed – committed people who will champion the learning philosophy, a stable home and continual funding. The learning model is complex, and it takes time for the young members to become truly engaged in the activities. It is important to have time to set up the program in a community and to track and evaluate the learning process.

The Computer Clubhouse model is not about gaining more access to IT, but about becoming a participant and producer. The model emphasizes using IT as a creative tool and learning how to learn. These are relevant competencies if we aim at a future based on life-long learning, innovation and creativity.

These issues are addressed at Computer Clubhouses. And this might also be why the initial responses to bringing the Clubhouses to Denmark have been so positive. In Denmark, the interest is strong from several partners. Learning Lab Denmark is spearheading the coordination efforts and hopes to start up two clubhouses in 2003 and two in 2004.

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Examples of European Computer Clubhouses: Amsterdam has a spectrum of sponsor foundation and academic affiliation, <http://www.computerclubhuis.org/>  
Dublin is newer and run in cooperation with local community organization, Foroige, and Intel:  
<http://www.computerclubhouse.org/locations/foroige/clubhousehome.html>



## MATHEMATICAL TALENT OF YOUNG CHILDREN

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*La Real Academia de Ciencias Exactas, Físicas y Naturales, Spain*

**The detection and stimulation of children's mathematical talent is an educational project being undertaken by the Spanish Royal Academy of Sciences. The aim is to show children what mathematics really means.**

**I**n 1998, the Royal Academy of Sciences decided to get involved in a problem of great importance to the scientific progress of the country. This article outlines the main ideas behind this decision.

Without doubt, in any of the important cities of the country each year there are more than twenty children of about thirteen years of age with a very special talent for mathematics. What will happen to them? If no particular line of action is taken, they will most probably suffer through their years at school, frustrated by not having their talent recognized, even by themselves. Their special abilities will be unproductive for the community in which they live. Moreover, it might even be the case that the boredom they have to experience will lead some of them to academic failure.

What would happen if an official institution could in some way pay attention to their guidance? Surely it would be bring about intense satisfaction for them and, in the long run, great benefits to society and the advance of science and technology in the whole country. Some might think that the fact that an official institution would take special measures in favour of such children would contribute to promoting elitism. One can easily observe, however, that exactly the opposite happens. If no measures are taken, then it will often be only

those children from affluent families who are able to develop their talents and achieve success. Social justice and attention to the common good should lead to an active involvement in this problem by those who share the responsibility of running the educational policy. The costs of such an action would not compare to the benefits it would bring. The society that is successful in channelling the talents of its members will certainly go much further than the one that remains indifferent. The Royal Academy of Sciences started out with a pilot program with a reachable goal: to identify twenty-five children each year, aged twelve or thirteen, from the region of Madrid, with a special talent and enthusiasm for mathematics, and to give them, for a certain period of time, the opportunity to properly develop these qualities.

Several different problems should be confronted: talent detection, the organization of activities for the children that could be compatible with their normal development, the selection of adequate monitors, the financing of the project, and so on.

#### **The road taken by the Royal Academy**

Luckily there have been many countries in which a great deal of attention has been paid to this problem. Their experience has paved the way for the initial actions taken by our Academy. Among the many possible ways of handling the problem, the Academy has opted for a method similar to those initiated first at Johns Hopkins University in Baltimore, USA, and later followed by the city of Hamburg, Germany.

We try to detect, stimulate and guide the mathematical talent of about twenty-five children, aged twelve or thirteen, in one of our big cities, without separating them from their environment. This should be done in a continuous way, i.e. not merely by specific events such as competitions etc., but by means of a steady line of activities. The method chosen consists of three-hour meetings on each Saturday of the academic year. The age group (twelve–thirteen) has been considered the most appropriate for different reasons. It is more or less the time of the awakening of formal reasoning. In addition, experience in other countries that have guided us involved work with children of this age. For practical reasons, we thought the pilot project should start with children in the Madrid area.

The selection is made according to the following steps: the project is promoted in the month of April each year at all centres of primary and secondary education by a letter that encourages all teachers to send their best students to the project. In addition, the attention of parents is gained through

several announcements in newspapers. At the end of May the candidates (usually about three hundred) undergo a special mathematical aptitude test. Its goal is not to assess their mathematical knowledge, but their mathematical abilities.

After the initial selection, separate interviews with the children and their parents are held. Through this, we try to evaluate the degree of enthusiasm among the children and parents for being included in the project and their willingness to make the effort it requires. It is to be emphasized that the project implies no cost to the children's families, but the parents do have to make a considerable effort in bringing the children every Saturday morning and picking them up three hours later. After the children have been selected, in the month of September, they get to know each other and also the teachers involved in the project at a weekend meeting in the mountains close to Madrid. The main activity of the project with these children lasts for two years and takes place at the Facultad de Matemáticas, Universidad Complutense de Madrid, which has generously offered its enthusiastic support and its facilities to this project from the very beginning. Each Saturday the children participate in three hours of mathematical activities that have little to do with their syllabus at school. Under the guidance of two highly selected teachers (some of them university professors and others very competent secondary school teachers), they explore subjects such as graphs, number theory, strategies for mathematical games, interactive geometry with the computer, and so on. The children work in groups of four and are usually very interested in, and satisfied with, their activities.

After the first two years of intensive dedication to the project, the children pass to a second phase. They come to the project once a month on Saturdays and explore deeper and more sophisticated mathematical activities.

### **Financing**

For the initial three years (1998–2001), the Spanish Royal Academy of Sciences funded the project, with around €30,000 per year. From 2001, the Fundación Vodafone entered into the organization and financing of the project, providing €50,000 per year, thus covering all its expenses.

### **Results**

It seems too early to undertake a serious evaluation of what effects a project of this type will have. A period of four years is too short to assess the long-term impacts of a project, one of the aims of which is the improvement of the quality

of research performed by the scientific community. But one can truly say that the short-range goals of the project are being reached with complete success.

The degree of depth achieved by some of the children and their creativity in different aspects of mathematics leads one to predict that, in the long run, their involvement in the project can be decisive in strengthening and reinforcing their orientation towards mathematics research in different fields, and so they will be able to contribute substantially to the scientific and technological progress of our country.

But what the project has already truly fulfilled in its current state is now quite obvious. It has afforded these children a deep vision of what working with mathematics means, a vision that fills them with plenty of satisfaction. And this was the main goal that the Spanish Royal Academy set out to achieve with the project.



## MY MOTHER WANTED ME TO BE A DOCTOR

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Marek Lešičko, Student at the Faculty of Natural Sciences,  
Comenius University, Slovakia

**“Hello friends, my name is Marek and I want to tell you the story of my life.” This is the story of Marek from Slovakia remembering his schooldays and, in particular, one specific event – a competition in biology that made him a big fan of competitions as a means of increasing motivation.**

I was born in a small town in Slovakia called Bardejov (I am sure it is the nicest town in the world). It was during the period of Communism, but in my childhood that did not matter to me. When I was six years old, I went to a compulsory school. It started off very well. Each year I had only the best marks. In the fourth grade, a teacher gave us the opportunity to enter a competition in biology. We had to work in groups, to observe the forest during the course of the school year, to paint pictures of the plants and animals living there, to answer plenty of questions. But we did everything, we learned a lot of new information and we won.

### **Then it started!**

The next school year, I entered four competitions. While looking for results and answers, I had to read many books and ask my teachers and parents. I felt I knew more than my classmates. I got more and more friends from the higher classes.

I wanted to know more, but I could not read all of the interesting books, I could not enter all the competitions, there were so many things I could not do that I wanted to. There was no free time left. I was lucky that I did not know about the Internet at that time.

Communism collapsed in Czechoslovakia when I was in the fifth grade. I did not understand what was going on. In the beginning, I didn't see any changes. Later, in the seventh and eighth grades, I noticed that a few school competitions had disappeared. I did not know why. There were many topics I was interested in. But I began to get more interested in the natural sciences. I continued my after-school activities at high school as well. I entered competitions regularly. Relationships with friends I met at the competitions became more and more important to me. Each year I longed to meet them again.

### **Meeting Stano**

Once, while preparing for the Olympiad in chemistry, I met Stano. He was the best student of chemistry I had ever met. We talked all night long before our exam. Everybody was sure he would pass the exam. He did, and so did I. We were hoping to meet each other at a higher level of the competition. We both put all the energy we had into the highest round of the Olympiad in chemistry. Afterwards, I had to eat four large bars of chocolate to get the energy to move, and Stano was so tired he could only see things in black and white. In the evening we had to drink two glasses of rum. These competitions were the purpose of our lives. But time flew and we lost contact with each other. Again, there were new friends and a new cycle of life began.

After finishing high school, I started to study at the Faculty of Natural Sciences at Comenius University in Bratislava. All the knowledge I had learnt in competitions made my university studies much easier. I was surprised when I met authors of the books I had read, when I met people who had prepared questions for my student competitions. I was older and my mind was open not only to natural sciences, but also to politics, society and the world around me. It was hard to have an opinion of my own. I started to see and understand many changes that had been brought about by the revolution. Many of them were negative.

Each country has a different school system. During the period of Communism in Slovakia, compulsory education was supplemented by various competitions. The most important of these were the Olympiads, students' scientific activities, and correspondence seminars.

Later, less and less money was available for organizing competitions. Financial support from the ministry was insufficient. A system of competitions still ran for several years thanks to the dedication of enthusiastic people. Later on, several competitions had been discontinued. Correspondence seminars were among them.

Next year, I met Stano. He had begun studying chemistry at the same university. We had both participated in the chemistry correspondence seminars in the past. We were sad that the same opportunity did not exist for the youngsters. Stano was well informed about the situation because he had prepared the last two chemistry seminars at IUVENTA (the organization responsible for them). There was a will to continue organizing competitions on the part of IUVENTA, but the amount of money was insufficient. At this same time, I thought of founding an NGO at the university. The main aim of the NGO called SOREN (*Societas rerum naturalium*) – Society of Natural Scientists – was to create better conditions for studying science. I spoke about this idea with several friends and we finally started to set things in motion. One of the most important projects became the chemistry correspondence seminars for secondary school students. Stano was the main coordinator, and he recruited a team of managers for the project. They prepared questions, checked answers, and entered all the marks and notes into a database. I had to find money for the project. When it finally began, it was composed of three levels of questions and two categories (juniors and seniors). First, a collection of tasks and questions was sent to all relevant secondary schools in Slovakia. The second and third levels were sent only to the students who sent answers and results no later than one week after the deadline. After three levels, Stano and his team checked the marks and points. The best twenty students (ten from each category) were invited to a seminar in the countryside. All fees for the seminar were paid by SOREN. We received financial support from the educational foundation of Jan Hus, and also from some of my friends and businessmen who helped as well. Each of these twenty students was given a certificate, which confirmed that they could study chemistry at the Comenius University without taking an entrance exam (the exam is compulsory in Slovakia).

So far, we have prepared three years of the chemistry correspondence seminar for secondary schools, one year of the biology correspondence seminar for secondary schools, and one year of the natural sciences correspondence seminar for basic schools. 143 students joined the chemistry seminar last year. I think they were the best 143 chemistry students from Slovakia. I am convinced that the seminar broadened their knowledge of chemistry.

**What my mother wanted**

This year, I wait for a response from the compulsory schools. Their seminar is on the Internet: [www.kstano.host.sk](http://www.kstano.host.sk). We prepared the first collection of the tasks in a printed version, which will be sent to more than two and a half thousand compulsory schools in Slovakia. Correspondence seminars do not cost very much and their effects are unbelievable.

Stano and I remember drinking rum after our exam many years ago. We are often scared by the question of where we will find money for the next correspondence seminar. But looking back over three years of chemistry seminars and one year of biology and natural science seminars, we feel that the correspondence seminar tradition is returning.

My mother wanted me to be a doctor. But my interest in the natural sciences was deeper. Now I am a student in my fifth year of studies in Environmental Sciences.

I would like to thank everybody who prepared the competitions in which I could participate when I was a secondary school student, because these helped me to find out what I really wanted to study.

## SUMMER SCHOOLS FOR YOUNG CHEMISTS

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Marta Sališová, *Faculty of Natural Sciences, Comenius University, Slovakia*

**Chemical Secondary School in the small town of Humenné in East Slovakia welcomed in July 2002 more than fifty grammar school students, whose hobby is chemistry.**

The idea of organising Chemical Summer Schools arose in the late sixties, during the National Chemistry Olympiad Competitions in the former Czechoslovakia. Summer Schools have been organised for almost twenty-five years – for talented young chemists – to encourage experimental work and improve their experimental skills and knowledge in different branches of chemistry. At the majority of grammar schools, chemical laboratories are not well equipped – especially for organic chemistry experiments. Summer Schools are organised at Chemical Secondary Schools, where conditions for experimental work are much better. Some additional equipment is borrowed from the university labs if necessary.

### **The organiser**

For the last ten years, the main organiser of Summer Schools has been Iuventa. Their task is to choose a suitable Chemical Secondary School (each year a different one, if possible), teachers, sponsors, equipment, etc. The Slovak Chemical Society guarantees the quality of the education. University teachers as

well as Secondary School teachers present lectures, discuss special chemistry problems during seminars and also help with experiments.

### **The atmosphere at the Summer School**

The atmosphere is usually very friendly and university professors or assistant professors appreciate their time spent with talented young enthusiasts very much. It is well known that despite the busy day (usually four hours of experimental work and four hours of seminars or lectures), students sometimes knock on a professor's door late at night with some questions, which "cannot wait until morning".

Every year, Summer School is a bit different, and depends on the behaviour and ability of the "natural student leaders". Sometimes there are students with good sports abilities – they appreciate the opportunity to play football, volleyball, go hiking, swimming, etc. In other years, it is very difficult to persuade students even to enter the gymnasium.

One summer day, students created a very interesting situation. Suddenly, there was a great number of "new professors, doctors and engineers" on the streets of the small town. Students spoke to each other, as if they were already adults, having established their professional careers, and used the corresponding titles. These titles were also pinned onto the doors of their rooms. They had a lot of fun – and following their "free time" discussions, full of Latin or English words, was sometimes very interesting and very funny.

The organisers of the Summer School try to prepare some activities besides chemistry, especially during the weekends, where students visit local cultural or historical places. During the week, they are usually welcomed at the nearest chemical plant or former gold mine, etc.

### **Is there any evaluation of the students and teachers?**

The corresponding chemical plant usually sponsors this Summer School, and some officials from the plant usually come at least for the last evening, when the winners of the Summer School are announced. It means that students like competitions, and teachers have to create some rules for their evaluation.

Theory tests are quite common, but the experimental results are even more important – despite the fact that some students perform experiments for the first time in their life. They are very interested in the accuracy of titration, the yield and quality of the prepared products or being able to use the correct analytical agents to prove the presence of certain compounds in the test tube, etc. On the

other hand, some students evaluate the teachers, and from time to time a shorter or longer poem is circulated about the accuracy of the teachers, crazy subjects, too much or not enough experimental work or dull theories, etc. The poem is sometimes turned into a song! Anyway, there is always a good sense of humour involved.

Once there was a lecture on the behaviour of gases – the youngest participant Miško (a very talented one) was not very interested in that subject. His conclusion after the lecture was: “when two gases are mixed together, they make “pF”, and one has to write down ten pages of equations.”

For the majority of the students, those two weeks of chemistry are usually unforgettable – not only do they gain some experimental skills and a new motivation to study chemistry, but they also usually find many new friends and sometimes their first love. For many of them, this is their first opportunity to be part of a group of schoolmates from different parts of Slovakia, who have all been “captivated” by chemistry, and so there is a lot to discuss about what they are interested in. On the other hand, for some of them, these two weeks without parents gives a bit more freedom and a feeling of responsibility for themselves.

Saying farewell is sometimes difficult and even tears may fall. There are a lot of promises that they will keep for sure in the near future – somewhere – most probably at university.

### **Do the students appreciate the tasks of the organisers?**

Sometimes – some of them do not forget to thank the organisers:

*Majka:* “I did not know that something like Chemical Summer School existed – but now I am happy that I could participate in all this. I met many new colleagues from the whole of Slovakia and I found among them several excellent friends – for the rest of my life. I can say that those were the most beautiful and most interesting fourteen days of my life ...”

Or *Zuzka:* “We remember with a smile - a beautiful two weeks – full of chemistry. And we are ready to repeat them – even with more lectures. We had good time with you and do believe that you also did with us. Thank you for everything.”

And the main organiser?

“I do believe that every drop that touched the heart of a young boy or a girl will turn into a stream, later to a river and will finally reach the ocean – and always it will be H<sub>2</sub>O.”

We still remember the time when Czech students participated at the Summer School in Slovakia and vice versa. Then the atmosphere was even more interesting. We would like to believe that in the near future we will also be able to welcome students from other European countries at Chemical Summer School in Slovakia, and prove that young chemists can understand each other despite minor language barriers. There is a chance of starting this new activity via the new project coordinated by Slovakia.

[www.luventa.sk](http://www.luventa.sk)  
[www.newnet.sk](http://www.newnet.sk)

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## OPENING THE CLOSET OF NATURAL SCIENCE

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Lone Bruun, *LBformidling, Denmark*

**“Videnskabet“ is a Danish multimedia learning programme for physics, chemistry and biology in secondary schools. The project began three years ago. Here, the project manager shares her experiences from this project with us.**

**A**n ongoing problem in Denmark is the decreasing interest in the sciences shown by young people from secondary school to university level. About four years ago, a Danish industrial foundation, Thomas B. Thriges Fond, decided to contribute economic support to help alleviate the problem.

After a period of selecting the teaching levels and topics, the company Malling Beck was chosen as the publisher and I, as editor of science at the time, was chosen as project manager for the programme. The aim was to develop a totally new way of teaching secondary school students (seventh to tenth grade) in physics, chemistry, and biology, including a high range of modern electronic methods, and at the same time make Danish science and scientists visible to young people.

During the first period, I spent a lot of time thinking and asking myself questions, particularly about what had made me become a biologist. Why was science so interesting for some people and totally unappealing to others? How was it possible to transfer my own enthusiasm and joy of science to young people? How can we reach thousands of students and their teachers? Last, but not least, how could we find a totally new approach?

This process of thinking resulted in a long list of possibilities, and having asked around, I found that, among other scientists, two answers were very common: “I spend my life working with science because I love the good stories,” and “Because I love the working process itself.”

### **The six books**

We ended up with a concept of six books for the students, written by six scientists, each telling a specific story in a different way, a multimedia programme, a Web site and seven books for teachers, in which we describe the whole system and how it could be used in the learning/teaching process.

The scientists were chosen by age, gender, scientific skills and their ability to communicate. The six scientists and their stories were:

Prof. Suresh Rattan, biologist, born in India and living in Denmark since 1984. He wrote a story about his life as a young boy in India, the death of his brother at the age of sixteen, and how this affected his life and made him become a biologist with a special interest in the aging process.

Dr. Kaare Lund Rasmussen, physicist, has for many years been interested in meteors, in particular the one that impacted at Tunguska, Siberia, on 30 June 1908. In the book, he takes the reader on a trip to Tunguska together with a Danish expedition. He reflects on what really hit the Earth, and the investigations that led to his conclusions.

Prof. Minik Rosing, geologist, has travelled in Greenland since he was a young student, and has carried out research into the earliest life on earth. The book takes the reader on an expedition to Greenland, and discusses the very interesting scientific results concerning the beginning of life on earth.

Meteorologist Jesper Theilgaard spent twenty-four hours at the Danish Broadcast News on 3 December 1999, when Denmark experienced its greatest hurricane ever. In the form of a diary, he tells an exciting story about how no one had expected what was coming. He includes descriptions of how to make weather forecasts, basic meteorological knowledge and how to keep the general public updated.

Ph.D. student and chemist, Mc. Iben Damager, was one of the two women in this group of authors. She has been working with starch synthesis, and wrote a

book about an alchemist and his day-to-day life at the time of the Spanish Inquisition in the Middle Ages, and concludes with a description of her own ongoing research about starch.

Ph.D. Anja C. Andersen, geophysicist and astronomer, was the other female author. Her book tells the fantastic story “Made by Stardust”, about how we are all made out of the elements that were formed when the Universe was created – during, and shortly after the Big Bang.

The books, however, were only a small part of the project, although the authors worked very hard and intensively. The main efforts were put into the multimedia CD-ROM. The idea was to create a CD-ROM based on the principles behind computer games. We wanted to reach youth in their own everyday life. Our aim was to get into their “hearts” using methods that we knew already appealed to them.

### **The CD-ROM**

The first task was to select the right company as co-partner. We made contact with a young Danish company, Ultimatum, which has been on the market for a few years, producing high quality computer games for children. Except for the director, who had studied agriculture some years ago, none of the people knew anything about science. I was not particularly concerned about this barrier in the beginning, but it turned out to be a major problem during the final production of the CD-ROM. We also wanted the presentation and the graphics to be youthful and modern.

The “universe” of the CD-ROM is divided into two different parts. The first part includes many different scientific skills: The elements are presented not only with primary, basic knowledge but also with drawings and a short text explaining the usage in everyday life. In the glossary, almost four hundred words are explained, not only in text, but also in drawings. Sixty-three lab exercises in a printable form can be used for hands-on activities in the school or at home with the family. The toolbox includes different scientific equations, tables, and graphs. Last, but not least, the CD-ROM includes nine interactive models and twenty-two animations. The second part, “The Working Box”, gives the students the possibility to “work as a scientist”. Here, you can follow your own route through the programme. You can write down topics that you want to return to and work on later. You can make your own lab journal and get hints as to how to make a good presentation of your work. You can also save animations,

pictures, and text from other parts of the programme, so they can be used in Power Point, for example.

The whole process took over three years. During this time, more than thirty people were involved, besides the six authors and two very hard-working secondary school teachers in physics and chemistry, who were associated with the project. Their job was to support the authors by ensuring that the learning level was precise, and by carrying out the lab exercises and writing the teachers' manuals. They checked all of the written material as well as the CD-ROM several times. They played a key part in developing the material, helping the scientists, and keeping our feet on the ground.

Another essential aspect was the graphics and illustrations. Four layout experts and two illustrators worked together to create the visual universe in the books, as well as on the CD-ROM. Many discussions regarding typography, layout, and illustrations were held before we could present a product that was completely different from previous teaching materials. One of the big problems was to get this creative group to understand that when you are working with science you have to follow the set rules. For instance, small and capital letters have different meanings in an equation. During the process of making the interactive models and the animations, it was sometimes very difficult to make the layout people understand the scientific part of what they were doing. It was hard to understand that if you had chosen Guanine to be red in the DNA-molecule, it must also have the same red colour in the RNA-molecule. Regarding this, I learned that you have to be more specific when you are building up the storyboard for each animation or interactive model. It takes a tremendous amount of time to make changes in a model once it has been programmed. The people creating it not only have to fully understand the scientific aims, but also the background.

People were also involved in sound and music, in speech, testing, draft reading, and many other parts of the production process.

Another job was to make sure that the facts presented by the authors were consistent in all parts of the material. All the authors were highly qualified scientists but they presented different topics. In the beginning, I thought that I could at least be sure that the things the authors presented were scientifically correct, but it turned out that although they were very good in their own areas, they sometimes presented old knowledge when they moved to more common skills. As examples of this, I can remember discussions about the age of earth, cell components, and number of elements. When I became aware of this problem, we attached a high school teacher to the team as a consultant, helping us to update and correct the information.

**Good planning is a crucial factor**

Time was another factor that very nearly “killed” me and all the others involved. On the one hand, the pressure of getting the material finished, and on the other hand, the wish to produce a unique, high-quality product, was very stressful. My experience has taught me that you need to spend a lot of time at the beginning of the process. Good planning is a crucial factor. It is very important to make a detailed storyboard for each part, and also be sure that all the people involved know precisely what a “yes” entails. Although I thought that we had done all that at the beginning of the process, and that our early planning went into enough detail, I realise now that, in order to save time in the long run, we should have been more specific in our instructions.

Altogether, we ended up with a new multimedia programme, which gives Danish school children the possibility of learning science in a totally different way. They can play games with starch, they can read exciting stories, they can explore the universe making their own stars, they can run two different nuclear power plants, they can change the atmosphere of the earth, they can take a trip inside the human body and they can work as real scientists do in their daily life. My hope is that with “Videnskabet“, we have helped to produce future scientists, and helped other young people discover a new approach to the society of which they are a part, by increasing their possibilities of discussing all the new techniques in medicine, health and science.





## BIOSCIENCE COMMUNICATION “ON THE ROAD”

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Andreas Jungbluth and Doris Pischitz, *Flad & Flad  
Communication Group, Germany*

**A mobile genetic laboratory provides information for German high school students, the media and the general public about modern biotechnology and genetics.**

First of all, the student mixes a cut tomato with a buffer solution and mashes this mixture thoroughly. Then, she carefully passes the mashed tomato through a coffee filter into a plastic test tube. She now adds ethanol, closes the test tube, and carefully turns it over a few times. Before long, white lumps form – the genetic material of the tomato. “The ethanol extracts the water molecules from the DNA, so the chromosomes cluster,” biologist Dr. Susanne Pauly explains. She is one of three scientists working for “Science Live”.

With the launch of “Science Live – Science in Dialogue” in April 2000, German bioscience communication gained momentum. Fuelled by growing public demand for innovative bioscience information in all German *Länder*, the nationwide Bioscience Communication Initiative was launched by the German Federal Ministry of Education and Research.

The innovative underlying concept of the campaign is based on the motto “Technology meets the user”. 250 days a year, a show truck serving as a flexible teaching and presentation platform is touring Germany. Its interior combines a biotechnology exhibition and a fully equipped genetic laboratory complying with safety level 1 rules of the German Genetic Engineering Act. In this way, a

highly attractive and comprehensive presentation and discussion of modern biotechnology and genetic engineering is made possible – at any location at any time, with any preferred target group, in practice and in theory, using numerous communication tools. The laboratory truck is ready for presentation within thirty minutes, thus allowing a large amount of usage time per day.

### **The attitude of the public**

Especially young people's attitude towards the life sciences has been severely affected by the often negative and one-sided publicity that modern biotechnology receives. Media coverage of genetically modified organisms (GMO) and related issues has generated growing scepticism and opposition towards the life sciences and science in general. All too often, information about advances in the life sciences and the promise they hold for healthcare, the environment and the economy is displaced by headlines bringing bad news. As a consequence, confidence in the life science industry and the scientific community is low.

At the same time, the industry is expanding rapidly while the number of young people opting for scientific studies and careers fails to keep up with demand. The poor image that the life sciences currently have makes this field unattractive for students considering a university career. Unless positive action is taken, this will eventually begin to affect the industry's growth and its ability to compete with other regions in the world, which have been more successful in managing public perception issues. It also threatens to damage investor confidence and public trust in the products developed by this industry, and it may even hamper scientific progress.

“Science Live” therefore aims to increase people's knowledge about modern biotechnology and genetic engineering, and raise awareness of the importance of the life sciences for healthcare, the environment and the economy, thereby promoting an informed public debate. The goal of the project is to demonstrate publicly the function and significance of modern biotechnology and genetics for society and, at the same time, contribute to the de-emotionalisation of the debate on modern biotechnology and genetic engineering.

For high school students, “Science Live” aims to reduce existing educational deficits in high schools and make young people aware of future opportunities in the natural sciences. Teachers are very pleased with the opportunity to apply theoretical knowledge in practice. But high school students



are not the only target groups, even though the “Science Live” show truck stops mainly at high schools, staying for one or two days to offer practical courses in molecular biology.

### **Contents of courses**

Obviously, the courses do not just consist of the simple DNA extraction experiment described above. At the moment, the students are isolating plasmids from genetically altered *E. coli* bacteria. Later, they will use the isolated genetic material for a polymerase chain reaction in order to multiply the inserted gene. A gel electrophoresis will then show whether the experiment has been successful. Expensive technical equipment and safety level 1 precautions according to the German Genetic Engineering Act are required for these experiments. Neither is available or possible at schools – which means that “Science Live” offers a unique opportunity to conduct advanced experiments in the professional atmosphere of a real, modern biotechnology laboratory.

The courses are complemented by guided tours, open days, evening lectures with plenary or panel discussions, presentations at public events such as festivals or trade fairs, and special training courses for teachers and journalists. To ensure a very high scientific and educational quality, a team of three scientists with excellent communication skills – Dr. Susanne Pauly, Dr. Stefanie Moll and Dr. Burkhard Kleemeier – carries out all activities.

By October 2002, “Science Live” had already reached more than 13,600 students and high school students and 119,000 members of the public at 187 locations. In addition, information is disseminated in the form of brochures, overheads, protocols, FAQs lists, a Web page, and so on at each event.

The discussions held in the evenings, in particular, show that modern biotechnology and genetics are a very emotional topic. This complex scientific field is hardly accessible to non-scientists and frequently arouses apprehensions, especially when people consider its applications in farming and the food industry, or, more recently, in stem cell research. “Whenever these topics have come up in the news, debates in the evenings focus on them,” says Dr. Moll, explaining why concern is expressed by the public.

As the project management organization for the campaign, the Flad & Flad Communication Group with its specialized division BioGeneCommunications is responsible for the entire scientific and organizational concept. Based on experience gained in road-show campaigns for clients in politics, science and industry since 1985, this unique set of services includes full editorial

responsibility for the scientific content as well as the planning and implementation of all marketing and communication tools, including press relations and event management.

As the project is financed by the government rather than by the biotech industry, an unbiased and objective presentation of modern biotechnology and genetics is guaranteed. The occasional reproach that “Science Live” is an advertising campaign for modern biotechnology and genetic scientists can be repudiated. “We want every visitor to take a close look at the topic and consider it critically,” says Dr. Kleemeier. After all, the main objective of “Science Live” is to encourage as many citizens as possible to reflect on their opinions regarding modern biotechnology and genetics, and thereby to enable a broad public discussion.

#### **We received feedback**

On the basis of feedback from target groups and of media coverage, the success of the campaign can be summarized as follows:

- Mobile bioscience communication facilitates intensive interaction between scientists and the general public, thereby increasing public trust in science and technology.
- Mobile bioscience communication easily spreads fact-based, objective information covering a wide range of bioscience issues including benefits, risks and ethical issues.
- In view of low school budgets and limited educational possibilities, high school students and teachers benefit from direct access to modern biology through a mobile genetic laboratory.
- Demand for informative material persists, and this material is obtainable through a Web response component and via a project hotline – especially for schools that want to support education in workshops.
- Schools and institutions ask to be visited regularly by a mobile genetic lab in the future.
- The practical, communication-based approach motivates young people to obtain first-hand information about educational and career opportunities in the biosciences.

## PLANET EARTH – THE YEAR OF GEOSCIENCE 2002

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Stefan Leonards, *Project Coordinator of “Year of Geoscience 2002”, Berlin, Germany*

**With the aim of popularising science in Germany, the “Year of Geoscience 2002” followed two other campaigns, the “Year of Physics” in 2000 and the “Year of Life Sciences” in 2001. Together, these make up the core of the “Wissenschaft im Dialog” initiative.**

**G**eoscience is the science of the earth. Sounds pretty straightforward. But do you have any real idea of what our planet is made of, or how it works? A quick look at the globe shows continents and oceans, volcanoes offer a glimpse of the planet’s hot core and, of course, there’s the source of our daily conversation, the atmosphere and the ever-changing weather. This is still very much clear-cut. The greenhouse effect and El Niño, the melting of the Polar Caps, isotope distributions and geothermal energy resources already sound more complicated. And if you start to discuss whether global warming is caused by human CO<sup>2</sup> emissions or by natural causes, you are in for scientific arcana, complex computer simulations and diametrically opposing expertise. Fascinating topics, but it is no easy task to present complex research to the pleasure-seeking general public. Yet, in the end, the “Year of Geoscience 2002” achieved wide media coverage and attracted nearly 700,000 visitors.

**How?**

The answer to the problem was elementary. “Earth, air, fire and water”, the classical elements known to the ancient Greeks, set the stage for the “Year of Geoscience”. Each element represents a sphere of the planet – biosphere, geosphere, atmosphere and the oceans – and gave a name to four events, held in Berlin, Leipzig, Cologne and Bremen, that united diverse branches of the geosciences in an attempt to familiarise the public with scientific research. The idea was to simplify a complex system without reducing its scientific results beyond recognition. The concept allowed a popular approach, wide media interest because of its journalistic potential, and an in-depth presentation of modern scientific methods and results.

The importance of the role of the scientist cannot be overrated in the campaigns. One of the foremost aims was to place the scientist in direct contact with students and the general public. The principal idea was to present science in non-scientific environments, to surprise chance visitors with science, to leave the proverbial “ivory tower”. The events therefore took place in public spaces – shopping malls, railway stations or marketplaces. The core of each event was an exhibition, the “Science Street”, made by scientists for the general public. Around the exhibition, a programme of talks and lectures, multimedia shows, workshops and screenings of popular movies with scientific commentaries was organised. The organisation set the stage for the scientists and their work, but the stars were the scientists themselves.

And the public was delighted with the stage. The usual everyday public, i.e. shoppers or commuters, frequented these public spaces. For these incidental visitors in particular, the exhibition provided a welcome change to daily routines and a focusing of attention. The other target group, consisting of students, was reached via the schools. The offer of a special programme of guided visits to the “Science Street”, workshops, and lectures was taken up by schools and teachers. Thus, the scientists were confronted with two kinds of visitors: students in the morning and the general public all day long.

The direct contact proved to be extremely helpful. The general public felt both somewhat in awe of, and honoured to talk to, real university professors or researchers. The students enjoyed the guided visits as opportunities to gain practical insight into science and research. That science matters, that it can be fun as well as understood, were the principal lessons for the visitors. But insights and lessons were also gained by the scientists. Questions that had never been imagined arose, the need to explain research in simple terms was felt, and

it was also fun to explain it in this way. To sum up, scientists and visitors shared the fun in explaining and understanding.

### **The big events**

This spirit of the events spread to the media. For each event, local partners in the media (press, radio, and television) were found, and they took an active part in the events. Again, the media appreciated the direct contact with the public and the scientists, as well as the regional background of the events.

This was the case, for example, with the “Fire” event in Cologne (June 2002), in which WDR, the regional broadcaster and one of Germany’s biggest public broadcasting institutions, took considerable interest. Themes relating to “fire” comprised the geosphere, with its volcanism and the hot core of the earth, earthquakes and the drifting of the continents, geothermal energy and conventional energy sources such as coal. Examples of all these themes could be found in the region of Cologne or in the city itself, a prominent example being the volcanic origin of basalt, one of the stones used in building the Cologne Cathedral. Thus provided with a host of regional themes, the WDR produced a live television programme and several radio programmes on site. In addition, a week of radio programmes concentrated on “fire” in historical, scientific and cultural perspectives. All in all, about twenty-five broadcasts and reports were based on the theme of “fire”.

For each event, special solutions had to be found to adapt the general concept to the specific advantages and disadvantages of each chosen public space. In Cologne, the event took place in a marketplace in the city centre. In order to compete with the other urban attractions, especially shopping, the open market was cut off from traffic and its urban environment by two rows of tents with their open sides facing inwards, thus creating a new public space in the middle. People crossing the marketplace found themselves suddenly in a science court. Right next to the crossing, a smith had set up shop, complete with forge and anvil. Together with other attractions, such as firemen and their vehicles and the “Science Corner”, this caught the attention of the public. Altogether, some 80,000 visitors decided to have a closer look at the exhibition and the programme being held in a big show tent.

But it was not only big events that made up the campaign. Scientists, universities and research institutes were generally encouraged by the Federal Ministry of Education and Research to organise their own part in the “Year of Geoscience”. About 1,100 lectures, excursions and exhibitions, etc. took place all over Germany. Another initiative organised events such as lectures by

geoscientists in six hundred schools for about 30,000 students on the “Earth Day” in April, and visits to three hundred geotops by nearly 20,000 visitors. Again, the enthusiastic engagement of the (geo)scientific community proved to be decisive.

The organisers were supported by the Ministry with brochures, flyers and posters and a calendar to advertise the activities on the Web site [www.planeterde.de](http://www.planeterde.de). The Web site and the corporate design of the “Year of Geoscience” had the function of uniting all activities under the logo “Planet Earth – Year of Geoscience 2002”. The corporate design took up the idea of the spheres, and used four concentric segments of circles symbolising “earth, air, fire and water” as the general layout of the brochures, flyers and posters, as well as the design of [www.planeterde.de](http://www.planeterde.de).

## SCIENTIFIC WEEK OF MADRID

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*La Consejería de Educación de la Comunidad Autónoma de Madrid, Spain*

**The Scientific Week of Madrid was an event held in 2002 that aimed to bring citizens together and to inform them about initiatives and increase interest in science and technology.**

**N**owadays, scientific knowledge is an essential part of our lives. Science and technology seem to have answers to almost every question, and hardly anything seems to resist its shrewd scrutiny. Europe aims at becoming a society based on technological knowledge and development; the expectations that both of these generate in all of us are increasing day by day. In a world dominated by science and technology, the scientist becomes a public figure, as well as a key point of reference. Paradoxically, scientific advance is perceived with increasing scepticism by extensive sections of society. It is more than a few people who accuse science and scientists of keeping away from the problems of daily life. Science has developed all its potential out of view of the public, and more and more people are now demanding greater participation in the making of scientific policies.

The European Union has launched an ambitious plan of action, the main point of which is to create a closer and more harmonious relationship between science and society. Its main goals are to:

- Promote the role of science in education,
- Promote scientific culture among European citizens,

- Provide the conditions for publicising results,
- Promote public participation in the definition of scientific policies in the European Union.

One of the activities proposed is the celebration of “Weeks of Science” such as the one held in Madrid 2002, which, for its second consecutive year, was promoted by the Consejería de Educación de la Comunidad de Madrid within the program “Scientific Culture and Public Participation”.

Scientific Week Madrid 2002 aims at bringing together the citizens of Madrid and the science and technology produced in the Comunidad de Madrid. This would enable access to scientific knowledge at its place of origin and promote the participation of the different municipalities of Madrid, as well as encouraging collaboration between scientific institutions. There were 130 participating institutions and about 500 different activities that achieved the proposed aims, and which served as an excellent reflection of the present-day position of science and technology in just one part of Spain (Comunidad de Madrid).

The activities were classified into six different sections:

1. Public sessions and guided visits of schools, laboratories, institutes, libraries and museums, etc.,
2. Roundtables and conferences, including seminars, debates, discussions, etc.,
3. Courses and workshops,
4. Educational itineraries and excursions, which could be environmental, pedagogical, cultural, scientific, and so on,
5. Exhibitions of instruments, objects, models, scientific equipment and tools for investigation, etc.,
6. Films, awards and other activities.

These activities corresponded mainly to areas such as astronomy, matter structure, biology, biotechnology, environmental sciences, zoology, geology, chemical engineering, aerodynamics, computing and simulation, robotics, applied physics, communication nets, cartography, climatic change and cloning.



## REFLECTIONS ON CHILDREN, BOOKS AND SCIENCE

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Erik Jørgensen, *Danish Museum of Electricity*

**Project “Green Touch” was part of the long-term plan of the school authority in the Municipality of Aarhus to create a green school system, where teachers and students are aware of what is good for the environment, and on such a basis to equip the citizens of the future with environmentally sound habits.**

*Let the students put away their books and give them real problems to work with. Let the students’ discussions and questions steer the teaching and they will themselves create knowledge. Let the students use their knowledge and they will get involved.*

This is my short answer when someone asks me what should be done to stimulate children’s and young people’s interest in the natural sciences. My answer is based on a series of observations I made while participating in a major environmental education project in 1999–2002. The project was called “Green Touch” and was carried out in Aarhus, Denmark’s second largest city, with a population of 260,000. Out of the city’s fifty-two primary and secondary schools, thirty-two schools participated in the project during its three-year period. Green Touch’s primary theme was “human interaction with nature”, with a focus on environmental problems. The goal of the project was to equip the students with *competency of action*, which means that “students in an independent and critical way, and on the basis of commitment, feelings, opinions and acquired knowledge, are able to take action on environmental

problems.” Project “Green Touch” formed part of the school authority’s long-term plan to create a green school system, where teachers and students are aware what is good for the environment, and on that basis to equip the citizens of the future with environmentally sound habits.

### **Project “Green Touch”**

Green Touch was not started from scratch, but drew into the planning phase experience from other environmental projects carried out in Denmark in the 1990s. Together, these experiences show that it is important to take the wishes and interests of the students into consideration in the planning of the educational content. Such wishes and interests are, of course, many and varied, but in general it can be said that the students value:

- Working cross-disciplinarily with real problems that speak to them at an existential level and that also speak to people outside the school,
- Working in groups with the freedom to organize their work and suggest topics for investigation,
- Having an influence on the actual teaching of the class as regards the aim, content, planning and concrete organization,
- Being respected for the work they produce, both by the school and by people outside the school,
- Gaining experience with institutions and environments outside the school and encountering people and viewpoints that inspire new thinking,
- Having the opportunity to do something to help solve environmental problems,
- Having the opportunity to reflect on their impressions, both intellectually and emotionally.
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Project Green Touch was planned by a group of persons from the Municipality of Aarhus school authority (ÅKS), The Danish University of Education (DPU), and The Danish Museum of Electricity (the national museum of the physics, technology and cultural history of electricity). Most of those in the planning group also participated as teachers and supervisors in the implementation phase of the project. Based on what we knew students valued in teaching, we decided that an important feature of Green Touch would be to allow the students to undertake project-oriented work with environmental problems seen as *conflicts of interest*. We regarded conflicts of interest as an

aspect of “human interaction with nature”, which could especially contribute to strengthening the students’ ability to formulate arguments, make commitments, take a stand and take action. We imagined that through engaging in conflicts of interest, the students would become active and would seek out and work with knowledge to promote their case – precisely as it works in all conflicts of interest, where what counts is having one’s arguments in order. The individual schools could participate with projects that involved the entire school or just individual classes.

Project Green Touch also served as a development project for the teachers who participated. Through the project, a number of these teachers would be trained as a future resource person who could instruct other teachers in environmental education. This goal would be achieved by letting the teachers work in teams of two, as sparring partners for each other’s projects, and with a supervisor to provide guidance. All the teachers in Green Touch were trained in the concepts of competency of action and conflicts of interest. As the education officer at The Museum of Electricity, I was involved in the project as a planner, teacher and supervisor.

When I was brought into the Green Touch project, it was partly due to my contribution to the development of The Museum of Electricity’s cross-disciplinary educational initiative in physics and technology, available to all areas of the Danish education system, and partly because the Museum itself is witness to a conflict of interests. Teaching at the Museum of Electricity is carried out in authentic surroundings, so that children and young people can experience how their surroundings are the object of questions, investigations, and answers. The conflict of interest, which the Museum is both witness to and is involved in, revolves around the Museum’s neighbour – Denmark’s largest hydroelectric power station, Tangeværket. The power station gets its energy from the Gudenå river, which has been dammed up to form Tange Sø, a lake regarded by many as a natural gem with great recreational value. The entire structure was built in 1918–1921, following an energy crisis during the World War I, and it constituted a violent invasion into the natural environment. Ever since, Tangeværket has been blamed for the extinction of the famous salmon of the Gudenå. The accusation is that the salmon were obstructed from reaching their spawning grounds by the power station. Today, some interest groups are trying to establish a new breed of salmon which, in the long run, could lead to the end of the power station, and perhaps also of Tange Sø. Other interest groups will naturally oppose this, and hereby arises a classic conflict of interests, where the parties concerned, through their commitment, feelings, attitudes and knowledge, attempt to reach a solution based on their wishes and beliefs. The

conflict is quite simply over what the Gudenå's water should be used for. Should it be used for the production of electricity or salmon?

I used the Gudenå conflict in the Green Touch project as a case study when training teachers in the concept of conflicts of interest. A number of the teachers said they did not believe that the students would be capable of identifying conflicts of interest, let alone working with them. There was, in their opinion, simply too great a gap between what I was teaching the teachers and what was possible in the classroom. Reality, however, showed itself to be completely different.

### **Rooks in the school forest**

Skjoldhøjskolen in Aarhus is a typical Danish primary and lower secondary school with eight hundred students, and class 5b is a typical class twenty-two students. In spring 2001, the two teachers of this class, Martin and Stig, told the students they would try to do a project on an environmental issue, about which everybody in the class agreed that something must be done. The students had an hour to discuss and come up with suggestions and, among several more or less serious topics, one came up that caught the imagination of the entire class, namely: "why did the young rooks in the school forest have to be shot, and who decided that they should be". It was a particularly relevant topic to take up. Just next to the school, there is a park area known as the school forest, which is inhabited by a colony of rooks. Every spring, a team of hunters arrives and shoots at least 1,000 of the rook young, just at the time when, almost able to fly, they leave their nests and sit defencelessly on the branches. All the children sitting inside the classrooms can hear the shooting, and many think it is a shame for the rooks, but none had so far done anything about it. 5b decided to take action.

### **Visit to The Natural History Museum**

Through in-class discussion, the students were to decide how they wanted to start their project. A small group of students moved the discussion towards the

"Why did the rooks want to live in the school forest?"

question: "Why did the rooks want to live in the school forest?" It wasn't very big, and it was a long way from the countryside outside Aarhus, where they could find food. The class decided to visit the Natural History Museum in

Aarhus to find out about rooks. This decision to seek out knowledge at the museum was taken very quickly, because all the students had been there, often several times, with their parents. The Natural History Museum is a popular day out for families with young children in Aarhus.

At the Museum, a biologist gave a detailed talk about rooks and all their habits. The students were very interested and asked many questions. It was of great importance to the further course of the project that the students should learn the concept “biological crashdown” – if there are too many of a certain species in a small area, changes will occur in patterns of behaviour, which the biologist colourfully described to the class. It can, for example, result in infighting and cannibalism. The students were so absorbed by the new concepts they had learned that in the following days they adopted “biological crashdown” as a slang phrase for everything that went wrong.

Back in the class, the students thought about their visit to the Natural History Museum. With the aid of posters, maps, drawings and photographs, they produced an exhibition that presented the habits of rooks. During the three weeks the rook project lasted, the exhibition formed the basis of the students’ knowledge about rooks. It was impressive to see how much knowledge the class had collected in the exhibition. The students always referred to it in their later discussions. The other students at the school visited the exhibition, and 5b’s parents were also invited to see their children’s work.

### **Questionnaire Survey**

A new class discussion would determine what the next stage of the project should be. At the Natural History Museum, the students had found out that rooks in colonies make a lot of noise, and that this is one of the reasons why they are shot – also in the school forest. A complaint about the noise from people living in the area around the school forest was an important reason why the municipality’s environmental authority had chosen such heavy-handed measures concerning the rooks. The students did not think that the noise was annoying, nor did they consider that a reason to shoot the rooks – “but it’s a natural noise”, it was stated. The result of the class discussion was that the students decided to find out how many local residents really thought the rooks made too much noise.

Martin and Stig taught the students how to carry out a questionnaire survey. The class was divided into five groups, and together the teachers and students worked out a questionnaire. Each group was allocated a survey area, and almost two hundred people were questioned. The answers were sorted according to gender and age on large wall-charts, and the students found it very exciting to

study the answers and see a pattern emerge. One surprising result was that a little over half of those asked had answered that they were not bothered by the noise of the rooks – in fact, there were even some individuals who had said that they actually took walks in the forest to enjoy the rooks.

### **What do the experts say?**

Now the students really spun into action. They wanted to meet the director of municipality's environmental authority, Niels Jørgen Friis, to present the results of their survey. Niels Jørgen visited the school and explained very clearly to the children the necessity of controlling the rooks in Aarhus municipality. The students listened and had their questions answered, yet were still not satisfied. They wanted to hear what a person opposed to the control of rooks had to say. Through a class discussion, together with Martin, they decided to ask Niels Jørgen Friis to visit the class once again with an expert from The Danish Society for the Conservation of Nature, so that the students could pose questions to them both. Søren Nørager, from the local committee of The Danish Society for the Conservation of Nature visited the class, and after one student had given a short presentation on the students' work and opinions regarding the control of rooks, questions were addressed to the two experts – a lot of questions. The students later formulated the answers into two categories – for and against rook control – and put them up on two large wall charts that portrayed a hunter and an ornithologist.

### **Bringing in the media**

In a subsequent class discussion the results of the day with the two experts were discussed. It was difficult for the students to decide how to progress from there. There was no longer a consensus in the class that the rooks should not be shot. Several boys thought it was alright to control them to keep the numbers down. Some students also thought that "there wasn't really anything to do about it", but the majority refused to give up. A suggestion to write a reader's letter in defence of the rooks caught on, and groups were formed to begin writing. The letters were sent to the major local newspaper, Aarhus Stiftstidende, and three students formulated such a good letter that it was printed in the paper. The reader's letter attracted a lot of attention locally to the class project, and Aarhus Stiftstidende wanted to cover the class and their project in more detail. The media coverage

was the high point of the project for the students. Even those who were getting a little tired of talking about rooks were clearly proud.

### **The rook project ends**

The students gradually had to acknowledge, however, that they could not prevent the shooting of the rooks. The class therefore wanted to know how the rooks were shot. Was it done in a proper way? A meeting was arranged down in the school forest with one of the hunters. He told the students about his work and showed them his rifle. A journalist and photographer from Aarhus Stiftstidende were also present at this meeting. The next day, there was a large photograph on the front page of the newspaper showing one of the boys standing with a rifle. This ended up being reported to the police – in Denmark, an adult must not allow a minor to handle a loaded rifle. But the hunter was cleared when a closer examination of the picture showed he was still holding the rifle tightly in one hand. For 5b, this episode was a powerful and dramatic conclusion to their rook project.

### **What was it that the students actually did?**

The rooks in the school forest was just one of the many projects in Green Touch. There were many other projects of different sizes, and all contained elements of a conflict of interest and a focus on the development of the students' ability to take action. I am recounting the story of 5b and their project because the students, through their work, revealed something central about learning and knowledge.

5b did not work with a "what if" topic, as is often the case in schools. The students were engaged in "an issue" from the world outside school, which they found relevant and perceived as a conflict of interests. The students formulated a problem that made it possible for them to act – and they designed their investigations themselves. The students learned through being able to take action all the time. Their learning was an activity that resulted in knowledge. This knowledge was not located in each individual student's head, but was distributed through the community made up by the class. It was the joint achievement of learning and knowledge that equipped the students with competency of action. Through the entire duration of the project, the students' learning consisted in the ongoing transformation of the conditions for their continued participation in the conflict of interests. In this sense, the learning processes of the students of 5b provide a fascinating example of the American

anthropologist Jean Lave's theories on learning and knowledge. According to Lave, learning is the transformation of the conditions that allow participation in communities of practice, where knowledge is constructed in the specific context of the community and is distributed throughout its membership.

What was the driving force behind the students' learning process? *It was clearly the class discussions and the construction of usable knowledge.* Through being allowed to discuss, the class arrived at precisely the questions that set the processes of investigation in motion, which the students themselves designed. The knowledge constructed by the students was their own knowledge, which could be directly applied and thereby helped to create commitment. Though the rook project at Skjoldhøjskolen may not be a shining success story, it does illustrate what students are capable of when the teaching is made their very own. Many investigations and considerations concerning the teaching of natural sciences point towards the importance of the students gaining ownership of the teaching, but do not explain how this can occur. It can only occur if, as a teacher, one considers two questions: *How do we get the students to discuss in the natural science classes, and how do we give them the opportunity to apply their knowledge?*



## HENDERSON CREEK

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Wolff-Michael Roth, *University of Victoria, Canada*

**I have taught science to several seventh-grade classes at Oceanside Middle School, where students generated knowledge that they contributed to the community through their exhibits at an open-house event organized by environmental activists. The environmental group and students learn science by focusing on stream and watershed health, and the sometimes severe problems with the quantity and quality of water that threatens Oceanside.**

Oceanside is located on the Henderson Creek watershed. In Oceanside and the watershed as a whole, water has been a problem for many years. Despite being located on the Canadian West Coast, Oceanside has a relatively dry climate (about 850 millimeters of precipitation per year) with hot dry summers and moderately wet winters. Concomitant with the climate, recent developments have exacerbated the water problem. Farmers have straightened the local creeks, thereby decreasing the amount of water retained in the soil available for filtering into and supplying the aquifer. At the same time, the farmers draw on the creek and groundwater during the dry summer months, further increasing the pressure on this valuable resource. Other residents have individual wells that draw on the aquifers. Their water is biologically and chemically contaminated during the dry period of the year, so they drive five kilometres to the nearest gas station to get useable water. Urbanization and the related increase in impervious surfaces (pavement), losses of forest cover throughout the watershed and along the stream banks, losses of wetlands and

recharge areas, and the loss of natural stream conditions, further worsen the water problem.

In addition to the decreasing quantity, the water has been affected by human activity in qualitative ways as well. Storm drains and ditches channel rainwater – along with the pollutants of suburbia, lawn chemicals and car leakage – into Henderson Creek and its tributaries and away from these newly developed areas. The community of Oceanside introduced an industrial park, carefully contained within a four-block boundary, to the watershed. The drains of its machine shops and biotechnology labs empty into a ditch (affectionately called “stinky ditch”), which, in turn, empties into Henderson Creek. To increase its potential to carry away water rapidly, the creek itself has been deepened and straightened, and much of the covering vegetation has been removed, thereby increasing erosion and pollution from the surrounding farmers’ fields. These physical changes have led to increased erosion and silt load in the wet winter months, and are responsible for low water levels and high water temperatures during the dry summer months when (legal and illegal) pumping for irrigation purposes taxes the creek.

Concerns about water quality led to the formation of an environmental group. The actions of the group include monitoring water quantity and quality, and contributing to the rewriting of community policies related to Henderson Creek, the watershed, and the quality and quantity of water. The group created and actively promotes a stewardship program, builds riffle structures in the stream to increase cutthroat trout habitat, builds fences designed to protect the riparian areas, and monitors the number of cutthroat trout in different parts of the creek. Other activities include replanting riparian areas for increased shading to lower the water temperature to a level more suitable for fish. The environmentalists engage in educational activities, which include giving presentations throughout the community and assisting children in their Henderson Creek-related investigations. Every now and then, a newspaper article features the work of this group. I have been using these newspaper articles to begin the science units at Oceanside Middle School – particularly one article that calls for the community to contribute to the currently available knowledge and direct action to understand and change the health of the Henderson Creek watershed.

### **Learning science**

Given the urgency and importance of the water problems in Oceanside, it was easy to convince the principal and a few teachers at Oceanside Middle School to

participate in a study where students would learn science by investigating the Henderson Creek watershed. I invited interested teachers to co-teach a unit with them, which means that we take collective responsibility for planning, implementing, and evaluating the curriculum.

Once introduced to the newspaper articles featuring the problems of the Henderson Creek watershed, and acknowledging the importance of the environmentalists' invitation to the community, the children's interests are sparked by their desire to help. This desire is further fuelled when the leader of the environmentalists comes to the class to talk in person about the salient issues. Students immediately volunteer to clean up the creek and to investigate its various facets. They design and conduct their own investigations at different parts of Henderson Creek, which they ultimately report, upon my suggestion, to the *community* during the annual open house event organized by the environmental activists. The idea underlying these lessons is to put students in a situation where they become active citizens who contribute to community life and collective knowledge accessible to all.

This way of organizing the science lesson makes it interesting for other members of the community to participate in various ways. That is, students produce knowledge in the context of a *community* that is much larger than the "classroom community" characteristic of most educational practice and theory. School science and village life begin to interpenetrate and, in the process, support one another. For example, members of the environmental group give talks, participate with students in collecting and interpreting data in and along the creek and, in the process, assist them in learning to use instruments such as dissolved-oxygen meters or Serber samplers. Some parents assist the unit by driving children to their research sites and others provide assistance to student investigators. Aboriginal elders give presentations, middle and high school students who have already gained research experience assist in teaching, and several graduate students of mine assist the children in framing research and collecting data. This participation of community members also changes the traditional division of labour, which leaves schooling to teachers and school administrators and excludes others who validly and competently could contribute to such an enterprise.

**Table 1:** *One student's list of activities and things she learned during the fieldtrip on 16 April 1998*

**What I did and learned**

- Researched three different sites, pollution
- What sites look like (grass, trees)
- Fish population decreased 100 years
- Testing to see which bugs like what water
- Working with university and Institute of Ocean Sciences
- Interviewed the mayor and ocean sciences rep
- Used to be spawning creek for salmon, only one fish found now
- Different places on sites: sandy or grassy or shallow site
- Used D-nets, microscopes, water sampler, buckets, nets
- Measuring speed of creek
- Measuring width of creek
- Testing water temperatures in different places
- Fish survived in cooler water
- Measure overhang
- Measure dissolved oxygen
- Seen what centre of stream was made of
- Riffles get water flowing faster
- Farms use water in spring and summer
- Found dragon flies, sun fish, crayfish, leeches, damsel flies, dragon fly larva
- Mostly found anthropods
- Animals have to be placed in ice overnight; always return them back to the creek

Consistent with my belief that emancipation comes with control over the means of production, the students in these classes frame their own investigations and choose the *tools* (e.g. instruments, computers, or camera) with which to represent the creek and its current state. It hardly comes as a surprise that within each class, students produce different representations of Henderson Creek and its surroundings, all legitimate, but contributing in different ways to an understanding of the creek and its problems. Because they are in control of much of the activity system, including the objective for a particular investigation and the means of production (*tools*), they are generally motivated by their work and the need to overcome problems to achieve their goal (rather than by the teacher), and designed an increasing number of investigations.

When students pursue investigations of their own design, their eyes and minds are fully engaged, productive, and absorbed by their interest – which is not unlike what can be observed everyday in factories where workers have the opportunity to contribute to the shaping of their workplace. Table 1 provides a

glimpse (here in the form of an excerpt from Shannon's notes) of how the unit provides students with rich experiences during one afternoon in the field. These excerpts document questions, observations, and future directions that were opened up, as well as outlining completed actions.

Some of the students are interested in producing scientific representations in the forms of graphs, bar graphs, charts, and tables. Other students are not so inclined, opting instead to conduct classifications of animal or plant species, construct photo series accompanied by audiotaped reports, conduct interviews, or use a video camera to report on other students' research activities, for example. We support these students by allowing them to learn the use of new tools on a just-in-time and as-needed basis – we found that this is the best and a highly motivating way for students to conduct very interesting and very competent investigations. Thus, when the students in a group decide that they want to look at the relationship between the frequency of different invertebrates and stream speed, I make sure that they use the stopwatches in an appropriate way. I also ask students how they want to measure stream speed. When they suggest measuring how long it takes for a floating object to move a certain distance, I ask them whether they think that there are differences between floating objects of different materials (e.g., a stick, a piece of styrofoam, or an orange). Although they may begin with wild guesses, they learn in the course of their investigations that a piece of styrofoam may be pushed by the wind, or an orange may get stuck in shallow parts of the creek. That is, in the process of their inquiry, my students learn a great deal about how to make an investigation work despite the continuous and unforeseen problems that arise in the process. In the end, one group recorded time and distances, sampled the creek in different spots for invertebrates, calculated speeds, grouped and counted the microorganisms, and produced line graphs for different organisms.

For example, students used a side-view drawing of an amphipod (Figure 1), which, together with other drawings of other organisms, assisted them in classifying and sorting the invertebrates and counting each incidence. These counts were later entered into data tables and subsequently plotted. I assisted students in interpreting their results, sometimes by helping them to think of their data points in terms of trends, and asking them to draw trend lines. Sometimes, they came up with interpretations that differed from those that one of the adult scientists may have arrived at. These scientists then engaged students in an exchange, often involving the concept of "outlier." Students ended by drawing conclusions such as "There are more invertebrates where the water runs faster" or "There are fewer amphipods when the creek goes faster."

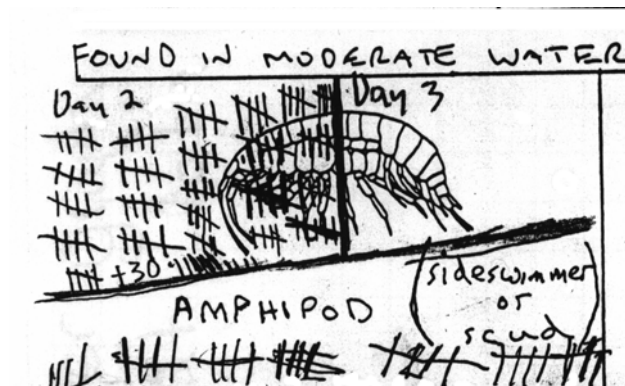


Figure 1. Some seventh-grade students used side-view drawings, such as this of an amphipod, to identify, classify, and count the incidence of different organisms.

Ultimately, the children presented the results of their work at a yearly open-house event organized by the activists, focusing on environmental health in the Henderson Creek watershed. They presented descriptions and photographs in the form of a Web site, which the visitors could peruse at the event because the children had brought a computer. Other children presented posters, showing the results of their observations or interviews with community members.

After the unit came to an official end with the open-house event, the result of their work was published in the local newspaper and on the Web site of the environmental activists. Thus, both through their exhibits during the open house event and the subsequent publication of their findings, the outcome of the students' production entered the *distribution* and *consumption* process.

The open-house event and the subsequent publications were key points in the unit because the students' work became legitimated as the community members accepted what they had done. The following comment by a student was rather typical:

"I worked hard in helping my group members out with the model, the home page, and presenting the picture board. In this project I learned that there are invertebrates in the creek, I also learned where Henderson Creek is located. I never knew that the creek through Community Park was connected to Henderson Creek. I noticed that since the Henderson Creek article was published in the Peninsula News Review that the public has noticed the creek." (Brandon)

For the children, the science unit was successful not because they received high grades but because the unit was useful and contributed to community life. They began to notice the creek and its problems; they also remarked that the community (their parents and relatives) began to notice it. Students' actions had a further impact in the community, as the environmental activists told me, because their presence in and contribution to the open house brought a greater proportion of community members (parents, family, neighbours) to the events. The parents who came to contribute or to whom we talked about the unit had very positive comments, particularly highlighting the usefulness and meaningfulness of the knowledge gained while coming to understand the creek through research.

### **Learning in, and as participation in, collective praxis**

In this example, my seventh-grade students participated in a collective practice, taking care of and generating knowledge about a creek and its associated watershed. What the students did made sense not only because they chose what to do and how to go about it, but more importantly because they engaged in a collective activity with a collective motive. That is, the students learned as they participated in a collective praxis, inherently involving other people from their village. They collected data that the environmentalists subsequently published and thereby made available to a larger audience, so that the students' data collection had the same motive as the data collection conducted by the environmentalists. The idea of learning in, and as participation in, collective praxis is, in some ways, a concrete realization of the idea of overcoming *defensive* learning through *expansive, object-oriented* learning. To further articulate what I mean by collective praxis, the relationship between individual and collective, and the role that science and other domains play, I draw on the analogy of a thread and the fibres that constitute it. A thread is made of many fibres, which can differ, among others, in colour, strength, thickness, and chemical makeup. Although the thread is made up of the fibres, its properties cannot be understood as a linear superposition of fibre properties. Furthermore,

“Think of a community  
of practice as a rope.”

whereas the thread is continuous, the fibres themselves are discontinuous. Shape and properties of the individual fibres contribute to the shape and properties of the thread and the thread, qua context, shapes and affects

how we perceive the shape and properties of the fibres. Threads can also be woven into ropes.

We can now think of a community of practice as a rope, constituted by its members (threads), themselves fashioned from many different fibres. In my example of Oceanside and its middle school, the community constitutes the rope that gives shape to its members, including school students (threads) who, as a class, form part of the rope. The shape of rope and threads are dialectically related because the threads determine the overall properties of the rope but the place in the rope determines the appearance of a particular thread. Once the rope exists (though this gets us to the limit of the analogy), we can imagine individual threads to be removed and new threads to be added. Each removal and addition does not significantly change the overall aspects of the rope, but changes it nevertheless. Each addition of a thread therefore contributes both to the reproduction of the rope but also produces new aspects of it. In this analogy, I view science at the individual level as one of the fibres that contribute to a thread; laboratory science is a collective practice that we get when we consider science-dominated threads as a group of threads in the overall rope. This analogy makes it quite clear that we cannot think of the few threads that make laboratory science independently of the rope that allows laboratory science to exist as part of the division of labour to maintain the overall rope.

In the everyday life of the community, science is therefore never but one of the many fibres that together make a theme in the rope. When twisted together with all the other fibres, it is not science that becomes continuous but the theme (part of the rope). I think of the rope as a continuous entity that forces me to think of scientific literacy as something that emerges from the collectivity. It is only when we unravel the thread that we find a fibre. I cannot understand the continuity of thread by thinking as if all fibres were going the entire length; I do not understand each fibre by thinking it from the continuity of each thread within the rope. For example, my study of the community of Oceanside showed that science is connected in deep ways with technological, economic, political, and aesthetic issues. In a contested issue over the assessment of local water, for example, there are different water treatment solutions offered, each with its own interconnected range of scientific and technological possibilities and constraints, there are costs to the community and individuals, and there are a variety of potential economic benefits.

The analogy of fibre, thread, and rope for the relationship between science and other forms of knowledge in controversies about problems forces me to rethink what knowledge means in the curriculum. Does everyone have to know the same things? Does every student have to be competent in the same issues? That is, does each thread (student) have to have fibres of the same kind (subject matter knowledge) or is it possible for rope to exist and provide support to each



thread even if particular threads do not have any science fibres? It is well known that there is simply too much specific content knowledge for any individual to know the relevant facts even in more constrained contexts. We do not have to master all areas of knowledge to live successfully in our society, and awareness of this fact may free us to explore more creatively how to deal with questions of scientific literacy. Educators may be tempted to teach science so that all students exhibit knowledgeability at some standard level. But then, we would spend much more time in school even if knowledge transfer from school to workplace and everyday life were less problematic than it already is. If we think of scientific literacy in different terms, as a particular kind of choreography in which we learn to participate by participating from the beginning, we take radically different approaches to teaching science in schools. Our children would already participate in doing things that benefit the community, and participate in the ongoing discourses and concerns that are relevant to their parents and the community at large.

In the case of Oceanside, scientific literacy emerged because the citizens were involved in an issue where there was something at stake. It has been suggested that scientific literacy as practical activity in the face of problems arising from everyday life include a number of competencies (Fourez 1997). These include how to use specialists; how to use black boxes efficiently; how to invent interdisciplinary rationality islands; how to use metaphors; how to use standardized knowledge; how to translate, negotiate, and transfer knowledge; how to use (different types of) knowledge in everyday life to make ethical and political decisions; and how to contrast the understanding of technology with the understanding of its scientific principle. In the present case, these aspects of scientific literacy emerge as aspects of irreducibly collective praxis rather than individual prowess. There is no inherent need for all students to be competent in all of these, like there is no need for all people to be able to repair a lawnmower, lay carpet and ceramic tiles, or produce organic vegetables. All that really is required is the ability to participate in the collective choreography and know how to access necessary resources.

When, how and where do we allow young people to be scientifically literate in these terms? The classical approach is to expose children and older students to the images of scientists' science. This science is a pure subject, often taught in special physically separated rooms, unsullied by common sense, aesthetics, economics, or politics that are characteristics of everyday life. It is also a subject in which each individual, so goes the idealist rhetoric, has to appropriate and exhibit a certain "basic skill". Whether students "have" this knowledge and skill, is usually assessed by isolating them from social and material resources

normally available in everyday situations. Conceptualizing scientific literacy as a feature of collective praxis changes the situation. Educators now have to think about how to set up situations so that contexts (rather than individuals) exhibit scientific literacy. How can we (teachers) possibly do this? Rather than preparing students for life in a technological world, I propose to create opportunities for them to participate in this world, and to learn science in the process of contributing to the everyday life of their community. Sample contexts are environmental activism, salmon enhancement, farming, or traditional food gathering ceremonies among aboriginal peoples. Early participation in community-relevant practices provides for continuous (legitimate peripheral) participation and a greater relevance of schooling to the everyday life of its main constituents.

### *Implications for policy*

It will not be possible to copy the Oceanside experience exactly with all of its dimensions into other villages, towns and cities, for each is characterized by its own practices, laws, population configuration, and contingencies. Rather, policy makers need to develop some trust, as by allowing teachers and students control over activities, tremendous learning will come about.

But I think that unless we design into learning environments some of the characteristic features of communities of practice, all we get is simply a grouping for which there is ultimately no real rationale, as long as students are tested independently and, based on these tests, compete against those who have been in their group. In this case, we do not need “community of practice” as concept for thinking about learning environments. “What then,” a policy maker might ask, “do we need in order to create learning communities (of practice)?” To answer this question, we need to specify some of the core characteristics. Thus:

1. Communities of practice are heterogeneous in terms of practical competencies, with a smaller number of newcomers than there are old-timers,
2. Communities of practice focus on particular projects that contain a motive and, in the pursuit of which, individual participants feel the need to learn,
3. Individual members have certain levels of autonomy with respect to choosing what to work on at the moment,
4. Communities of practice interpenetrate with other communities and society more broadly, and
5. Individual members access diverse social and material resources, including time and space.

When we think about these dimensions for a little while, it becomes evident that traditional educational structures are not set up to accommodate communities of practice. Educators interested in using the community of practice would strive to:

1. Do multi-age and competence grouping that allow slowly changing communities to come about and sustain themselves over time. For example, a new charter school in Philadelphia was created on the idea of having four pods of one hundred grade 9–12 students rather than four grade levels,
2. Let the curriculum be organized around projects that arise from the needs of individuals and collectives, allowing activity and motive to coincide, and therefore the emergence of intrinsic collective motivation,
3. Let individual students choose how they want to contribute to the overall project in which they are currently involved, even when this means that they do not contribute because they are currently “taking a vacation”. More likely than not, projects will be multi-disciplinary and thereby allow individual students to divide labour and take different parts best suited to their learning needs,
4. Open up to allow school and society to interpenetrate. The environmental project at Oceanside showed how such interpenetration can begin; it also showed that children can take part in and contribute to the pressing issues in the life of the community. There are different projects around the world that have shown the feasibility of this approach,
5. Allow open access to the resources that individuals and collectives deem necessary, within the constraints of the more encompassing community that includes parents and city officials. Importantly, and similar to most everyday practices other than hospitals and prisons, students would not be confined temporally (rhythmically shifting to a different subject every 45 minutes) and spatially (confined to seat and classroom). (When engaged in authentic activity, soccer practice, children and adolescents don’t have to go to the bathroom all the time!)

The idea of learning communities in thinking about science education is a different conception of knowing that arises from different relations between the individual and collective than those which underlie much of schooling in countries around the world. Reconceptualizing the relationship between individual and collective, and therefore the nature of knowing, requires a reconceptualization of learning. Underlying the idea of communities of practice is the fundamental assumption that learning involves a changing subject-world relation on the part of the learner. Here subject and world are not conceived in terms of content and container, two separate entities, but a dialectical relation from which each emerges in and as of praxis. Learning to become a citizen can

then be understood as part of the students' changing participation across the multiple contexts of their daily lives.

Thinking about learning in terms of practice and community requires us to rethink the role of teachers, too. Present day organization of school life is antithetical to object-oriented expansive learning; they interfere with learning rather than support it (Holzkamp 1993). To a considerable degree, this is the result of the role that society ascribes to teachers, or equivalently, that teachers feel has been ascribed to them. They are said to be responsible for teaching something to students. That is, in most schools, the subject of learning is not the teacher, who configures the learning environment to make students learn; rather, the subject is the student. Typically, teachers rather than students ask questions, though it seems intuitively evident that we ask questions when we don't know rather than when we do know something. In community of practice type learning environments, students ask the questions and others, teachers and peers provide the support in answering these.

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## LIVING SCIENCE

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**The Italian education system is currently undergoing great changes, and "Vivere la scienza" is one of the Science and Technology Education projects, an initiative that aims to lead the way towards the autonomy of schools. The project won the competition held by the Ministero dell'Istruzione, dell'Università e della Ricerca 2000.**

**T**he project was launched in November 1999 and aims to develop the overall growth of scientific technological culture, improving the quality of teaching and using the full potential of teachers' professional skills.

The official document of the SeT project underlines a unified vision of Science and Technology; a broad notion of the concept of a laboratory in its widest sense as a gathering of both internal and external opportunities, which permit the concrete exercise of scientific procedures such as observation, analysis, spotting analogies and differences, variables and constants, and the use of information technologies. The basic document recommends:

- An experimental approach to science subjects ranging from observation and experimentation to formalising concepts,
- Research methods,
- An pedagogical methodology for problems and projects,
- Setting up school networks for communication, the exchange of ideas and materials, and working together at a distance,
- Systematic monitoring of experiences and the production of materials.

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Over the years, the SeT project has promoted many educational and research activities, and has also financed the purchase of laboratory equipment. This has been carried out in collaboration with teachers, students, universities and other bodies concerned with science teaching.

### **The “Vivere la scienza“ project**

The “Vivere la scienza“ SeT project was carried out by a network in Cava de' Tirreni, a picturesque town in southern Italy, and almost all the town's schools took part, so the experiment included approximately eighty teachers and 1,500 students. The basic aim of the project was to produce innovative multimedia teaching materials that could be shared through a network. The materials are developed by teachers for teachers, and should be easily usable both in the situations where they were developed and also in other contexts.

The starting point for any investigation always lies in real problems linked to the students' experience and fields of interest. It is therefore the students who look to science for a key to reading reality. The traditional, academic approach involving theory with some applied exercises and perhaps a demonstration laboratory experiment was discarded. Starting with students' questions a didactic path was drawn up, with the onus placed on experimentation. Laboratory work included the use of both easily found materials “stolen” from everyday life and technologically advanced instruments such as on-line sensors, and data analysis and processing software.

The prevailing methodological hypothesis adopted was constructional: students actively, gradually and personally construct their own understanding, starting from spontaneous ideas or common concepts emerging from their own past experiences. The lessons therefore included continuous teacher-student interaction, leading to debate, cooperative learning, and dynamic operations. The same theme was developed for the various school levels: teaching planning, carried out according to roles, is attached to the cognitive levels attained at the previous school level, and looks forward to the following level. Rather than keeping each subject to its own sector, problems are faced in a global sense.

Educational materials are produced in electronic format, to exploit all the potential offered by multimedia: simulations, animation, the insertion of video footage and photographs, interactive tests and networked sharing. The teachers from different school levels, with different experiences, have worked on a common project using the same methodologies, sharing materials and resources,

and their experiences and views on a network. The teachers worked under the guidance of university lecturers, which proved extremely fruitful and effective.

The work produced is not educational research, but aims to be an example of good pedagogical practice carried out by a network of schools.

### **Stages of work**

A group of teachers, coordinated by experts from the scientific partner bodies, delineated the pedagogical layout of the work. These programme lines were discussed during a seminar involving experts in the field of science teaching. All the teachers involved also took part in this seminar, a “production simulation” was carried out, and its outcome discussed.

The most difficult problem faced in the planning stage was how to ensure that the large number of teachers would work in a way that would guarantee homogeneity and uniformity in the methodologies and goals to be achieved, and at the same time would respect individual ideas. Therefore, the production work began with the allocation of tutors to the teachers. At the same time, the project’s scientific coordinator held a training course for the teachers involved, both experimenters and producers, on the theory of measures: a fundamental subject for the correct approach to any type of scientific work. Teachers, tutors, the scientific coordinator and all the other partners interacted constantly. They met frequently, but above all used the intranet managed by the Intermedia centre. The scientific coordinator and tutors revised drafts. The outcomes of the revisions were discussed with the teachers during a seminar held at the University of Salerno. This seminar also included updated laboratory training for the teachers – the partner companies contributed greatly to the successful outcome of activities by providing materials and the know-how of technicians who coordinated the work.

The classroom experimental stage of the materials produced took place during the academic year 2001–02. This stage began with a seminar: experts on evaluating and monitoring pedagogical experimentation were invited to contribute. During the seminar the mode and timing of teaching activities were discussed, and a protocol to document and compare the outcomes of the experimentation was drawn up and discussed. During the seminar the teachers also presented the work produced to the local educational community. Arranging and assembling the materials required particularly hard work, which was coordinated by the Intermedia centre. The work of the teachers was backed up by a great deal of work by school head teachers and the heads of school services, who looked after the administrative aspects of the project.

**Conclusion and future prospects**

For the whole of the town's educational community, the project proved to be a unique chance for debate leading to positive and fruitful cooperative relationships, which we are certain, will continue to produce meaningful results. Plans are under way to set up a local pedagogical laboratory, with the support of the university and local bodies, making structures and skills available for the local educational community. The products of the "Vivere la scienza" project will be available in this laboratory.

This project has led to the birth of a stable working group, which will carry out further research in science teaching.

The didactic product is available on the INDIRE site:

[http://www.indire.it/set/vivere\\_la\\_scienza/vivere.htm](http://www.indire.it/set/vivere_la_scienza/vivere.htm), on CD and on the project's site: [www.intermedia.sa.it/Set](http://www.intermedia.sa.it/Set)

It is a dynamic product in the sense that it is constantly updated with information on the results of experiments that are still under way. The results of experiments consist of photographs, multimedia products made by the students, statistical analyses of entry and exit tests, teachers' logs written up following a protocol decided by the teachers themselves, and analyses of questionnaires distributed to teachers and students.



## OLIN COLLEGE

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Martin Burcharth, *US correspondent, Dagbladet Information, Denmark*

**They are two young women who recently graduated from high school with a very high score. I met them at the newly inaugurated engineering school, Franklin W. Olin College of Engineering, in Needham, 20 miles west of Boston, on a recent visit.**

**T**he blond Scandinavian-looking Susan Fredholm and petite Que Anh Nguyen, born in Vietnam, could probably have been accepted at any top-notch technical university in the United States – such as Massachusetts Institute of Technology, Georgia Tech or California Tech. Instead, they picked this small new experimental college that is still so fresh from the oven that you have to navigate the bulldozers and unfinished paved paths in order to access one of the four buildings that make up “Olin”.

But nothing seemed to deter Susan and Que Anh in their quest to get an education equal to that of Leonardo in Renaissance Florence – the unofficial mascot of this most unusual American liberal arts college. “We’re in business to produce renaissance engineers,” president Richard Miller claimed in a long interview earlier the same day. And indeed, they are.

The two girls’ faces radiated concentration and hyper-excitement as they explained how, together with a male student, Michael Curtis, they were working intensely to construct a rocket that was supposed to take off on a lawn outside the building on 11 October, as part of a competition among nine teams, each made up of three students. The rocket itself was a left-over plastic coca-cola

bottle – not much to brag about if you work at Cape Canaveral - but the challenge was to build a launch pad and an air compression engine powerful enough to lift the 0.75-litre bottle of water as high up in the air as possible.

Needless to say, the winner would be the team whose rocket displayed the best behaviour and reached the farthest up in the sky. The reward? “Just bragging rights,” conceded one student.

Well, you might say that the assignment is something any student of engineering in their third or fourth year at a polytechnic university in Europe or an engineering school in the US should be able to accomplish. That’s quite true. The exceptional thing about Olin, however, is that these tasks are doled out to freshmen like Susan and Que Anh who are in the first month of their first semester at university. The theoretical underpinnings they bring to the challenge are minimal at best.

The reason they will be able to solve this, and many other more complicated engineering problems in the first semester of their studies is a curriculum that places considerable emphasis on integrating disciplines such as mathematics and physics, and on developing applied skills

“They should apply theory as soon as possible.”

in mechanical engineering right off the bat. “They should apply theory as soon as possible,” explains John Stolk, one of the three assistant professors who designed the course.

“The students take a math course in the morning and get to use theory in the laboratory that same day, then they might wrap up the day in a physics course which addresses some of the questions they’ve been working on a couple of hours earlier.”

This approach is totally unheard of in other American colleges. “Before I arrived here,” says Mark Somerville, one of the other assistant professors, “I taught at Vassar College. I never got to integrate disciplines like math and physics. Sure you get to apply theory, but much later at Vassar. It’s clear to me that the students here at Olin feel much more involved. I mean they’re doing something real, and of course they get confused, but the fact is that they learn much more.”

As for Susan and Que Anh, they don’t get much sleep. “We work all the time. There are so many things to do,” says Susan and adds that she takes dance classes. Que Anh is involved in a film club and loves French movies. “As a matter of fact, I am also learning French,” she explains.

To understand the mission Olin College of Engineering set out to fulfil earlier this fall – the first semester of a regular school year with seventy-five

students – you need to grasp two things. First, the crisis that education in engineering is facing in the United States. Second, the legendary engineer Franklin W. Olin and the foundation he established in 1938. There are about 330 college engineering programs in America, of which twenty-five are new programs established over the last decade – all of them affiliated with colleges or universities. But the increasing number of schools stands in contrast to a rapidly declining student body. According to the National Science Foundation, the number of engineering undergraduates fell from 441,000 in 1983, to 361,000 in 1999.

For too long, engineering schools have been caught up in the old-fashioned idea that students should spend the first two or three years taking science and math courses and only at the end of a five-year period be provided with hands-on experience in engineering. The predictable result of frontloading theory has been a tremendously high dropout rate. Fewer than half of those who enroll actually complete their degree and go on to become engineers.

In response to this problem, the National Science Foundation has started to encourage schools to retool their curricula, but that is no easy feat in a university system that is set in its ways and resistant to major change. “People from different departments don’t speak to each other and no professor is ever asked to teach anything that’s far from his specialization,” remarks Olin’s president Richard Miller, who has a bachelor’s degree in aerospace engineering and a Ph.D. in mechanical engineering.

Moreover, the tenure system (secured lifelong employment as full professor) tends to be an obstacle to change. “There are no more challenges in life, no more reviews by peers, simply no accountability,” explains Miller, a former dean of the engineering school at the University of Iowa.

He adds: “Worst of all, no tenured professor is forced to retire at 65 because of a federal law against age discrimination. People can literally stay on the faculty until they die, and many do. Universities don’t know how to deal with this problem and the students suffer.”

Franklin W. Olin was an entrepreneur, engineer, scholar and professional baseball player, born in rural Vermont in 1860, and largely self-taught. Educated in engineering at the prestigious Cornell University in New York, he founded his own company, which still exists today, and turned it into a Fortune 500 company before his death in 1950. He invested twenty million dollars in a foundation whose main purpose was to finance the construction of engineering buildings and their interiors at a number of university campuses across the US.

Today, there are seventy-two Olin buildings on fifty-seven campuses, and as the years passed the Franklin W. Olin Foundation’s endowment grew from

twenty to six hundred million dollars. In the early 1990s, the board of the Foundation realized that there was a considerable risk that it would deviate from the course set out by the founder when new generations would take control.

At a board meeting in 1945, Olin had expressed his wish that the Foundation “establish, equip and provide for maintenance of a school or college for the training of young men and women in the industrial arts, the arts and sciences,” as the Foundation’s executive director Lawrence W. Milas discovered.

This was exactly what Milas himself had thought would be a wise way to stick to Olin’s ideals.

The Olin Foundation decided to spend its entire endowment on building and operating a new type of engineering school which would offer free tuition for its students, who, in the future, would number about 600 – 140,000 dollars to each student over four years! Parents need no longer worry about dipping into their last savings to support a talented child’s undergraduate studies in engineering.

In a speech to thirty prospective students held in August 2001, Milas said: “Franklin W. Olin was versatile and had many talents. Like him many people blessed with engineering also have talents in other fields. The arts, for example, or, in the case of Olin, in athletics. Leonardo da Vinci is perhaps the most well-known example of this - the engineer as a renaissance person.”

Lawrence Milas then went on to assert that: “Olin College intends to encourage among its students and faculty this blending of engineering with other skills and talents.”

That Olin College truly wants to fashion a new generation of engineers is embodied in the character and ideas of its remarkable president – the ebullient and inspiring Richard Miller. I spent an hour and a half with him, listening to a stream of words that made a lot of sense to a non-engineer’s ears.

Miller and nineteen other faculty members had, together with thirty selected students (eighteen years old), spent the entire academic year 2001–02 debating the curriculum, student life and even who the mascot of Olin College should be. In one bland moment they chose the latter to be a Phoenix.

“We decided to start at the beginning,” Miller recalled. “We asked: What’s an engineer?”

Well, you don’t want to ask twenty faculty members that kind of question if you’re busy. But they had no strict time limit. “We came up with a list of 2,500 things you need to know to be an engineer. It took two months. The list was posted on a bathroom wall. But it was too unwieldy. The whole thing just collapsed under its own weight.”

So, the group decided to turn the binoculars around and consider the question in reverse. “We simply decided that to a large degree we’re not in the business of producing engineers – that is, to create a product which is consumed by the employers of engineers,” emphasizes Miller.

“We don’t want to be clients of the companies. We view engineering as a vehicle, not as a destination. It’s a way to think of the world, it’s a valid pathway for enlightenment. You don’t have to major in philosophy at a university in order to understand how life works.”

Okay, Olin College of Engineering is not abandoning engineering. Students will have an option of graduating in computer engineering, electrical engineering or mechanical, and will be hired by a company soon after school. But the point is that most students graduating from Olin College will have taken a broadly defined education in general engineering, which includes courses in the liberal arts. This should prepare them to take up any profession or continue graduate studies at a law school or medical school, whatever.

“No one thinks it’s odd that a graduate in law becomes a politician, or an English major turns out to be the CEO of a company. That’s how we want to think of our graduates,” says president Richard Miller. “They don’t have to become engineers. On the contrary.”

### **Olin College**

\* At capacity, the college plans to enroll about 650 students. The inaugural freshman class includes seventy-five students – thirty-eight men and thirty-seven women; fifty-eight white, ten Asian-American, six Hispanic and one African American. From a pool of 664 applicants, the college enrolled twenty-nine student partners last year. From an applicant pool of 536 this year, forty-nine were admitted and thirty-two will enrol.

\* Three degrees will be offered: Electrical/computer engineering, mechanical engineering and a catch-all degree called general engineering.

\*Tuition and campus accommodation is free for all students – a value estimated at 140,000 US dollars for four years.

\*The Olin College Web site can be found at: [www.olin.edu](http://www.olin.edu).



## A SCHOOL FOR THE FUTURE

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Robin Engelhardt, *Research Consortium Math and Science,  
Learning Lab Denmark*

**Can you imagine a school without classrooms, without timetables, without school bells, without school bags, and without a teacher's desk? If not, you must visit *Futurum* in Sweden, a radically new school that combines creative architecture with modern learning and teaching methods.**

**S**tockholm is built on seven islands. The water separating the islands creates natural boundaries which, at least until the 1950s, meant it was common for the citizens to live separately. They kept to their own neighbourhoods without much contact with people from other parts of town, and it was difficult for parents to send their children to schools situated on another island, somewhere across the sluices towards the town centre. This turned out to be very convenient for educational experts when they began to rebuild schools and to experiment with new kinds of educational systems in the 1950s. The differentiated school systems in the northern parts of Stockholm were kept intact, whereas the school system in the south was restructured into comprehensive schools where the students are taught together until the tenth grade.

When school experts evaluated the experiment they were surprised: students from the north and the south performed equally well when examined. But students who were taught at a comprehensive school received better marks in social conduct and were regarded as less egotistical and more cooperatively minded. When the final study was published in 1963, the Ministry of Education

in Sweden did not have any remaining doubts about the benefits of a comprehensive school system. Since the beginning of the 1970s, most students in Sweden have been taught in undivided comprehensive schools. Students are not examined until the tenth grade and they do not risk having to repeat a year. Within a few years of the Swedish implementation, this system was unilaterally introduced in all Scandinavian countries.

### **“The Open School” movement**

In the mid-1990s, yet another revolution began in the Swedish school system. This revolution did not occur on the basis of concrete experiments as it had thirty years earlier. Rather, it was due to the realisation that large amounts of pedagogical knowledge had been developed during the last twenty-five years – but without being used. Also, a variety of new demands for what students should be able to know and do obliged decision-makers to try out other kinds of school systems and to introduce modern teaching methods. Naturally, this was only possible because of a simultaneous political consensus in Sweden that aimed to improve education through the strengthening of local autonomy.

The most prominent school in this regard is Futurum, located in the Håbo district, about 50 kilometres northwest of Stockholm. In many respects, Futurum does not even resemble a school. Built as a collection of detached wooden houses at the outer limits of the small town of Bålsta, the architecture reminds you more of art studios or rebuilt laboratories. High ceilings and plenty of light give the impression of visiting a wooden greenhouse built for the evolution of a new human species. Flexible working conditions and modern educational theories are truly reflected in the whole construction of Futurum.

When you enter the front door of Futurum, the first things you notice are not the usual things. There are no long corridors with shouting children. There are no classrooms with lecterns and desks. There are no school bags. And you don't hear any school bell. What you see is a busy house where students walk around carrying books and equipment. Their minds are occupied with the things they do. They sit in the computer area studying Web sites, they read books about modern art in the corners of the many open study rooms, or they walk and talk about the forthcoming play in the school's theatre.

All rooms are built around a large space that resembles a town square. There is a sculpture and a stage, and the canteen in the middle is arranged invitingly with self-service tables and milk bars. Some of the adjoining rooms are used for woodwork and needlework, others for physics and chemistry experiments. Next door is a fully equipped music studio, from which you can



enter a dressing room overflowing with hundreds of peculiar costumes. There is also a place called Africa with five-metre high palms imported from the Netherlands. Here, the smaller kids normally sit and read picture books. The teachers' room has computers for all and the gym on the ground floor is so big and luxuriously equipped that one automatically asks what it has cost.

### Creating a new learning culture

Even though it was not cheap to create, Bålstå has a school it can be proud of. The physical appearance of Futurum is so different from normal schools that you will have a hard time grasping the implications for the way a school day is organised and the learning methods used. A year ago, when one politician was shown all the outstanding qualities of the rooms, she asked the guide Hans Ahlenius: "That's altogether very nice, but where does the teaching take place?" The answer came promptly: "This *is* teaching!"

"You never meet a child who asks 'What should I do now?'"

In complete contrast to conventional customs in schools, it is not the teacher who talks and walks around. And it is not the teacher who poses the questions. It is the students who are active. They find the things they need to work with, they help each other, they go to the computer desk, to the library, or they ask the teachers for advice. You never meet a child who asks "What should I do now?" The teachers function like advisors and stay quiet as long as they are not needed.

How can this be achieved? Every morning the students meet the team of teachers in their contact group and decide what to do. Together with the teachers, the student settles on the amount of work to be done. Thus, the students are responsible for the planning and carrying out of their own work. Depending on the needs of the student, working hours and subjects are planned as flexibly as possible. Through all ten years at school, the same group of teachers attends to the student, and this creates a close social adult network. Headmaster Gunnar Lundgren explains that this concept of "the small school within the large school" creates an atmosphere of self-government and responsibility. The "small school" is the working unit for the students and it consists of several rooms built around a large central space. There are six "small schools" with about 160 students of all ages in each. Each unit is named after a colour. Sixteen teachers and other personnel are responsible for keeping the unit functioning for up to twelve hours a day due to the older students' flexible hours of attendance. Bullying is an unknown phenomenon.

Without the “*Loggbok*” things would probably not work well. This logbook is individual and follows the student throughout the years. It contains the learning objectives for each week. There are no working hours; there are only working weeks. The students are responsible for recording their work in the logbook. At the end of the week, the student, the parent and the contact teacher sign the book in order to seal the week’s work. For most of the students, the logbook means a great deal of freedom and independence, because they do not need to obey school bells and timetables any more. Only around seventeen hours a week are spent in some kind of class teaching. The rest of the time, the students decide themselves whether they want to improve their French vocabulary, study Swedish or help some of the younger students in their own unit. In addition to this, a lot of combined-age and cross-disciplinary projects add to the diversity of learning styles at Futurum.

### **Supporting individual learning styles**

You might call Futurum an experimental expedition into learning, which has been successful in creating a new school culture. The autonomy given by the state to the local community is here passed on to the teachers and the students. And the result is freedom and responsibility. More importantly, perhaps, the pedagogical principles have been greatly improved. Subjects are not taught as facts. There is no learning by rote. The subjects are always integrated into a

“It might look chaotic.  
But it is creative chaos.”

context and students approach them from a problem-oriented perspective. This means that disciplines such as Swedish, physics, and biology are very often interconnected via an overall theme. “When students begin

to work on a project they run all over the place,” says the physics teacher, Fredrik von Euler, “It might look chaotic. But it is creative chaos.”

When studying electricity, for instance, von Euler’s students do not have to follow standard textbooks that slavishly go through the various ways in which light bulbs and batteries can be arranged in an electrical circuit. Instead, they are asked to answer questions based on a small figure of an electrical arrangement, and to read and present the biography of one of the many famous physicists that contributed to the field, such as Alesandro Volta, Andre Marie Ampere, Georg Simon Ohm, Michael Faraday, etc. This approach automatically strengthens the project-oriented working habits, while also helping individual students to frame their own depths of inquiry and to use their own learning styles.

David Larsson and Rosemarie Wolf, two bright students from the ninth grade who have been given the extra job of guiding visitors around, think this freedom is great: “We can learn things in our own way,” they say. “This helps the good students. But less independent students might need a bit more guidance.” Therefore, they are supervised more frequently by the team of teachers and, if necessary, placed in a support group. The promotion of individual learning styles is integrated into the physical space even down to the careful selection of colour and temperature in the rooms. For example, after a small enquiry among students in the purple unit, David and his mates were granted the right to furnish their own ideal study room. The result was a room that is not too warm, has subdued light, and can be reserved for individual meetings with music by Enya playing in the background. Other purple learning places are called “Milky Way” (light, warm), “Ocean” (dark, cold) and “Lightyard” (light, warm, quiet).

The combination of project work, group work and self-tuition, supported by a well-equipped and caring environment, creates the perfect preconditions for the declared pedagogical goals of Futurum: an atmosphere of security, prosperity, respect for the background, an interest in other people, the development of individual responsibility, and a strong focus on reflection and critical thinking. “Here we have three teachers,” says Gunnar Lundgren. “The first and most important teacher is the child. The second is the teacher and the third is the environment.”

### **Spreading the word**

The story of Futurum is not only a story about educational experts who wanted to try out their ideas in a concrete setting. Rather, it began when the mayor of Bålsta, Søren Andersson, had to renovate the Kvarnback School. Instead of using seven million Euros for the restoration of the old school, Andersson and the town council decided to try something entirely new. They asked Hans Ahlenius and some of his colleagues to do some research into the possibility of creating a “school for the future”. After three years, several council meetings and public discussions, Futurum was built. Today the school is used as a model for the Vibyskolan, Skogsbrynet and Annehill schools in Bålsta. The pedagogical ideas behind these schools are framed by the concept of “School 2000”.

School 2000 regards learning as an active and creative process that is acquired through interaction with other people. Competence development and the growth of social capabilities are an intrinsic part of learning. One of the main

philosophies of the School 2000 approach is that people are different and that each child as well as each adult has individual needs, methods, and approaches to learning. The roll of the teachers is to make individual learning possible through cooperation and guidance. They must be able to listen and follow the ideas put forward by the students. Teaching styles as well as learning styles are individual, and students are actively engaged in planning, carrying out, and following-up the work. Also, the physical milieu is regarded as an active element within all this. Providing a stimulating atmosphere and up-to-date technology creates a flexible and functional working environment for all.

School 2000 has achieved widespread recognition throughout Sweden. Several schools are following the example from Håbo. A rough estimate says that about ten percent of all Swedish schools have started to use the School 2000 approach to learning. In Denmark, the local school in Hellerup, north of Copenhagen, has started a similar project, and there has also been considerable interest in Germany. But whether this new school concept from Sweden will actually change the school systems in European countries depends on many things. Above all, there are huge cultural differences that are not easily changed – and maybe should not be changed. Some countries emphasize competition, others cooperation. Some countries prefer a highly selective and differentiated educational system, while others prefer a comprehensive system. Some countries choose to promote extensive local autonomy, while other countries might not be able or willing to do so.

There can be no doubt about the importance of the educational system to the way children are brought up and shaped in a particular culture. Schools are the mirrors of society. And schoolchildren are their reflection. But they can also become the representatives of another future. Therefore, educational reforms, in whichever direction they go, must be rooted in a clear vision of a future community. In order to succeed, reforms must depart from the preconditions and contexts that already exist in a given society. And they must make the best use of their virtues.

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**La Real Academia de Ciencias Exactas**, The Royal Academy of Exact Sciences, Physics and Natural Sciences was created by the Royal Order of 25th February 1847, and its antecedent is the Madrid Academy of Mathematics, created in 1582. The Academy is composed by 54 full members, 90 national members, several non-fixed suprafull members, and a number of foreign members. It serves as the highest-level forum in Spain for information and discussion concerning the field of Sciences.

**La Consejería de Educación de la Comunidad Autónoma de Madrid**. The Autonomous Community of the Madrid Education Department is the unit that is now responsible for educational competencies. The Spanish Ministry of Education, Culture and Sports had this responsibility before it was transferred to the Autonomous Communities. The Autonomous Community of the Madrid Education Department is an elected body that deals with educational matters in collaboration with other Autonomous Communities and the Spanish Ministry of Education.

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