SCIENCE: PERCEPTION AND PARTICIPATION

edited by Adriana Valente

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…la voix du vieux monsieur changeait sans cesse: tantôt, c'était une belle voix d'homme qu'on eut supposé tout jeune, une de ces voix qui font penser à des lèvres pleines et des belles dents. D'autres fois, c'était une voix de jeune fille, très douce, qui riait et babillait comme une source.

Marguerite Yourcenar,
Comme l'eau qui coule

Summary

SECOND PART
Communication, science and…

Science Communication and Education
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We wish to thank all students participating in the project

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Foreword

Guido Bertolaso

Ever since its institution in 1992, one of the distinctive features of the National Civil Protection Service has been, and still is, the ability to ensure the active participation of the population.

The reason justifying this choice is simple: the national territory is subject to almost all risk categories, both natural and anthropic. Earthquakes, floods, forest fires, volcanic eruptions, landslides and industrial accidents put people, goods and infrastructures at risk. Precisely because these accidents are quite widespread, the national civil protection system must be able to count on everyone's collaboration. Basically, each citizen plays a leading role in this system: he or she must be aware of all the main characteristics of the various hazards and must know how to behave before, during and after a calamity, interacting with the rescue workers in the best possible way.

This far-sighted choice, however, requires a considerable and widespread effort aimed at increasing the population's awareness and common knowledge, especially among young people.

For this reason the Civil Protection Department was enthusiastic about taking part in the training initiative on water crises organized within the *Science Communication and Education* Research Unit, coordinated by the Institute of Research on Population and Social Policy of Italy's National Research Council, and by the British Council, in the framework of the *Ethics and Polemics* initiative, which consisted in a series of debates that focused on particularly controversial science topics, adopting innovative methods to in-

volve the population, especially secondary school students, in order to obtain the public's participation.

Indeed, we believe that a clear and exhaustive understanding of the causes and mechanisms that trigger natural calamities and anthropic accidents is indispensable to convince citizens to consciously adopt the most appropriate prevention measures and behaviour.

From this point of view water crises can be considered to stand midway between a natural and an anthropic 'hazard', given that the scarcity of water is more often caused not so much from a physical lack of the resource but from significant managerial and/or infrastructural inadequacies. Another of the causes determining water crises lies in the considerable and widespread waste of water, which could be reduced through rationalization and water saving measures. Moreover, the topics of drought prevention and resource management offer many cues to this debate ranging from the role of climate change to the never ending public/private diatribe regarding the management of water resources to the risk of real water wars.

Thanks to this project, the results of which are collected in this book, hundreds of students were able to understand the causes and original characteristics of the water crisis, and were encouraged to further examine the matter by turning directly to the experts in the sector, consulting qualified sources and, last but not least, getting to know the possible remedies to implement an actual water crises mitigation plan.

I hope this publication will not serve as the final act of an extremely useful social initiative but rather as an encouragement to continue in the same direction with the determination and confidence that are born from positive experience. I would like to thank all those who made it possible and, in particular, my colleagues of the National Research Council and of the British Council, who generously contributed to the success of the project with their commitment and their expertise.

Introduction

Luciano Maiani

In recent years, international studies and surveys on science and technology have shown that many countries are increasingly concerned with the lack of attractiveness that scientific careers have among young people and, generally speaking, with the insufficient diffusion of scientific culture.

We frequently refer to this phenomenon as the crisis of *scientific vocations*, but this label recalls the image of a holy science, as lofty as it is distant from society.

The planning and testing of educational and participative methodologies capable of contrasting this phenomenon can be effective only if it goes hand in hand with the goal of a deeper knowledge of the phenomenon itself, starting from teaching and communication aspects and influencing, in the imagination of each young person, the *social significance* of his or her professional choice.

The *Perception and Awareness of Science – Ethics and Polemics* Project of the *Communication of Science and Education* Research Unit, which includes the Irpps, Ceris and Irea institutes of the Cnr, was based on these premises and this book presents both the activities carried out to improve participation in the scientific debate and the results of the surveys on the perception of science and its values in young people between the ages of 11 and 18.

Originally addressed to upper secondary schools, the project was extended to lower secondary school students. Indeed, it is extremely important to intervene promptly in the relationship between young people and science, before it has time to turn sour:

international studies showed that the confidence in one's ability to study mathematics follows a descending curve as one proceeding in schooling.

In order to enable participation in the fascinating aspects of 'science in action', to *get to grips with the concepts*, which goes beyond the traditional 'hands on' method, it was necessary to prepare a complex methodology, which was listed among the best practices of the European project *Research and Education Cooperation*, which selected it out of 160 educational research projects in Europe.

For this purpose, the collaboration between Cnr, British Council and the Civil Protection Department was all-important. I would thus like to thank Guido Bertolaso for having understood the innovative scope of this research and for having supported the project.

Moreover, the presence of the British Council, which has partnered the Cnr for years in the implementation of these activities, enabled the project to be placed in an international context, contributing to create a connection between local aspects, scientific knowledge and global problems.

The Cnr surveys have contributed to debunk all sorts of fallacies, for example that confidence in science is inversely proportionate to the concern about the use of the applications of scientific and technological research and to relative risk perception.

At the same time, apparent contradictions were highlighted in the image of science as a profession: the social usefulness of scientists and doctors, for example, is very widely perceived, while their social prestige is considered very low.

Finally, the surveys produced some results, supported by the time series on which the data is based, which lead us to believe that, considering the influence of social and family variables, those who have had a sound schooling in science see themselves more readily as future scientists, despite the fact of being aware of the low earning potential in Italy in the research sector.

Of course, the young people and students' universe is not a homogeneous and stable whole, therefore it is important to try to understand the image that different groups and types of young people have of science, by also employing multivariate statistical techniques of data analysis.

The results of the surveys presented show that answers are

never easy, implicit or final, and must be stubbornly sought in the theories and practices of the various social systems.

For this reason, in the second part, the book opens up to the scientific community as a whole, to those who, within universities and research labs, in the media, in public and private institutions, interact with *communication and science*. Each author was asked for short considerations on the topic added with a third keyword, expression of the experience that he or she has matured and as a contribution to further the debate on science and society.

The result is a fascinating journey, divided among the three topics of *ethics*, *media* and *education*, in which doubts and certainties on science communication are revealed and recalled, such as the struggle between knowledge transfer and participation practices, between guarantee of authoritativeness and search for an active involvement, between commitment, fun and constructive challenge.

FIRST PART

Participation and images of science in secondary schools

1. The scientific debate on the water crisis in schools. Introductions

Ethics and Polemics: the UK and Italy face to face

Susan Costantini

Science matters to every single one of us. It affects our everyday lives in thousands of different ways, and the scientific advances of today will shape how our lives change in the future. Climate change affects all generations but it is young people who will inherit the impacts of climate change for many decades to come.

The British Council has offices in 110 countries and has been running education programmes for young people for many decades and so is uniquely positioned to help tackle climate change. We have made it one of our three strategic priorities advancing the climate change debate through programmes such as the global *ZeroCarbonCity* campaign, the touring photographic exhibition *NorthSouthEastWest*, the *Greening Cities International Student Summit* and now with a new programme of activities called simply *Climate Change*.

Ethics and Polemics, conceived with Italy's National Research Council, has been an important programme in engaging young people to focus on key controversial issues from society's and the citizen's perspective. The fact that the last two debates covered two important 'green' issues: the impact of climate change on cities and

the disastrous consequences of drought and flooding, is an example of our commitment to build understanding of and action on climate change, involving young people.

On a personal note it has been a great pleasure working together with Adriana Valente and her colleagues on this rewarding project. A few of the many highlights include the unusual moderating technique of UK television presenter, writer and newspaper columnist Vivienne Parry and the image of her striding down from the conference platform and thrusting her microphone at various members of a startled audience, demanding their opinions on ethical issues; carrots and cucumbers covered in colourful condoms presented by some enthusiastic activists during the GMO debate; Anthony Barker and his electro-magnetic stimulating machine and the face of the student on whom he was demonstrating during the "Electrosmog" debate; hundreds of students crowding into the Naples' Science Museum to meet the Italian astronaut Umberto Guidoni during our debate on the ethics of space research; Rome's students putting their environmental councillor on the spot with their questions on local policies or lack of them, and finally the inspirational speech by Guido Bertolaso, Head of the Italian Civil Protection Department, regarding water shortage and the effects we could be facing in the very near future if we continue to ignore the problem.

Science and society in *Ethics and Polemics*

Adriana Valente

The results and observations achieved by the *Perception and Awareness of Science – Ethics and Polemics* Project in the last two years and collected in the first part of this book, bear witness to the activities of our research group[1] aimed at *encouraging and observing* the encounter between a society and a science which are both 'complex' (Funtowicz, Ravetz, 1999) and in continuous evolution (Latour, 1998).

What is *complex* need not be considered also or necessarily *difficult* or *distant*: complexity implies a wealth and articulation of points of view, which are vital elements of the social debate and, above all, catalyse the debate among scientists. Yet, there is no trace of complexity in text books (Caravita *et al.*, 2008) and young people are presented with a watered-down version of science, lacking its dynamic, conflicting components, or even with science in pills, removed from its original context and with no reference to its application or multidisciplinary aspects.

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[1] The institutes Irpps (co-ordinator), Ceris and Irea of the Italian National Research Council, the British Council and the Italian Civil Protection Department are partners of the Project *Perception and Awareness of Science – Ethics and Polemics*. This is a project of the Cnr Research Unit *Science Communication and Education*, http://www.irpps.cnr.it/com_sci/. From this website it is also possible to download the book *La scienza dagli esperti ai giovani e ritorno / Science: from specialists to students and back again*, ed. A. Valente, Roma, 2006, that includes the results of the first years of the project activity in the fields of GMO, "Electrosmog" and Space exploration, in the schools of Bologna, Naples and Rome.

Bringing into schools the wealth and articulation of the scientific debate, including the «unavoidable uncertainty» (Trench, 2008) of science, which is the foundation and fuel of the scientific method (Falchetti, 2007), in order to encourage a process of study, participation and exchange of opinions between young people and experts was the main goal of the *Perception and Awareness of Science – Ethics and Polemics* Project. The process was based on the creation of study and discussion groups in the lower and higher secondary schools of Rome and Milan and on the organisation of a round table and a conference including a political debate, with parallel events in each of the cities involved. During these events, students, experts and their audience exchange ideas on the central topics of the scientific debate on the water crisis and on climate change, on the economic, social, environmental and ethical consequences.

Creating spaces and establishing processes to *encourage* and enhance the meeting and exchange of opinions between science and society is something like building arenas, in the sense indicated by Bonneuil, Joly and Marris, of «sites where individual and collective actors interact to define the cognitive and normative dimension of a problem» (Bonnueil *et al.*, 2008).

In these sites, in these communication arenas, researchers, teachers, tutors, students and experts are all part of the process of change, and the site itself is modified through collective contributions. This is why the methodology[2] followed by the project over the years has always distanced itself from the original design carried out in the year 2000 and is more and more oriented to enhancing the participative aspects described in the second chapter of the book.

In carrying out a further study on the issues connected to the water crisis we began with the infinitely small, the tacit knowledge of each student on the topic, to arrive at the international debate

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[2] The methodology of the *Perception and Awareness of Science – Ethics and Polemics* Project was selected and included as one of the two Italian Best Practices by the European *Form-it Take Part in Research* Project, which analysed 160 research and education cooperation projects (REC), with the aim of «creating a set of quality criteria and guidelines to carry out research and education cooperation projects and to produce policy documents for decision-makers».

with Italian and British experts. The core of the process is the study of the scientific documentation selected by the Cnr (described by Luciana Libutti in the *Information and education* essay); indeed, participation cannot do without commitment, and the logic of understanding can be overcome only by integrating it into the new science communication models (Valente, 2006), taking note of the «simultaneous coexistence of different patterns of communication» (Bucchi, 2008).

A strong motivating force for students in their journey to gain an opportunity to take part in the scientific debate was the institutional collaboration with the experts of the Italian Civil Protection Department, who assisted the teachers as tutors in the study stages and in paving the way for a first debate with the classrooms.

The project's attempt to propose and test various communication models was combined with the intent to *observe* the situation in which the work was being carried out, in view of better understanding it and increasing the awareness of all participants: to this end, two questionnaires to check the perception of the water crisis and the understanding of the values of science were given at the beginning and at the end of the communication and training process.

The approach and main results of this survey are described in the third chapter of the book.

The comparison between the answers given in the first and second questionnaires enabled us to assess the efficacy of this process, as well as young people's degree of reflection, permeability and interest in the water crisis problem and in science in general.

During the course of the *Perception and Awareness of Science – Ethics and Polemics* Project, questions had to be confronted that seemed taken for granted but which cyclically came up in the educational debate: why must science be taught and what kind of science should be taught.

It is on the basis of these topics that the studies on science communication are joined by those on scientific education. Steven Turner, in «a tale of two research fields» (Turner, 2008), explains how the two fields of study are starting to interact feverishly, also involving ethical, technological, pedagogic and cultural issues that, all things considered, refer to the role or, better, to the roles of science in our society.

An overview of the range of issues at stake is presented in the second part of the book, which opens out to contributions and experiences outside of our research group in a few crucial contexts: ethics, media and education. Of course, not even these frameworks can complete the «mosaic of arenas» (Hilgartner, Bosk, 1988) of which the public space is made up, but they certainly give us a glimpse of the intricate design that is at their basis.

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Information and education

Luciana Libutti

Today's young people are more motivated when they have to solve problems connected to the real world, since they prefer acting to listening. We tried to take this into account in our *Science Communication and Education* Project, in which young people from different high schools approached a series of controversial problems involving current scientific topics with a significant social impact.

A series of controversial topics were tackled during the course of the project, such as GMOs, environmental pollution in big cities and, last but not least, the 'water crisis'. The choice fell on the latter, given the urgent nature of this phenomenon throughout Europe, where raising the population's awareness and obtaining their contribution is fundamental. Moreover, since it is a complex, controversial topic with powerful social consequences, it was well attuned to the spirit and aims of the Cnr project. As a confirmation of this we can quote the following passage from the Italian Civil Protection Department article: «Tackling a complex, interdisciplinary topic such as the water crisis will require the individual and collective adoption of new forms of behaviour that will have a better chance of being accepted if shared on the basis of clear, detailed and scientifically grounded information».

The students who took part in the project gathered information on the debate topic from a selection of sources made available by the Cnr, the British Council and Italian Civil Protection Department. The material brought to the young people's attention came

from various public and private institutions, research centres and consumer associations. Keeping in mind that these kinds of topics involve multiple points of view, methods and analyses, as well as environmental, social and ethical consequences, in choosing the documentation divergent points of view, elements of uncertainty, differences in scientific sensibilities and the various pros and cons surrounding the issue were taken into account. All sources were screened for quality, pluralism and international relevance (Libutti, Valente, 2005).

Teachers were there to guide these young people along the way and help them, first of all, to become aware of the problem, improve the quality of their questions and integrate the material supplied with their own research. The youngsters were urged to compare and assess the information retrieved, considering the different contexts in which it was produced and rejecting what they did not consider reputable. Finally, they were encouraged to express themselves in new ways when making their proposals.

The correct use of information and communication technologies aims at teaching young people to plan and follow their research appropriately, both at the information stage, i.e. when retrieving the sources, and at the dissemination stage, i.e. through their proposals.

The students also used multimedia tools when they presented their proposals to the water crisis experts, proving they were in step with the times and capable of expressing themselves in ways other than the traditional ones.

The aim of the methodology used by the Cnr to retrieve sources was to teach youngsters to develop a real information culture in order to approach science topics correctly. It is important that young people understand that there may be several different solutions to the same problem, and that every solution has to be put into the historical context that produced it. They also need to grasp that there may not be a solution to a problem, or that the solutions may be worse than the problem itself. Asking questions becomes more important than giving answers.

Education and awareness-building are essential steps in the process of attracting young people to the world of science. Through participation, knowledge and the effective delivery of information,

young people can become informed and active participants in a process to which they feel they belong.

It is vitally important to ensure that schools offer suitable learning environments and provide innovative teaching techniques to encourage students to explore the social dimensions of the scientific issues they are dealing with, ask questions, explore, collate experiences and form individual and group opinions. In this way, their science studies can be imbued with a new significance.

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The water crisis

Andrea Duro, Giacomo Losavio

Water crises have become one of the most significant environmental problems affecting our planet. Drought, water wars, desertification, water privatization etc. are quite common topics of discussion these days; an issue spoken of either in a tragic or oversimplified fashion.

Without claiming to be exhaustive, in this short paper we would like to make a few considerations on this topic and on the causes and factors that have made things worse, providing at the same time some indications on the possible approaches aimed at forecasting and preventing this risk.

Water is an essential resource for all human activities and ecosystems, and is a precious asset not only because it is limited but also and especially because it is not easily or equally accessible to all. Indeed, globally, water scarcity or deficiency, i.e. the imbalance between water supply and demand, is caused not so much and not only by the physical lack of this resource, which is a problem affecting a few 'extreme' territorial contexts (such as Sub-Saharan Africa), but also by the scarcity of available economic resources, by the inadequacy of water plants, by abuses of power and inequalities. The 2006 Report of the United Nations Development Programme (UNDP) showed that water deficiency is mainly a prerogative of poor countries with high political instability and strong power imbalances. Moreover, in a perverse retroactive process, the scarcity of water slows down economic development and contributes to exacerbating social tensions.

Indeed, water crises, which are not normally the main or exclusive cause of real 'water wars' between entire nations, nevertheless contribute to increasing tension between nations and/or social groups in regions that are already unstable (for example the Middle East and the Indian subcontinent), as shown by the accurate chronology compiled by the Pacific Institute (Gleick, 2006). In most of the conflicts between different nations (for instance Syria and Israel), water crises can be considered an additional cause of the disputes rather than its exclusive source.

Even a topic such as climate change, a recurring issue in the news, must be clarified: although we can't underestimate the risk of an alteration of the water cycle, and in particular of the increase in evaporation following an increase in temperatures (European Environment Agency, 2007; IPCC, 2007; Gautier, 2008), it must be acknowledged that imbalances between availability and demand, which begin to appear even in territories where water has always been abundant, today originate not so much from the change in water parameters as a consequence of climate change, but from conflicts in the use of this resource, delays and infrastructural deficiencies, managerial inadequacy, etc.

Italy may help shed some light in this respect, since it is the case of a country that has been able to build its fortune precisely on the abundance of this resource, as shown by last century's rapid and massive industrialization process, which was especially based on the exploitation of the so-called 'white gold' for hydroelectric production, mostly through the creation of hydroelectric basins and dam-controlled lakes in the Alpine and pre-Alpine mountain ranges. However, in the last few years, both in the North and in the South of Italy, the population and the various manufacturing sectors have had to face ever more frequent droughts and water crises, even in areas that had rarely suffered these problems previously. Suffice it to think of the recent water crises that have hit the Po basin and in particular the area of the major dam-controlled pre-Alpine lakes (Lake Maggiore, Lake Como, Lake Garda and Lake Iseo) where water has always been abundant.

The coexistence of various uses and the subsequent emergence of conflicts between the various sectors (agricultural, energetic, hydro-potable and industrial), as well as the impact of the legisla-

tion on minimum vital flow have highlighted the contradictions in the existing approach and, in particular, in the allocation of water resources, which has often ignored the complexity of the system, its impact on the territory and the consequences of our country's water and energy policy (Giupponi, Fassio, 2007).

Despite the unquestionable progress achieved during the past century, the Italian water sector continues to be plagued by many weaknesses: unequal distribution of the resource, infrastructure backwardness, high losses from the network, high managerial fragmentation, lack of wastewater treatment plants, considerable waste, etc.

In short, at least as far as the national territory is concerned, water crises are mostly caused by the difficulty in accessing water rather than by actual resource deficiencies. Moreover, infrastructural and managerial inadequacies have also been caused by significant planning failures, scarcity of available public funds (further sharpened by the country's ongoing public finance crisis that began in the 1990s) and water tariff/billing revenues that are among the lowest in Europe (Massarutto, 2008).

Lawmakers tried to redress this chaotic situation by introducing the so-called 'Galli Act' of 1994, which laid the groundwork for the industrialization and 'privatization' of the sector, and envisaged a clear-cut separation of roles between direction and monitoring activities, which are of public competence, and the more strictly managerial functions which could be assigned to private subjects. The implementation of the Galli Act, however, brought considerable difficulties to the forefront, mostly linked to the low economic 'appeal' of a sector, such as the water one, which has reduced profitability margins, especially if compared with other much more profitable sectors (gas, energy and telecommunications). Therefore, even though with the necessary caution, it will be indispensable to raise tariffs/billing costs (Gilardoni, Marangoni, 2004; Robotti, 2004). One of the effects of this will also be a reduction in waste and a decrease in consumption, in the wake of what happened in Germany and France, where high billing forced users to reduce consumption. In Italy, on the contrary, the current billing system does not seem to encourage sustainable consumption with the goal of saving water.

Moreover, the public's manifest reluctance to accept the 'privati-

zation' of an asset of high symbolic and cultural value such as water, even though by means of concession contracts, further reduces the appeal of the water sector in the industrial world's eyes. Although the concession system makes it contradictory to speak of a real 'privatization' (water remains publicly owned), however the complexities connected to the presence, in some cases, of concession systems that are inconsistent with the ecological needs of water companies and with the ordinary criteria of economic equity cannot be overlooked. Therefore, it will be necessary to accurately review the procedures and terms of existing concessions, especially in the light of the general deterioration of water ecosystems and of the emergence of new requirements, uses and lifestyles that have radically changed the framework of water availability over the years, making it necessary to completely rethink intended use, priorities and restrictions.

At a European level, the year 2000 Water Framework Directive was the first to introduce new paradigms in water use, breaking old-fashioned conceptual schemes and contributing to the promotion of a new water culture, more oriented towards conservation and saving. One of the most significant innovations of the new European regulations, establishing a framework for community action on water, was the adoption of an eco-systemic approach to the management and protection of water resources, promoting the sustainable use and long-term conservation of water as well as preventing and reducing the pollution of water basins. The framework directive also stressfully reiterates the European cardinal rules of 'user pays' and 'polluter pays', prepares the ground for a participated management of water resources and promotes water saving and waste reduction as instruments aimed at sustainable water usage.

Today water conservation is precisely one of the most innovative cornerstones of the framework directive: indeed, if, up to a few decades ago, the growth in water demand was almost exclusively dealt with by creating new and ever more complex hydraulic plants to collect, regulate and transport water (the so-called 'hydraulic structuralism'), more recently we have become aware that it is necessary to prioritize the improvement of the existing water systems rather than create new infrastructures and, especially, to address our efforts towards an efficient management of the water demand.

From this point of view, the inadequacy of traditional techniques and trends concerning such a complex and inter-departmental issue as the water crisis has emphasized the need for a profound innovation to be implemented as soon as possible, not just from the technical point of view but also from the institutional, normative and managerial ones (Pereira *et al.*, 2002; Figuères *et al.*, 2003; Cech, 2005). From the technical point of view the most significant innovations can be ascribed to the widespread trend towards the improvement of water efficiency (particularly in agriculture), saving, recycling and reuse, also by revisiting such good practices as, for example, the techniques collectively known as water harvesting, aimed at collecting and reusing water, for instance by gathering it from the roofs of buildings, accumulating rainwater, etc. (Rossi, 2005). Other non-conventional techniques such as wastewater treatment, desalinization and the recycling/reuse of water have also been boosted in these last few years following an increased environmental awareness.

As previously mentioned, from the economic and managerial point of view it will be necessary to review the current tariff/billing systems, particularly in agriculture, keeping in mind that, for the most part, the use of water for irrigation purposes is considerable and water is billed at a flat rate, not based on actual consumption, as would be advisable in order to encourage greater savings.

From the cultural point of view and in order for the importance of water conservation and saving to be fully understood by the users, it will be necessary to continue the process of building the population's awareness and knowledge, which we hope can also be an integral part of the environmental education addressed to all students, starting from elementary school. Dealing with a complex and interdisciplinary issue such as the water crisis one requires the adoption of an individual and collective new kind of behaviour, that is more likely to be accepted if shared on the basis of clear, detailed and scientifically sound information. Furthermore for those responsible of carrying out institutional tasks involving decision making, also on the basis of complex technical contents, the need to communicate one's choices is clearly of utmost importance, if necessary turning to experts and clarifying the reasons for those approaches and decisions which may even be unpopular.

Within this context, if, on the one hand, the role of the state and, more in general, of the public authority, appears irreplaceable, as the only subject capable of mediating between the various and often contrasting interests of the territorial situation and of the manufacturing sectors involved, on the other hand the importance of the active role of the clients (industrial, irrigation, etc.) and of the population is confirmed. Indeed, by changing their habits in a 'virtuous' sense, they can give an important contribution to the conservation of our water heritage and, in particular, to the prevention of water crises.

To this end one of the most characteristic elements of droughts and water crises is represented by the phenomenon's dynamics, which unlike many other natural calamities (earthquakes, volcanic eruptions, floods, etc.) often develop over very long timeframes, in the order of months or years: that is, a prolonged period of hydrological deficit is necessary for drought to manifest all its effects. In general there is sufficient time to prepare the indispensable prevention and mitigation measures; however, the approach can more frequently be considered of a 'reactive' type, that is, contrasting measures are taken only after the emergency is already in progress.

A strategy that has proven to be undoubtedly more effective is the so-called 'proactive' one (Rossi *et al.*, 2007), based on identifying and arranging preventive measures and interventions before the advent of the critical situation. This proactive approach is based on the accurate monitoring of water availability and long-term needs (necessary for the assessment of the water crisis risk), on a rough estimate of the impacts and on the drafting of a plan of long-term prevention measures (to reduce vulnerability). In the short and medium term the monitoring of the hydro-meteorological variables (rain, temperature, etc.) and of the available water resources enables a warning and/or alert of a water crisis to be issued in due time, while at the same time preparing and, if necessary, implementing a plan of contingent short-term measures (distribution of water by means of water tankers or water sacks, reduction of supplies, awareness building campaigns, etc.).

On the one hand the proactive approach guarantees a cushioning effect of the crisis encountered during the emergency stage, and on the other can prevent the insurgence of the phenomenon it-

self, at least in its extreme forms. Obviously, implementing a strategy that entails the constant monitoring of the phenomenon and the adoption of policies aimed at reducing the causes, and not only aimed at an emergency-type management requires greater effort but yields far more satisfactory results.

The National Civil Protection Service is actively engaged in implementing this project: in particular, the Italian Civil Protection Department, together with the Regions, has promoted and implemented a network of centres responsible for the assessment of expected and/or ongoing risk scenarios, named Centres for Forecasting and Surveillance of Effects (CFSEs), which collect, process and analyze meteorological and hydrological data etc., model and monitor events and consequent effects, in order to issue warnings to prevent and deal with different emergencies in real time, not only hydro-geological and hydraulic ones. In other words, these technical assessment activities are carried out by sharing data, information and knowledge among state, regional and local components, both public and private, present in the national civil protection system, according to a typical 'networked' collaboration model fully in line with the institutional architecture put in place by the reform of Title V of the Constitution. The role of the network of CFSEs also includes the monitoring and assessment in real time of hydro-meteorological variables and of the availability present in surface and below bodies of water, in order to warn and/or alert competent authorities of a water crisis.

This demanding but also very exciting challenge sees the involvement, besides the network of CFSEs, of Ministers, Prefectures, Regions, Basin Authorities, Local Authorities, Agencies and public and private enterprises, Research Centres, etc. The exchange of data and information among all these subjects has grown significantly in the last few years and a large amount of knowledge on water bodies/companies and on the catchment infrastructure, regulation and transportation has been streamlined. However, there is still a lot of progress to be made and, as of today, in many cases the data on withdrawal rates, influxes, losses and even on availability is not sufficient or adequately updated whereas it should be in order to recognize promptly and fight the beginning of a water crisis: one of the most important branches of activity consists precisely in

identifying at best the 'risk thresholds' (such as, for example, reservoir volumes or well flows) and the relative critical scenarios for manufacturing systems and for users. Reaching such thresholds and the relative critical scenarios can be associated with specific stages of the emergency plans, centered on actions and/or mitigation interventions (i.e. alternative water supplies, shifts, reduction in non essential use, etc.).

It is clear from the above that forecasting and preventing water crises should be based on the skilful integration of long- and short-term measures. In the first case the measures are aimed at increasing the 'resilience' of the water system *vis-à-vis* the crisis, i.e. to reduce the degree of vulnerability of water supply systems; on the contrary, short-term measures are mostly aimed at mitigating the impact of water crises in the various sectors involved. It is a very complex challenge, requiring considerable effort (at the institutional, organizational, technical and managerial level) and also the ability to identify innovative solutions where traditional methods and techniques have proved inadequate.

However, the most significant contribution towards water crisis prevention must stem from a profound, widespread and lasting reconsideration of the value of water as an asset, from the most diverse points of view: social, environmental, economic etc. This is the only way in which it will be possible to consciously adopt approaches, choices and behaviours, aimed at protecting our most precious asset.

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2. School and participation

From the Metaplan to the Open Space Technology: integrating a participated process in schools

Adriana Valente

Encouraging the participation of non experts and, in particular, of students in the scientific debate is the main contribution of the *Perception and Awareness of Science – Ethics and Polemics* Project to the «participatory turn» (Jasanoff, 2003; Lengwiler, 2008) that has characterised the evolution of studies on science in the last few years.

The entire course of our project was designed in view of this participative goal and of the preconditions to implement it. However, over the years, as the testing of the project in the secondary schools of several Italian cities progressed, after reflecting on it and on the cues that emerged from schools and research, we also tried to encourage the adoption of further, specific participative practices in the individual stages of the project.

Several participative practices were conceived through international practices[1]. The main problem consists in adapting and including one or more of these practices in a process that is consistent with the project's requirements and general methodology, and enhancing its goals.

To this end, first of all we identified the trickiest stages of the

[1] An overview of the main participative methodologies may be found at the Cipast website: http://www.cipast.org/cipast.php?section=1017.

Ethics and Polemics Project: the initial ones and the final ones. Indeed, right from the beginning it is necessary for each student to feel that his or her knowledge and intelligence are integral parts of the project's process and that in it he or she will encounter important new information but will also recognise parts of him or herself.

For this reason, on the occasion of the activities on Climate Change, seminars based on the Metaplan methodology were organised in a limited number of classrooms already in 2006. Why was the Metaplan chosen? In a nutshell: because it presupposes the existence of tacit knowledge and because it enables the alternation of moments of individual reflection with exchanges of ideas within groups. The *experiment* was led by Michela Mayer with the collaboration of Prof. Angela Fanti of "Francesco d'Assisi" scientific high school in Rome. The testing convinced us (researchers, students and teachers) and we permanently included it in the project's methodology, presenting it again a year later to all the classrooms of the schools in Rome and Milan.

Moreover, we took many other issues into consideration, also related to the project's final stages, and, in particular, to the possibility of ending it with a participated agenda autonomously created by male and female students. But we also wondered how to assess the teachers' point of view on the aspects of the didactics connected to the implementation of participated projects in schools, beyond the simple filling out of an evaluation sheet. Elena Del Grosso and I thus used an opportunely modified version[2] of Open Space Technology for both needs.

Between the two stages described, the pathways that had been predefined by the researchers were joined by other, spontaneous ones, autonomously conceived by schools or student groups. We

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[2] Changes concerned different aspects for the teachers' and students' OST. In both cases, in view of obtaining a result in the short time available for the seminars, it was decided to propose to all the groups to draft the final *instant report* following a predefined format (although the groups could choose not to follow it). The following took part in the teacher's OST: Grazia Maria Bertini, Sara Sidoretti (LC "Virgilio"), Daniela Donisi, Alessandro Freddo (ITIS "Leonardo Da Vinci" sez. Agraria Maccarese), Silvia Garibotti (IPSIA "Cattaneo"), Francesca Sartogo, Cesare Vettucci (ITIS "Enrico Fermi").

consider this another good example of participation. Precisely because these activities are self-defined and self-managed, we were not faced with a number of identical initiatives: many of the students involved, often guided by their teachers, improved the scientific documentation provided by the Cnr by creating multimedia presentations and clips, short essays and reports, and taking advantage of the project to become familiar with a culture of information. We cannot describe them all. Part of the material can be found on our website[3] (conceived by students of the following high schools: LC "Virgilio", IT "Fermi", IT "Da Vinci", LC "Giulio Cesare", LS "Plinio Seniore" and IPSIA "Cattaneo"), but I will leave it to Luciana Libutti to speak about the importance of these aspects in the educational process.

Other groups spontaneously organised meetings and seminars. This year, in particular, the students of two schools involved in the project, the IPSIA "Cattaneo" in Rome and the Istituto "Rinascita" in Milan, after taking part in the round table and public debate organised by the project with national and international experts on the Water Crisis, planned and held a conference on the same topic, in which they played both the roles of audience and speakers. I was able to take part in the conference of the IPSIA "Cattaneo" in Rome, and was satisfied and amused by the good combination of seriousness and irony attained by the students. Further on in the book, Alba L'Astorina's contribution relates the experience of the younger students of the Istituto "Rinascita" in Milan.

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Expressing oneself in order to participate: tacit knowledge, learning and the Metaplan

Michela Mayer, Adriana Valente

The Metaplan: why and how should it be used in schools?

The Metaplan is a «task-oriented method of organisational analysis» that was conceived in Germany for corporate training (it is not by coincidence that it is also a trademark), with the aim of streamlining communication flows within enterprises and involving in change planning those people who will then implement it.

The Metaplan presupposes prior knowledge and different practices and interests corresponding to the various roles within a company, and that this knowledge and these interests can be joined to work out an acceptable approach to change that is also desirable for most of the people involved.

The techniques suggested by the Metaplan, which alternate individual moments, activities involving small groups and ones involving the entire group with the visualisation of collective knowledge-building processes, encourage communication flows, try to minimise unfocused discussions, and, when properly managed, stimulate and strengthen the creative process, making each person feel he or she has contributed constructively to the final solution/proposal.

It is easy to recognise the validity of this type of technique not only within a company but within a territory every time it

is necessary to involve the 'stakeholders' in collective decisions requiring organisational and individual changes: local Agenda 21 programmes have used the Metaplan widely and still do, in conjunction with other participative techniques (EASW[1], OST, etc.). However, in the case of enterprises and territory, the goal is to arrive at an 'action proposal', not the knowledge-building process necessary for that action to be effectively understood and shared by all.

Applying this methodology to schools thus implies changing points of view: the main goal is no longer the action but the knowledge acquired during the process which, at least in our experience, does not require a final action (this does not mean that the Metaplan cannot also be used for its original goal, that is, to arrive at proposals for change that are shared by the school organisation). The starting hypothesis is that, through participation techniques of which the Metaplan and the OST are examples, schools can once again become aware of the social and collective nature of knowledge building, which is often limited to an individual process that is, at best, guided and stimulated by the teacher and even more so as the school level increases.

Another difference in the 'school' use of the Metaplan, compared to its ordinary use, is the 'non heterogeneity' of the participants: indeed, that diversity – of experiences, of practiced theories and of roles – which greatly enriches the process when it is carried out in a company or in a territory is lacking when the technique is used in schools, and even more so in classrooms, where we are faced with considerable standardisation in terms of age, role and cultural and social background (which in Italy schools is strongly determined by the school's location and course of studies).

Therefore the Metaplan has also been used to achieve new goals, originally not considered in the project:

- One of the first was to rouse interest in the suggested topic,

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[1] EASW, European Awareness Scenario Workshop, is a method born in Denmark and aimed at finding an agreement among the various groups of interest bearers in a local framework.

causing elements of uncertainty and debate to emerge even before the documentation was distributed: the goal was thus to pave the way for the next step in the process;

- This first goal was quickly joined by a second one, linked to 'citizenship' competences and to the possibility of using the technique to develop dialogue and reasoning skills;
- The first test of the technique, carried out at the "Francesco d'Assisi" High School in 2006, also highlighted the possibility of using the Metaplan to better understand dynamics – among groups but also among the sexes – and to hone skills that are often not taken into consideration by traditional learning-teaching processes: the role of facilitator in the group, for example, or communication skills using visual tools. A reflection on the roles that the students adopted during the testing of the technique, and on those that they 'usually played in class', clearly showed how school tends to pigeonhole and crystallise roles and skills by presenting the same tasks time and time again, while the Metaplan managed to mobilise a different kind of competences;
- Finally, a central research objective emerged concerning the knowledge-building process and, in particular, the mobilisation of 'tacit' and implicit individual knowledge to implement a spiral process leading to new forms of knowledge, both tacit and explicit, both as individuals and as a group, as we shall explain better later.

The Metaplan was therefore proposed in 2007 to all the classrooms that took part in the project. The researchers' main aim was to follow the collective knowledge-building process, obviously without neglecting the other goals necessary for the project's implementation: encouragement and motivation, skill improvement, and introduction to democratic participation in debates and decisions.

The following diagram, proposed for the school version of the Metaplan, is a simplification of the original diagram (which envisages several divisions into microgroups and reunifications into wider groups, above all to enhance the differences).

Diagram of the Metaplan sessions that took part in schools

N.	Stage	Duration (min)	Goals	Activities
1	Presentation of the activity and of the methodology to follow	5	Sharing the aims and understanding the reasons of the requests that will be made	The research group introduces itself, socialises and explains the stages to follow
2	Organisation of groups and spaces	5	Offering an adequate context for the work to be carried out	Teacher/ facilitator divides the youngsters into groups of 8/10 students, around a table/ desks, with a poster available
3	Production of 5 individual ideas on the sentence suggested as a stimulus	15	Focusing attention on the topic suggested. Rendering tacit knowledge explicit	The participants write their ideas on post-it notes
4	Collection of individual inputs and organisation of collected ideas	20	Comparing explicit knowledge, rendering other tacit knowledge explicit in the group debate	The participants attach their post-it notes to the posters divided by subjects and a coordinator is chosen
5	Selection of the most relevant ideas	20	Implementing a debate on the basis of shared knowledge	Each participant votes by choosing the ideas he or she agrees with
6	Organisation of the results to present them to the whole group	30 + 5xN	Rediscussing the knowledge made explicit and its links also in view of "communication"	The groups prepare a final product that they then present in a plenary session (5 minutes per group)

Metaplan, cooperative learning and key competences

When the Metaplan is employed in schools, mainly to motivate and encourage learning, it can be included in the processes of cooperative learning. When we speak of 'cooperative learning' we refer to «a vast educational movement which, although starting from different theoretical viewpoints, applies particular cooperation techniques to classroom learning» (Midoro, 1994).

M. Comoglio defines 'cooperative learning' (1996) as

> A method of class management that involves the students' resources in the learning process. Hence, it is different from traditional methods that aim at increasing the quality of the teacher's didactic and content knowledge and extending it.

As in the Metaplan methodology, cooperative learning envisages the students undertaking responsibilities in a process that is not guided but 'facilitated' and in which interacting with others is fundamental. This kind of process has a good chance of inducing 'autonomous, significant learning' in the sense suggested by Rogers (1978):

> When a school develops an education system centred on the person, in a climate that encourages growth, learning goes deeper, proceeds more rapidly and extends to the life and behaviour of the student more than education acquired in a traditional classroom. This happens because the direction is self-chosen, education is self-established and the entire person invests feelings and passion in the process at the same time as intellect.

Cooperative learning is organised around complex tasks that 'challenge' individual students and groups. The Metaplan is a technique that enables this challenge to be introduced gently. The task is progressively accepted, sharing with group members happens gradually – criticism is not allowed during the first sharing of ideas criticism, only requests for clarification are – and everyone is given the chance to their own opinion, both rendering their own tacit knowledge explicit and undertaking the task of restructuring ideas within the group.

The Metaplan technique thus enables those skills defined by Comoglio (1998) to be put in practice and developed as «a series of

motivated and cognitively controlled behaviours that enable a person to start, develop, maintain and effectively implement a good relationship with the others, ensuring he or she is well inserted in the surrounding environment». Social skills are usually neglected by schools, which take them for granted or entrust them to family and society (in Italy more so than in other countries). In actual fact it is extremely necessary to learn these skills, possibly precisely in a protected context, and among one's peers, such as schools can offer. Indeed, these are interpersonal communication skills, leadership skills, problem solving skills, action skills for positive, constructive conflict management, decision-making skills, all competences that society requires and that the Metaplan methodology strengthens. Of course, a Metaplan session is not sufficient to build them but it is certainly sufficient to denounce their absence, the lack of practice with them and the difficulty of considering them as school competences.

These very competences appeared again as part of the key competences in a fundamental research in this field: the OECD DeSeCo project (Rychen and Salganik, 2003; OECD, 2005). Key competences are those necessary and indispensable competences that enable individuals to play an active role in multiple social contexts and to contribute to the success of their lives and to the good functioning of society. One of the three fundamental categories of competences is that of «functioning in socially heterogeneous groups». In this category the focal point is the interaction with the 'other', who is different from oneself, which is considered fundamental for physical and psychological survival. The essential skills of this category are:

- The ability to establish good relationships with others: it enables personal relations to be established, maintained and managed;
- The ability to cooperate: it enables people to work together and aim at a common goal;
- The ability to manage and solve conflicts: it presupposes the acceptance of conflict as an intrinsic aspect of human relations and the adoption of a constructive way of managing and solving it.

The Metaplan thus appears as a useful tool that can be used in schools not just to rouse interest, motivation and participation but

to build social skills and, as we shall see in the next paragraph, cognitive skills as well. But are teachers prepared to use it? Discussing its use outside of the project was not one of our goals, but while all the teachers got involved and seemed very interested, our impression was that they considered the experience as 'exceptional', tied to the project and not capable of being implemented again in the daily practice of teaching.

Metaplan, participation and tacit knowledge

Some of the Metaplan's characteristics, the fact that it is a 'dynamic', 'democratic' technique aimed at visualising the debate (Lauche, 2002) undoubtedly encouraged us to choose this methodology for our communication project which focuses on the very aspects linked to participation. However, another of the Metaplan's characteristics was no less relevant to our chosen goals: even though it is a participative methodology which, by definition, is based on the simultaneous presence of individuals and groups, emphasis is devoted to individual reflection, which is particularly significant precisely in the first stage of the process.

Antinucci pointed out that the learning method we are used to is of the *symbolic-reconstructive* type (Antinucci, 2001) in which symbols are first decoded and then reconstructed in one's mind (interpreting text and language). Unlike the very old learning techniques of the *perceptive-motor* type, *symbolic-reconstructive* learning has a minimal exchange with the exterior: moreover, this exchange ends in the initial input. But is the initial stage the one in which exchange with the exterior is the most useful? Is it possible to define learning methods whose central significance is given by the possibility of roaming around within ourselves, of giving our thoughts free rein for a while?

The use of the Metaplan methodology, if well carried out, is aimed precisely at expanding thought in view of its subsequent synthesis.

It is a similar process to the one described by Nancy Tague (Tague, 2005) regarding the need to both expand and focus our thought accordingly on the decision-making process. Tague defines

a sequence of expansion and focusing phases, the first of which are apparently connected to identifying problems, analysing causes, and generating solutions. The focusing stages are apparently connected to the moments of synthesis, such as identifying the root of the problem, its ultimate cause, and the choice of the optimal solution. Adopting this model stimulates the awareness that, in order to focus, it is first of all necessary to expand one's thought. The outcome is a process of expansion and contraction, in which it is necessary to dwell on the first stage in order to go on to the second. The subsequent focusing stage enables the creative potential produced not to be dispersed, formalising ideas, judgements, proposals, and giving them fixity, albeit in the framework of a continuously evolving process. As with respiration, only a calm and complete exhalation enables a long inspiration. This metaphor is well suited to the methodology used in our project, in which individual (and then collective) reflection spaces and times are defined for students who are about to undertake a process of articulated and challenging further study.

In reality, however, it is not easy to operate a clear-cut distinction between the focusing and expansion stages. Moreover, the reflection on the role of tacit knowledge cannot be left out when the initial stage of thought expansion is elaborated upon. Tacit knowledge is of an unconscious subsidiary nature, based on practice and experience rather than on concentrating on the focal aspects of knowledge, which only subsequently can become explicit knowledge but which, according to Polanyi, is the primary source of any kind of knowledge (Polanyi, 1988).

However, in reality it is also difficult to pin down the linear stages in which the transformation of tacit knowledge into explicit knowledge is fully and completely achieved. The Nonaka model (Nonaka, Takeuchi, 1997), in contemplating the various kinds of knowledge conversion (from tacit to explicit, from explicit to tacit, from explicit to explicit and from tacit to tacit), suggested considerable innovation along the line traced by Polanyi, envisaging the recursion of the processes. However, reality is even more complex, inasmuch as it is quite likely that the different modes of knowledge conversion will coexist simultaneously in a plurality of synchronously-connected cognitive processes. The Nonaka model

that keeps the various stages separate, not only logically but also temporally, inevitably operates a simplification that makes the model more easy to use for the analysis of certain corporate processes but less suited to grasping the complexity of knowledge-sharing and conversion processes, which is fundamental to test participative approaches and science communication models (Valente, Luzi, 2000).

It is thus necessary to reflect on the role of tacit knowledge accepting the coexistence of various knowledge conversion possibilities, as they appear in Figure 1.

Figure 1. Main conversion methods of tacit and explicit knowledge in the Metaplan's stages

Stages and levels Knowledge	Reflection and first formalisation *individual level*	Group debate and classification of the contributions *inter group level*	Presentation, final discussion *intra group level*
from tacit to tacit socialisation	New tacit knowledge is in part produced		New tacit knowledge is in part produced
from tacit to explicit externalisation	Part of tacit knowledge is externalised (indiv.)		Externalising of tacit knowledge by individuals and groups
from explicit to tacit internalisation		Production of tacit knowledge of the group	Production of shared tacit knowledge
from explicit to explicit combination		Production of explicit knowledge by the group	Production of shared explicit knowledge

The Metaplan methodology adopted heightens the initial stage of reflection and formalisation of concepts and opinions on the topic. Each participant is required to express the same number[2] of considerations on the topic in full and possibly[3] complete autonomy. Each participant, therefore, tries to render explicit his or her points of view on whether and how climate change and the water crisis are experienced as problems on the basis of his or her own personal experience, on the causes and possible solutions. Each expresses his or her own points of view making a considerable effort to externalise part of his or her tacit knowledge, of that knowledge that he or she did not even know he or she possessed on the topic and that, although mixed with the universe of beliefs[4], is at the basis of the cognitive (Polanyi, 1988) and learning process. In order to do so, each will have to provide a contribution that starts from the deepest self, potentially facing the risk of it appearing as 'banal'. Normally the result is a plurality of reflections, including ironic ones, which express more or less articulately an attention towards local or global, individual or collective aspects of the problem, with a bias that is more social or political, more scientific or technical or linked to health, etc.

This initial stage of becoming aware of one's own knowledge is fundamental in order for everyone to be able to recognise parts of him or herself both in the course of the Metaplan, in the stages of exchanges of opinion within the group and with the other groups, and in all the project's subsequent activities. And in particular:

- In the study of the scientific documentation provided by the Cnr and by the teachers (explicit knowledge);
- In the interaction with national and international experts, in

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[2] To this end, a standard number of post-it notes was handed to each person.

[3] In relation to situations of greater difficulty or in consideration of the age of the participants we tempered individual 'isolation' with actions aimed at facilitating the explicitation of knowledge.

[4] I will not enter here into the issue of the relation between knowledge and beliefs, for which I devolve matters to Silvia Caravita *et al.* 2008, Boldrin, Mason 2007, Cerroni 2003, Valente, Luzi 2000.

which tacit and explicit knowledge integrate with one other.

Indeed, next to the fact of being fascinated by the novelty, the Sartrian concept of recognition is very influential in each learning process, i.e. finding parts of ourselves, of our thoughts, judgements and values in the new knowledge that is offered to us. However, this is neither an easy process nor one to be taken for granted, since it implies determination and individual effort and, especially, requires that time and space are reserved for it.

The second stage is characterised by two fundamental phases: a group discussion starting from the concepts highlighted by each person and the organisation of the contributions according to criteria defined by the group. In this phase the externalisation of tacit knowledge is less important, while the combination of already explicated knowledge takes on particular consistence. The main cognitive activities consist in:

- Analysing and comparing the concepts (opinions and judgements) expressed by each person;
- Seeking the relations among concepts (analogy, synonymia, affinity, oppositivity, hierarchy[5], cause/effect relation, logical-temporal relation, etc);
- Graphic representation of the concepts and relations among them[6].

Normally students are not aware of the various knowledge classification and representation models, thus their choice of criteria and methods happens unconsciously. Moreover, it is interesting to note that several representation models are frequently used, with the consequent creation of very interesting schemes.

The third phase is characterised by the presentation of the group's work, the final discussion and the drafting of the reports.

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[5] The relation of hierarchy is one of the most used by male and female students.

[6] Some male and female students spent their time and energy devising the graphic design and the other aesthetic aspects of the poster summarising the group's work. This shows a sense of belonging and identification with the work carried out, but also the willingness to contribute to the group's work: in some cases the 'artists' took part in the debate within the group to a lesser extent compared to the other students.

First of all what is witnessed is a combination of explicit knowledge among the groups, but, during the debate, the tacit knowledge belonging to each group is externalised and new tacit knowledge is generated as an outcome of the final discussion.

Although the greater dynamism of the exchange of tacit and explicit knowledge happens in this phase, the impulse given to the process finds its origin in the activity of elicitation of one's own tacit knowledge that took place in the first phase. Tacit knowledge fosters the dynamic process of stabilisation/construction of knowledge and the result is extra tacit knowledge generated by the knowledge production system.

Conclusions

In our project we tried to stimulate a *condensation* process from a *nebulous*, *vague knowledge* in which scattered information was memorised without connections, and thus wandered freely, to a *liquid knowledge*; the latter is more defined, but still flexible and better suited to a situation of exchange of ideas and learning than the less flexible and less usable *crystallised* one that schools provide. Like a crystal, with a well-defined form and structure, school knowledge can be memorised rather easily but has a difficult time aggregating around it the unordered structures of thoughts being formed.

This process, from unordered nebula to liquid, from tacit knowledge to explicit knowledge, but always liquid, which is different from codified knowledge, happens in continuous spirals in which exchanging opinions with others is fundamental for the process of condensation of ideas. It is especially important for the exchange to be among peers (and the Metaplan technique helps in this), in the sense that there is no established authority that imposes the crystal as the truth even before the individuals have had the chance to present their own knowledge and intelligence. In this process, it is not only the individual who learns: the group learns too and learning is not just about content but also about the aforementioned social competences.

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Introducing Open Space Technology in schools to educate towards citizenship in science and society

Elena Del Grosso, Alba L'Astorina, Adriana Valente

«Technology is becoming too complex and dangerous for health and the environment to be left only to scientists» (Barinaga, 2000); this statement, made during the 1975 Asilomar conference by the scientists who had organised it after the appearance of the first recombinant DNA technologies, places scientific research in the public arena for the first time, revealing the social nature of the scientific endeavour and its link with democracy. Having left its ivory tower, science becomes more and more participative and experts and non-experts find themselves involved in «a diversified set of situations and activities, more or less spontaneous, organised and structured, providing their own inputs in the processes of agenda definition, decision-making, formation of research politics concerning the production of knowledge, and innovation in the scientific and technological field» (Bucchi, 2006).

Science, like a city, turns into a habitable place where various subjects request citizenship based on their own desires, needs and interests, which are sometimes in conflict with the values of academic science and can create changes in the very ethical codes of science and scientists. However, in order for scientific knowledge and the new technologies to become instruments and 'common goods', this 'city' needs a new way of intending Governance, which be no longer a series of public and private, expert and non expert, scientific and secular, ethical, legal and political civilisation (and not just civic) resources owned by a complex society (Tallachini, 2006),

but be also a new instrument to understand democracy, which includes the development of the kind of knowledge that is relevant to decision-making processes and the citizens' participation.

Therefore, the 'participated knowledge' society is not a given but a process that should be built through the interactive communication of parts of the civil society requiring an ever greater involvement, parts of the scientific community, and politics, where the various needs, requirements, and values can be debated and reformulated.

Building participated science

Scientific communication and the relationship between science and society are undeniably being given ever more frequent and accessible space today. The topics are debated from the sociological, science communication, scientific research and funding plan points of view. However, Sara Calcagnini wonders whether «we are absolutely sure that we should discuss science and that science has anything to do with citizenship» (Calcagnini, 2007). This seems like a rhetorical question but it is not for two reasons at least: a) because the European Commission in its sixth, and even more so in its seventh Framework Programme aims at the citizens' active participation in the public debate on science for the construction of the European Area of Scientific and Technological Research; b) because, within a scientific knowledge that includes communication and is, effectively, 'communicated knowledge', finding the connection between science communication and democratic participation in collective decisions means giving significance to that society of knowledge that the Lisbon strategies so look forward to.

In this context, «reflecting on the forms of communication – as Donna Haraway rightly points out – is as important as reflecting on the method» (Haraway, 1995). And, as Sandra Harding adds, «who speak, when they speak and how they speak is as meaningful as the subject spoken about» (Harding, 1991). Hence the need to promote a critical debate around science, starting from communication forms, and to activate physical and virtual places for dialogue, such as open labs, scientific cafés, 'science in the squares', science

springs, Internet websites, blogs, and thematic citizen networks (Falchetti, Carovita, 2004), to understand how, in this way, knowledge and experience, i.e. 'tacit knowledge', are socially shared.

This is the only way in which participated knowledge can strengthen public secular ethics that repositions and reconsiders scientific and technological knowledge not only as a motor of social and economic development, from a liberalistic, technocratic point of view, but especially as a common good and universal right of humanity, which, as all common rights, whether material or immaterial, is not a good that can be traded, sold or privatised (Cini, 2008).

Participative methodologies as tools to educate towards science and citizenship: Open Space Technology (OST)

At a recent conference on participative methodologies in science and technology[1] in Procida, the theoretical and methodological framework of which concerned the processes to build public areas of deliberation, the starting question was how to convince people to participate. During the various workshops, however, other questions arose: how to involve politicians and groups of experts and get them to share their decision-making responsibilities with the civil society? How can participated science projects take into account the relations between the values of society and the knowledge needs of scientists, reconciling them with the economic, civil and military aspects of science and technology? And again, what does participating mean, what are the goals and on behalf of whom should we invite citizens to participate?

The reflections stemming from the Procida Conference confirmed our group to steadily maintain in the *Perception and Awareness of Science* Project those participative methodologies that, besides arising new ideas and points of view, emotional aspects, difficulties and fears, could also enable new forms of mediation between different stances for a participated consensus. Apart from

[1] 2nd CIPAST training workshop on *How to design and organize public deliberation?* June, 17th-21st, 2007, Naples, Italy.

the Metaplan, among the methodologies we tested we were particularly interested in Open Space Technology because of its focus on the decision-making aspect of the public debate on science.

Open Space Technology (OST)[2] is an open assembly methodology promoting the self-organisation skills of the participants (whose number can be between 5 and 1000) divided into many small groups, whose only constraint is undertaking a responsibility in a short but clear timeframe. At the end of the works, that can last from a few hours in the adapted version for schools, up to 2-3 days in very complex situations, an *instant report* is drawn up that divulge the results of each group to the entire assembly.

This survey and decision-making method particularly suits to heterogeneous groups with different viewpoints on complex issues and can turn out to be very useful in schools to re-establish collectiveness among teachers and their respective disciplines and to develop new forms of teaching, on the basis of requests and assessments coming from students and from society as a whole.

Freedom and responsibility are two fundamental values for the effectiveness of this participative practice, whose public ethics facet lies in its goals (Owen, 1995). In the 'ideas market' that OST creates and physically represents by an open, circular space, in which no one is at the centre and everyone is sitting around, each person is called to express his or her point of view on the designated topic through a question or a statement, to invite debate on it and to try and built consensus around it so that the final question(s) are the expression of the discussion group and not just of the single individual.

In order for this to take place the most important thing is to aim at active listening (Sclavi, 2003), at the formal aspects of being together: OST's Law of Two Feet, which enables people to leave the group if they are not capable of contributing or if they are not interested, is a normative rule besides being a standard procedure. This methodology, inspired and based on a concept of time that,

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[2] Open Space Technology (OST) was born in the first half of the 1980s from the creative skill of a conference organiser called Harrison Owen, who discovered that the informal coffee-breaks present in all conferences are a special space-time to face up to and find creative ways and solutions to complex and controversial problems.

although limiting the duration of the debate, must not be considered as a restriction («it starts when it starts and it ends when it ends»), and on a concept of random formation of the group and of its results («the right person is the one who takes part» and «what happens is what should have happened») alludes to a close correlation between answers and the individual and collective contexts that determine their expression.

Testing OST in schools

OST was suggested to teachers and students who took part in the *Ethics and Polemics* Project, at the end of all the project's stages (documentation on the water crisis, meeting with the experts and public debate). For the students it was the last stage in a participative process which began with a Metaplan that had enabled them to express all their 'tacit or explicit' knowledge necessary to gain the tools to 'articulate and formulate proposals' to be debated.

Since it was an experimental proposal with an empowerment perspective, i.e. aimed at promoting new roles in teachers and students, respectively as facilitators and participants, we organised different groups and interpretations. In order to facilitate the task a list of points was prepared as a guideline for the debate proposal, following: the issue suggested, the group's spokesperson and the names of the participants (name and school). We also suggested drawing up a diagram of the action plan in the final report in which the following would have to be outlined: goals, subjects involved, modalities, timing and cost of the procedures. The results of the two meetings are presented hereunder.

OST Teachers

The initial question we suggested, regarding the experience gathered in *Ethics and Polemics*, and, in general, the importance and value of participated methods for the teaching of science and in schools, was followed by other questions, solicited by the teachers themselves, regarding relational aspects and consensus building with colleagues, students and institutions.

The replies of the group of teachers engendered further ques-

tions on the relations among disciplines (i.e. «how useful is the participative method to encourage an interdisciplinary approach?»), but also a new way of thinking, seeing and managing today's school («how should we combine the participative method with the monitoring needs of the manager of the 'school that is run as a company'»?) and/or work relations and conditions («how can school programming be managed in schools with a large number of temporary teachers?»).

The answers showed that under normal conditions there were discrepancies between the school's goals as seen from the managers' point of view, the expectations of families and students and the teachers' experiences. Teachers are often left to cope with the various tensions with tools that operate only on the school's efficiency rather than on the effectiveness of teaching. The consequence of this is a compliance with the respect for civil liberties, which does not coincide with the expected results.

These complex questions were answered constructively, redefining the teacher's role both as an educator capable of identifying, together with the students, 'focus' themes appreciable with methodologies such as problem solving, and as a facilitator and moderator between the various instances coming from the students, organising coordination meetings and finding precise places and spaces during the school year in which to check the effectiveness of the chosen procedures, enabling teachers to become more involved in the choices made *in itinere*.

Punctual remarks on specific topics were not lacking: a group of teachers, for example, pointed out that the school manager, in guiding the school's policy and defining its agenda, should «also allow temporary teachers to play an active role in the school's choices, in planning and in extracurricular projects, postponing, where possible, the deadline for the candidature to already approved projects».

OST Students

While the teachers who took part in the OST 'hijacked' the discussion towards issues concerning work and working life organisation, the students focused more directly on the topic of the water crisis, also because in their case the question was: «if your opinion

as a student counted, which proposals would you make to deal with the water crisis and how would you get the outside world (friends, school, family, institutions, active citizenship) involved?».

The questions formulated by the students largely confirmed the interests already emerged in the Metaplan, i.e., the need to find instruments to diminish water waste; finding ways to get young people involved; asking governments to implement an information and awareness-building policy aimed at citizens on the topic of the water crisis and getting everyone to play their part. Although keeping in mind «that general culture and the intrinsic evolutionary haughtiness of the human being can be restricting and cause problems» and that the final goal is dealing with and solving the political and economic problem, the students expressed the need to formulate an ideal information and awareness-building plan suited to the citizens, combining the right to water availability with the need to prevent waste. According to the students, everyone should feel involved in the process of making individuals undertake their responsibilities, starting from one's role, from political bodies to experts, from communication and information media to schools and individual citizens. Everyone should share the goal of changing the culture of waste and useless consumption currently rooted in society. The students suggested the entire process should have a pyramid scheme starting from the players most involved in the political choices (governments), which should concentrate on issuing effective laws and on involving competent authorities (civil protection, scientists, experts, etc). An important step in this 'pyramid' suggested by the students is occupied by the media, which should make programmes and promote specific elaborations on the water crisis inviting experts to speak, but also organising major cultural events in a language and with methods that can be more enticing for the younger generations. Schools, in turn, should implement «a project for all classes involving competent professionals who can be entrusted with a programme to illustrate the problems, for example by means of widely-distributed detailed flyers».

If these solutions do not lead to a real change within a short period of time, drastic measures should be taken, for example increasing water tariffs, starting with the sectors that are more responsible for excessive consumption (agriculture and industry).

After drafting the report the students were invited to a debate held in the classic OST geometry (the circle) to enable a re-elaboration of the suggestions received, to improve interaction among them and to overcome a few obstacles inherent to their belonging to different schools and classes, which is an important factor in that age group.

The discussion that took place at this stage of the participative process proved useful to inspire further, more creative proposals, freer from scholastic-institutional conditionings. At the same time it also helped the students become aware of the fact that they themselves are the new interlocutors for institutional representatives such as the managers of the Civil Protection Department, whom they consulted with on the specific topic of the water crisis.

Discussion on results and conclusions

Both students and teachers who took part in the *Ethics and Polemics* Project enthusiastically adhered to the proposal, meeting the challenge and providing interesting and creative points of view. However, we would like to point out a few critical aspects that emerged which should be considered if we want to introduce participative methods in this framework.

When Owen describes OST, he remarks that this methodology has its limits and can fail for two reasons: if the people who take part have no passion or if one of the participants tries to take control of the situation leading it to a predetermined result. Only two conditions but they are not unusual. In OST the commitment to keep the space open for inclusion and responsible self-organisation starts with the premises of the meeting, «when the question is posed to invite others to discuss it». But this commitment is constantly threatened as students and young people in general lack 'training' in participation. As Enrica Giordano remarked, «the older one is, the more the adults give instructions, information, rules, laws, formulas to follow and to apply, often without worrying whether the origin and the consequences have been understood» (Giordano, 2007). Even the younger students understood the critical points of participation, when, in the survey in lower secondary schools, they

told us that «participation (which is fundamental if the goal is to raise the awareness but also to urge people to suggest solutions) is difficult, must be thought over, must be 'guided', is a skill that must be learned, that implies respect for the other's theses, listening to reasons, needs and time for further study».

On the other hand, the only institutions in which Italian students can express their school interests or needs are Class or School Council Meetings, but these are almost always places where collective interests are generally comparatively expressed (as it is for other school members such as teachers and non teaching staff), and they are not always discussed by mobilitating individual interests and resources. Marianella Sclavi, who was asked in the 1980s by an American teacher whether Italian schools had counsellors[3], replied they did not, «because Italian students have nothing to choose». Besides, she added, «in the Italian context, where not just schools but all the state administrative bodies are organised on the premise that both the employees and the customers must adapt to the needs of the state administration», providing a greater decision-making autonomy «would be perceived as a go ahead for the students' desire not to study, for the professors' demagogy, and for the administration's patronage system. When one is used to commitment as an obligation, it is difficult to conceive commitment as a choice» (Sclavi, 1994).

The fact that the limitations of science education in Italian schools are also 'structural' is proved by the strong legacy of the idealistic visions of Croce and Gentile's '*res cogitans*' still present in Italian schools. In a culture that has separated doing and thinking, or theoretical and applied research, into two distinct worlds (and this separation is felt by the students all along their school career), it is difficult to think that science education can be something other than this. Participative methodologies cannot prescind from this debate and this context.

The rhetoric on laboratories is no longer sufficient and, moreover, does not help understand the 'gaining of experience'; in fact, it separates thinking from doing even more. If methods, method-

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[3] Adult figure who personally advises and defends the student.

ologies and processes were discussed more in depth, laboratories would gain back their handcrafted cultural character that would bring science closer to art and culture and not simply exclusively to its technical usefulness. And this might attract more male and female students to scientific subjects.

Moreover, it is difficult to obtain a greater involvement of the students in a school that does not encourage and does not reward collective work, especially if the kind of work that encourages the search for the link between perception and awareness is not part of the required curriculum. In an ever more competitive system, where competitiveness is in fact encouraged from a utilitarian point of view, we can ask ourselves (and some students, even lower secondary school ones, are asking us) why and on behalf of whom and what they are asked to participate. In this sense the public communication of science and the scientific education linked to it take on a central role of educational and social change insofar as they will be able to build up in young people a conscious perception, a critical consciousness of «science as usual».

The low participation, which paradoxically increases the further along the school career one is, is probably also due to the fact that, through schooling, young people lose their unity of knowledge, their capacity to enhance the subjective dimension of experience, their ability to inter-connect it with knowledge deriving from other contexts (different family traditions, television, virtual reality, lifestyles, etc). So-called tacit knowledge, which an agriculture student creatively (and unconsciously) defined as 'the mud of ideas' is in practice more and more repressed by the 'canalisation' of disciplines following the classic model of the dual world in which places, methods and languages create insuperable borders that cause a split between students (and among the students of the various courses of study) and school world, respectively referred to as 'us' and a 'them'.

If we want to interconnect these separate worlds we must build 'bridges' to 'cross disciplines' along the entire school 'chain', stew by step. Participative methodologies that encourage students' empowerment, such as OST, can give a valid contribution to this project if we admit that the way to reply to the right/duty of participation is promising but still in progress.

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Young people and Information Literacy

Luciana Libutti

Today's high-school students have never known a world without the Internet. New communication media have great potential and have paved the way for a type of knowledge made of collective writing and global distribution of information, where everyone can publish opinions and give their contribution. Thanks to these media, young people have become the creators and distributors of information they have generated and are no longer passive consumers of pre-packaged information.

Technology is an integral part of the lives of this generation. The web is used to make purchases, keep in touch with friends and study. It is a means of creating, commenting and collaborating on content, and no longer just a place to retrieve information.

However, beyond the simple access to technology, are young people really capable of using these instruments appropriately? In a world where technology is so pervasive, being able to use digital media correctly and critically interpreting retrieved information is an important success factor for young people who want to make a name for themselves (Alvermann, 2004).

However, we should not take young people's ability for granted. A recent survey of the Council of Europe on the information needs of young people (Selwyn, 2007), which analysed the literature produced in the various European countries on this topic, highlighted some critical points, thus summarised: young people are easily capable of finding information on sports and entertainments but much less on science; they find information easily but

lack confidence in the use of search engines (Buckingam, 2005); young people are missing much of the richness of an environment saturated with information because of poorly developed information seeking skills or a propensity to take the easiest path possible (Dresang, 2005); they seek specific answers rather than developing an understanding of the information found (Bilal, 2004); young Europeans find it difficult to locate high quality information and develop the critical skills needed to interpret it.

On the basis of the Council of Europe's analysis and our direct experience, we see that young people know how to functionally locate and acquire information but do not have the necessary instruments to interpret, discard or manage it. However, since they find using technology easy, the next step should be to try to introduce them to a real information culture, helping them to become '*information literate*' as soon as possible.

The American Library Association (ALA), Presidential Committee, defined, since 1989, 'Information Literacy' (IL) as follows: «the ability to know when information is needed, and to be able to identify, locate, and effectively use that information for lifelong learning and problem solving» *(*ALA, 1989*).*

In the Anglo-American world, as opposed to Italy where it is as yet scarcely considered, IL is considered a discipline in itself, so much so that a series of models and standards have been developed, starting from the 1970s, to try to explain its goals and characteristics[1]. For them, information seeking is a constructive process

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[1] The most well-known models and standards connected to the information seeking process are: Big6 (accessible: http://www.big6.com), cf. Eisemberg M., Berkoviz R., *Information problem solving: the big six skills approach to library & information skills instruction*, Norwood, NJ, 1990; the Kuhlthau model, cf. Kuhlthau C., *Seeking meaning: A process approach to library and information services*. Norwood, NJ, 1993; the AASL/AECT standard (accessible: http://www.ala.org/ala/aasl/aaslproftools/informationpower/informationpower.cfm), cf. American Library Association and Association for Educational communications and Technology, *Information power: building partnerships for learning*, Chicago, 1998; ACRL standards for higher education (accessible: http://www.ala.org/acrl/ilcomstan.html, cf. Association of College and Research Libraries (ACRL*), Information literacy competency standards for higher education*, Chicago, 2000; the SCONSUL model, also known as the 'Seven Pillars of Information Literacy', cf. Task Force

that develops through a series of stages or levels, from the lowest to the highest, involving the individual as a whole from his emotions to his intellect (Kuhlthau, 1991).

These models and standards, although different from one another, have one feature in common: the understanding that IL is a dynamic learning 'process' characterised by a sum of connected activities that include a certain way of thinking and using information.

Information Literacy is not just that group of skills/prerequisites and knowledge that enables us to *find*, *assess* and *use* the information we need: first and foremost it must teach us to *filter* and *discard* what we do not need.

Becoming 'information literate' is certainly not something one can learn from a textbook. It is a long process, which should begin in high school. At this stage students should be made aware of some of its basic principles, drawn from the most qualified models or standards. As aforementioned, they begin with the lower levels, such as for example the «ability to recognise an information need» finally reaching the higher ones in a crescendo, such as the «ability to summarise and build upon existing information, contributing to the creation of a new knowledge» (Oblinger, 2007).

The first step will entail becoming familiar with the lowest levels of the scale, such as *acknowledging* the need for information; *improving* the quality of the questions to find pertinent information; *comparing and evaluating* sources, in order to be able to identify the most reliable ones.

The activity of *comparing* and *evaluating* sources is considered one of the most important basic principles to teach students. Thanks to his longstanding experience with young people, Godwin, the author of a popular blog and a university librarian, has stated that the best way to work with students is to change their Internet habits and teach them to «valuate, valuate, valuate», which is the new imperative in a world in which greater importance is

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on *Information Skills in Higher Education,* Standing Conference of National and University Libraries, London, 1999. For this model, the activity of *comparing and evaluating* is considered a key point of the information process.

given to the container/network than to the content/information (Godwin, 2008).

Until not very long ago, education was based on a single information source, the textbook. Today, with the new information technologies and with the explosion of information available on the net the perspective has changed and it has become necessary to consider these other means too (Eisenberg, 2008). However, as stated, in order to be able to use digital information efficiently and usefully it is necessary to acquire a certain number of new skills that go well beyond simple technological ones: «no longer is it enough to be able to read the printed world; [...] youth [...] need the ability to both *critically interpret* the powerful images of a multimedia culture and *express themselves* in multiple media forms» (Thoman, Jolls, 2005).

Guiding young people in acquiring the right skills also requires some thought, especially on behalf of those who have to help them most in this process: teachers, as subject experts, and school librarians, as experts in information accessing techniques:

- the information culture should become a mental habit;
- it is necessary to ensure that young people develop a critical sense in order to be able to cope in an environment, such as the Internet, where all kinds of information can be found, both true and false;
- it is important to teach young people to use information ethically and be respectful of copyright in an environment where it is very easy to cut and paste information.

On the basis of the previous reflections and of experience gained in the *Science Communication and Education* Project, we believe students today need to acquire abilities that go well beyond the traditional ones such as reading, rote learning and communication. They will need to learn to give more importance to content rather than to the container, and to express themselves in new ways and forms, to become accustomed to the tools that can span the entire range of available information sources, and to know how to evaluate them, developing that critical sense that will help them in their future working lives. By acquiring these competencies they will also be able to understand the many financial, legal and social implications connected to the use of information, and will learn to access and use them ethically and legally.

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Introducing participative practices at school: a reflection from and with lower secondary school teachers

Alba L'Astorina

The last two years of the *Ethics and Polemics* Project, the final results of which are published in this book, saw a lower secondary school in Milan take part in the experiment. For certain aspects this paved the way for a parallel approach to the main one, which was taking place in Rome and was specifically addressed to high school students and teachers. Although the Project in Milan faithfully mirrored the original one in its approach and methodology, aims and execution[1], its introduction at a lower school level and, especially, its identity straddling various learning models[2], in part

[1] The Project followed the same development stages (documentation, Metaplan, discussions in class with tutor-teachers, debate) but required a few 'corrections' in order to use it with a younger school age. The documentation supplied by the Cnr, although complying with established criteria, was trimmed and, in some cases, made linguistically more accessible, and enhanced with material on the local aspects of the topic. The debate took place in Milan at the same time as the one in Rome, as the teachers' request, motivated by logistical reasons, and to enable all the youngsters who had taken part in the project to be present at its 'final' stage. Some of the experts who were invited to the debate were chosen locally.

[2] According to Simonetta Fasoli, the identity of the lower secondary school can be found in the simultaneous presence of immediate ways of gaining knowledge, on the one hand, which are close to the global perception of the self and of the world, and on the other of learning methods of a strongly symbolised nature, which explicitly refer to disciplinary bodies.

strengthened some of its aspects and in part generated unexpected developments, suggested by the students themselves, which, if adequately interpreted, can offer useful cues for the practicality of such an approach in lower secondary schools.

One of the distinctive elements of this participation is the age group concerned, 11-14 yrs old, defined as pre-adolescent, which is characterised by a different personal investment in the schooling process. The teachers pointed out that, at this age, the group component is very strong but, at the same time, so is subjective experience; contact with the youngsters' families of origin is very evident and considerably conditions their attitudes towards science; girls and boys explain at home what they do in school and vice versa, trying to verify whether what they are studying (especially scientific subjects) holds true also in their everyday lives. In general we can say that this age group, which tries to face and solve problems and not just learn topics, privileges a 'pragmatic' approach to studying.

The school age of the students, combined with the method used to teach/learn the sciences, whereby the process of division by disciplines (physics, chemistry, biology, etc.) is completed in high school, while in lower secondary school it still influenced by their belonging to a common group of knowledge (although a more 'specialised' one than at elementary school), formed a good breeding ground for the implementation of one of the project's main points: the proposal to take part in the debate of an awkward interdisciplinary scientific topic of great social impact. Although the lower secondary school students who took part in the Cnr Project were not unused to this kind of approach to the study of the sciences, because of the special kind of school they come from[3], by participating in the project and in the debate with the experts they were able to grasp the possibility of creating that link between local and global that many surveys denounce as lacking in the way in which

3 The Istituto Rinascita "A. Livi" in Milan is an experimental school that offers an educational project based on research-action and on education towards an active citizenship.

science is often presented in schools and textbooks[4]. The students' comments to the questionnaires, their reflections with their teachers all along the project, and especially their questions during the public debate with the experts, indeed showed that the students were preponderantly interested in concrete aspects and in the possibility of understanding how individual behaviours can contribute to solving global problems, such as climate change, pollution or the water crisis. In other words, the students, faced with the request to take part in the debate on such important topics, asked themselves (and us): what are the aims of our participation and on behalf of whom and what are we being asked? And, especially, what are our chances of making our own decisions?

This question was so 'pressing' for them that they suggested, as a personal contribution at the end of the two years of the project, that they themselves should organise a conference on the water crisis, a 'conference of students for students' in which they could involve their schoolmates of the first year of lower secondary school who had not taken part in the debate organised by the Cnr. Had it not been followed by posthumous reflections on the weak and strong points of their proposal, the 'conference of students' might have been interpreted as an attempt to emulate the grown ups, pretending to be experts and almost copying on a 'smaller scale' the Cnr Project itself. And certainly the 'recreational' component was strong for many of them, but this does not diminish the scope of their 'gesture': in fact, it is its original trait. In de-constructing the process that led them to their proposal, together with their teachers, during which the students retraced motivations, expectations and the way in which they would organise their 'event', the genuine although ingenuous attempt emerged to explore the ground around some very 'serious' topics such as the public communication of science and public participation in science.

The students' personal motivations had already emerged in the Metaplan that took place before the public debate of *Ethics and Polemics*, together with the priorities and possible viewpoints to

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[4] See the data of the survey carried out within the framework of the *Biohead Citizen* European Project.

suggest for the water crisis topic. By means of the self-organised conference on this topic, where the youngsters themselves were to play the role of 'experts' and the younger students that of the 'public', the youngsters suggested venturing further, wanting to share with their other schoolmates the knowledge and awareness matured collectively in the course of the project. In doing so they laid bare a few crucial points of their relationship with science which, as we shall see hereunder, revolve around the role of scientists, the importance of public communication and the difficulties of practicing an active participation.

The 'conference of students' took place in the school auditorium in the presence of students, some parents and a few invited guests. During the conference a folder on the water crisis was distributed, largely based on documentation acquired during the *Ethics and Polemics* Project and translated into more simple terms to make it accessible for the youngsters of the first year of lower secondary school. This documentation stage was considered preparatory for the meeting and useful to «fully take advantage of the presence of the experts». However, the students admitted that, in order for it to be used during the conference, the documentation would have to be distributed beforehand and discussed in the classroom, thus confirming the validity of one of the first points of the *Ethics and Polemics* Project, in which all the documentation on the topic (collected on the basis of strict criteria) had been the starting point for the debates with the tutor-teachers, with the other schoolmates and as preparation for the debate.

The youngsters, helped by a PowerPoint presentation, took turns at the microphone, each illustrating one aspect of the 'water crisis' issue. The experts, in the 'interpretation' given of them by the youngsters at the conference, speak as people who have a (more or less) strong knowledge of the topics and, since the topics are many and complex, they also need to transmit this complexity. They give replies but also admit they cannot give an answer to everything because many issues are still unknown or have not yet undergone debate. Finally, the experts are not only scientists, since some scientific topics such as the water crisis include aspects that concern more than one sphere of society: economics, technology, politics, administration and community. However, experts some-

times make 'mistakes': they take for granted the public's basic knowledge, they use a language that is too technical and 'cryptic', they do not check whether everyone has understood: in a word, they are not able to communicate. Instead, their language should be simpler and more immediate, clear and full of references to day-to-day life («suited to the public, more accessible, simpler»), it should sensibly use accessory elements facilitating communication (i.e., presentations rich in visual and audio suggestions, but not redundant and too full of text!) and, every so often, the experts should check whether the audience is following.

However, in taking stock of their initiative, the students highlighted another important fact: even if communication had been effective and the speakers brilliant, the conference would still have 'failed' its goal, because the people present (that is, their schoolmates of the first year and perhaps they themselves) did not participate and did not 'really' get involved in the game. Some suggested that the formula chosen for the meeting, that is, the conference, did not help, since it traditionally does not leave much space for a debate. Many youngsters became distracted or asked questions that could have been avoided if they had read or discussed the documentation beforehand. A frustrated few even ripped the folder apart during the conference! Participation (which is fundamental if the goal is to raise the awareness but also to urge people to suggest solutions), as the youngsters admitted, is difficult, must be organised, must be 'guided', is a skill that must be learned, that implies respect for the other's theses, listening to reasons, the need for further study. All these elements were lacking and would have probably benefited from a more limited context, made up of small groups, better if previously 'motivated' towards the topic, and if there had been more time for listening to one another's opinions. Despite the critical points and weaknesses, the students' suggestion was generally recognised as «a good self-learning method». Moreover, the desire to stand out motivated the youngsters to undertake some responsibilities *vis-à-vis* the knowledge they had acquired: organising and arranging the documentation gathered not instrumentally to comply with schoolwork but to convey their newly-gained knowledge to their other schoolmates; re-elaborating what they had learned in order to conceive questions that could in-

terest the public was felt by the youngsters as «a conclusion that was consistent with the methodology adopted and is effective at this stage of taking stock of what has been learned, which is usually the most difficult stage to manage when one is working both actively and interactively»[5]. As a whole, participation in the *Ethics and Polemics* Project welcomed with enthusiasm both by students and by teachers, who declared they «want to repeat and continue the experience», was positive. By reviewing what worked and did not work in their participation and in their proposal, the youngsters had the chance to reflect on the image of science with which they had arrived at the conference and thought they could propose to their schoolmates, and in some cases change it. The project's participation system contributed to this small 'change'; this method of schooling by means of experiments changes the students insofar as it enables the production and build-up of new knowledge through action and collaboration. But the experience with the lower secondary school students also gave rise to a clear request on behalf of the youngsters to use knowledge to solve concrete problems, recognising not only the «social and collective nature of knowledge building» but also the need to use (and learn how to use) knowledge to suggest shared solutions. School and society should make the most of this experience.

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[5] *Il sapere scientifico della scuola*, Milano, 2007. The book gathers the experience of the *Scienza under 18* Project (http://www.scienza-under-18.org), a science education project that uses the public communication of science produced in schools as a learning framework for students of all levels and as a research and training framework for teachers. The project is coordinated by the Milanese Institute that took part in the *Ethics and Polemics* Project.

3. Images of science facing the water crisis and climate change. Survey results

The kind of satisfaction you get from asking people questions

Maria Girolama Caruso, Loredana Cerbara, Adriana Valente

«What kind of satisfaction do you get from asking people questions?», James Stewart was asked in the movie *Magic Town*, where he played a well-known pollster. If we were asked the same question, we would answer that the goal of our polls is to arrive at a greater and better understanding of the context in which we operate and in which we test education and science communication approaches. Therefore, the goal of the questions we posed to the students of the secondary schools involved in the *Perception and Awareness of Science – Ethics and Polemics* Project was to test their knowledge on the topics of the water crisis and of climate change, and gauge their awareness of and interest and confidence in the values of science. In 2008 we carried out our tenth survey on science: each questionnaire features a few key questions that are used over and over again, in order to be able to monitor the main aspects of the scientific and social debate, as well as some new themes, inspired by analysis and experimentation activities. The results of the surveys are then used to reconsider processes and methods of science-society communication and interaction.

However, our intent is not just to review the young people's knowledge but also to motivate them in becoming aware of and taking into consideration a few *ethical and polemical* aspects of science, to increase their interest in science itself and to promote their participation, as citizens, in the scientific debate, making sure they grasp the importance of the role of science in its close relations with society.

Indeed, the questionnaire is an addition and an important complement to the communication and participation processes proposed to students, and also helps us test forms of thought laboratory. Since one of the project's goals is to contribute to changing the relations between science and society, improving them, the questionnaire is one of the instruments that helps us do so.

The articles in this chapter analyse the replies given by students in the course of the events organised between 2006 and 2008 on a few key topics of the study of the water crisis and climate change: knowledge, information sources, confidence in the scientific system and the possibility of undertaking a professional career in science, which the four essays of this chapter respectively refer to.

The two events, the one on the water crisis and the one on the greenhouse effect, carried out a year apart from each other, both involved classrooms of secondary high schools in Rome (classical and scientific high schools and technical and professional schools) and lower secondary schools in Milan. For this reason, and due to the fact that the two surveys concerned topical and controversial subjects of environmental research, it was possible to use the data from both, reaching almost 800 cases. Nevertheless, as far as each commented analysis is concerned, the two subgroups surveyed were considered separately and provided results that were very similar to each another, apart from minor variations based on the different sampling choices.

The girls and boys who took part in the two abovementioned experiences came from different kinds of schools and guaranteed representation of at least 4 major school types (classical and scientific high schools, technical institutes and lower secondary school), with rather varied presence percentages among the various types. Hence it was possible to consider the different points of view of people coming from rather varied school and family backgrounds.

In fact, also as regards the parents' profession (a very important datum because it can act as a proxy[1] of the social context in which the young people interviewed are growing up), the declarations of the young people showed that the main professions were covered although there was a prevalence – which we were anticipating, given that the respondents were for the most part high school students – of freelance professionals and families in which both parents work.

In the four following essays, the results of the surveys on water crisis and climate change are compared with those obtained in the first surveys carried out within the *Perception and Awareness of Science – Ethics and Polemics* Project on GMO, "Electrosmog" and Space exploration (Valente, 2006)[2], since they are based on questionnaires with a partially identical structure and on a similar project methodology. This enabled us to monitor the aforementioned data, confirming the hypotheses expressed and verified in previous surveys and noting the new elements in each, in order to better understand what the youngsters imagine in relation to the major environmental issues and the perception of science and of its values.

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[1] A proxy is a variable that is used in place of other variables that cannot be directly surveyed.

[2] The surveys on GMO, "Electrosmog" and Space exploration, connected with the *Ethics and Polemics* Project, were only carried out on secondary high schools (and universities), therefore the youngest students were already 14-16 years old, while in present surveys on Climate change and the Water crisis the youngest students are those of the lower secondary schools (12-13 years old).

Cognition, knowledge, understanding, participation: students' cognitive levels

Sveva Avveduto

In archaic peasant societies contact with the natural elements was more direct and the *locus* of education was the family workshop: that was the school and the main question was the transmission of knowledge. Only very few privileged people had access to schooling. This framework remained unchanged up to the beginning of the industrial age, and the weight of new things to learn compared with acquired notions to be passed on was low. It was a stage when education and learning were oriented to the past.

A clean break happened with Tocqueville onwards, when societies began looking at the present instead of the past. The great change began in the 20th century, between the development of the industrial societies and the thrust of globalisation, which caused the intermingling of social, cultural, scientific, economic, industrial and political lives, and of everyone with everybody else.

Nature became a distant boundary that could be manipulated, the reality was that of biofacts, of biological products that could be and were manipulated, mixing artefacts from different realms that used to be very distinct. In these kinds of societies, oriented towards the future rather than the present and defined as Post-Modern according to Lyotard's now overused expression, education must anticipate – not follow – innovation or at least foresee innovation and anticipate its social impact and results. We happen to live in this kind of society and the school-science-society relationship must be and does become complete and complex.

And this is where the concepts of knowledge and awareness

also come in to the picture, according to the way they have been used for many years in the activities of the Cnr Project entitled *Perception and Awareness of Science*.

In order to define these concepts in relation to their meaning connected to science we have to refer to a vast literature previously examined in another similar setting (Avveduto, 2006), which is here only just mentioned in passing to define the initial concepts of knowledge, rendered as '*conoscenza*' in Italian and awareness, usually translated as '*consapevolezza*', which interest us so much since they are fused in the knowledge-awareness combination that ends up being broadly connected both to the behavioural area and to the skills area which, in this case, combine skill and competence. The need to investigate in this field is triggered precisely by the possibility of investigating the underlying skills and competences present before and after the impact of the *Perception and Awareness of Science* Project.

This project does not follow the approach of the many surveys on the public understanding of science that also measured public levels of understanding and are still carried out, although to a lesser degree. We are interested in measuring the students' level of understanding since it is a measure of their interest and involvement but especially since it is correlated to the experiences of participative communication in which they took part.

Using Bauer's tripartition (Bauer *et al*., 2000) of the instruments and methods to measure the public understanding of science, i.e. interest in science, understanding of science and attitudes towards science, we dealt with the third possibility regarding the aspects relative to awareness/participation, leaving aside those of mere understanding, as previously understood.

However, in the surveys conducted on the water crisis and on climate and the greenhouse effect we tested the students' knowledge correlating it to the area linked to themes of knowledge and awareness by means of a few specific questions. The questions we asked the students in order to examine their specific knowledge in this field were very limited due to our interest not so much in measuring previous knowledge but in activating a system of answers to another kind of questions. However, with the obvious *caveat*, it is thus possible to correlate the greater or lesser knowledge

of the specific topic treated in the project/process of communication and perception of science with other significant indicators. Indeed, even our survey data shows that knowledge level does not invalidate interest levels.

Students were asked to reply to questions on topics that they would later study in class with their teachers and, subsequently, by taking part in the public debate.

In most cases, students showed quite a satisfactory knowledge level, replying correctly to most of the questions asked. However, when we went into detail we noticed some interesting gaps that we will examine hereunder.

As regards topics concerning the water crisis, students were presented with a range of questions covering the whole spectrum of the problem, from the effect of atmospheric agents to the impact of anthropic activities, to test their previous knowledge.

Students replied to the four questions posed to them with the values reported in Table 1.

Table 1. Previous knowledge of the water crisis. Statements of the sample on the truth of certain propositions. Total percentage values and values by gender.

	true	false
The water crisis is caused exclusively by low precipitations	11.3	88.7
males	*13.8*	*86.2*
females	*6.5*	*96.5*
Only the southern regions have been hit by the water crisis	23.5	76.5
males	*25.0*	*75.0*
females	*20,6*	*79.4*
It is impossible to predict the beginning of a water crisis	27.6	72.4
males	*28.1*	*71.9*
females	*27.2*	*72.8*
Agriculture requires considerable amounts of water	95.0	4.0
males	*95.8*	*4.2*
females	*97.2*	*2.8*

There was greater uncertainty on some propositions and we asked ourselves what made these answers more difficult to give. For example, the conviction in 23% of the sample that water problems only concerned Southern Italy might have been caused by the contingent concomitance of a catastrophic event in the South or by the widespread perception that Southern regions, which are always perceived as more fraught with difficulties, suffered greater problems also in this case.

A high degree of uncertainty was also measured regarding the possibility of forecasting events. Many students did not believe it possible to foretell when water crises would happen, which might be a sign that the culture of emergency still prevails over that of prevention.

As the data show, female students systematically gave more correct answers than male students, with considerable margins of up to eight percentage points.

The questionnaire on climate topics and the greenhouse effect gave students three possible alternatives to use as a reference to highlight the knowledge level of the topics treated. Two were of a decidedly scientific nature and one was tied to general information on the topic. Students were asked to give their opinion on the effect of the excessive concentration of CO_2 in the atmosphere, on the effect of the reduction of the ozone layer in the stratosphere and, finally, on the contents of the Kyoto Protocol.

The students' overall knowledge should be considered good, altogether better than their knowledge of the water crisis in the survey. Nevertheless, while answers to science questions were quite satisfactory, we noticed greater gaps on the information front: 12.5% of the students ignored the reference terms of the Kyoto Protocol, despite the fact that, for quite a few years now, it has been possible to find popular articles, documentaries and information sources of various kinds in the various media.

In this survey male students showed greater competence than female students, and their answers are prevalently more correct than the ones of the female students (Table 2).

Table 2. Previous knowledge on the topics of climate and the greenhouse effect. Statements of the sample on the truth of certain propositions. Total percentage values and values by gender.

	true	false
An excessive concentration of CO_2 in the atmosphere is responsible for a concentrated increase in global temperatures	90.2	9.8
males	*94.0*	*6.0*
females	*85.6*	*14.4*
The reduction of the ozone layer in the stratosphere protects the earth from the sun's ultraviolet rays	8.2	91.8
males	*5.5*	*94.5*
females	*10.7*	*89.3*
The Kyoto Protocol is an international agreement regulating trade among far eastern states	12.5	87.5
males	*10.2*	*89.8*
females	*15.6*	*84.4*

Although, as we have already mentioned, our activities did not intend to measure the degree of knowledge but to ask questions of a cognitive nature in the broader framework of the participative processes that come into play, we considered it interesting to ask the same questions to the students once the participative process itself was over, that is, after the public conference-debate and at the end of the process of debate and learning in the classroom with their teachers.

The students' answers to the questionnaires administered at the end of the process show that 78.6% of the students believed they had gained greater knowledge than what they had at the beginning. Faced with the same questions they had answered months before, at the start of the various activities of the project, the situation seemed somewhat changed. For example, concerning the initiative on climate, the knowledge gap relative to the Kyoto Pro-

tocol had been bridged and the students were able to place it according to its correct contents in 94.9% of the cases (vs the previous 87.5%). Knowledge on CO_2 concentration had also improved (94.2% of correct answers vs the previous 90.2%), while the rate of correct answers to the question on the role of the ozone layer in the stratosphere had decreased (89.1% vs the previous 91.8%). That approx. 22% of students who expressed a negative opinion on the opportunities they had had to acquire new knowledge, overall overestimated their knowledge gaps. While there were no significant gender differences in the overall perception, females seemed to have improved the most in their replies to the questions, with over 90% of them answering each of the three questions correctly (95.6% for CO_2 concentration, 93.7% for ozone, 96.4% for Kyoto).

The students' perception of their increased knowledge on the questions relative to the water crisis was more positive, with 85.3% believing they had acquired greater knowledge at the end of the entire course of the project. Females were less sure (80.6%) and males were surer (86.5%). In checking the correctness of the answers given after the whole participative process we noted that knowledge had undoubtedly improved except in one area, i.e. previous information on the causes of the water crisis.

Final conclusions

As previously pointed out, no didactic or defining intent was behind the introduction in the survey of a small part of the questionnaire aimed at testing the students' degree of knowledge on the topics dealt with in the project. As in the previous editions, we deemed it useful and appropriate to continue including an explorative area, the decidedly cognitive one, following the model of knowledge quizzes. Some authors believe that individual exercises and quizzes are an important research area in e-learning studies (Brusilovsky, Miller, 2001). Many agree on the importance – if not of a self-assessment proper – of transferring judgement on competences from outside the classroom to inside it. Indeed, this is the opinion emerging from one of the final recommendations that the US Committee on the Foundations of Assessment and the US Na-

tional Research Council considered it useful to draft at the end of a laborious study activity (Pellegrino *et al.*, 2001).

The topics treated in the course of the two editions of the *Perception and Awareness of Science* Project, taken into consideration here, have two characteristics in common: the multidisciplinary nature of the approach to knowledge, which ranges from physics to geology, to chemistry and so on, and the considerable diffusion and media impact of the recent events linked both to the water crisis and to climate change. Therefore the students, both on the school front and in the area of information and widespread knowledge, were in a favourable condition to be able to have available significant previous knowledge. Indeed, their conformity was relatively good, although their naivety and uncertainty on topics that were considered to be common knowledge are surprising.

From the point of view of a greater participation and awareness of choices as opposed to a one-way communication from the experts to the citizens, even mere knowledge aspects take on considerable importance. A correct, conscious participation cannot be separated from a high level of knowledge and culture, otherwise a problematic inability to really influence choices will come about.

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Interest, information and participation in science and technology: evidence in the framework of environmental research

Emanuela Reale

Interest, information and participation are essential elements to increase the confidence that the population and young people have in science and technology, its developments and the debate centred on the practical applications of the new knowledge produced. This paper intends to consider the results that emerged at the end of the first stage of the *Perception and Awareness of Science* Project (Reale, 2006) in the light of new evidence collected during two other meetings organised in 2006 and 2007 on the water crisis and the greenhouse effect.

As indicated in the book's Introduction, the structure of the project and of the questionnaires administered to the students taking part in the events on the communication of science underwent changes that do not invalidate the possibility of comparing the results. In actual fact, it is interesting to note that the new meetings focused on controversial and extremely topical themes relative to subject matters that fall within the framework of environmental research; moreover, in both cases, the events simultaneously involved high school students in Rome and lower secondary school students in Milan. This enabled us to consider youngsters belonging to the age group in which future courses of study are chosen and interest in subjects learned is more clear-cut.

Interest and information on science and technology

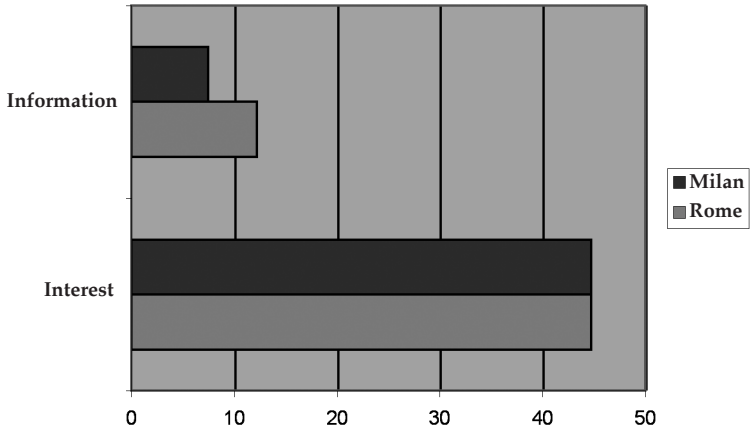
The students who took part in the first phase of the *Perception and Awareness of Science*[1] Project largely expressed average interest in a few topics relating to science and technology. However, some differences emerged among the different topics: participants were less interested in the more controversial and ethically sensitive topics (GMO and stem cells) compared with other topics such as food safety. Moreover, interest in science topics turned out to be influenced by gender: although, on average, girls' interest levels were lower than those of the boys, data on the individual topics showed that their interest was different rather than lower, favouring topics connected to food safety rather than energy or science and technology. Finally, information and interest did not appear closely linked: evidence collected strengthened the consideration that a higher degree of information guaranteed greater interest in the topic. On the other hand, greater interest can also develop in the absence of a high level of information.

These results were also substantially confirmed by what emerged from the meetings on climate and greenhouse effect, with a few peculiarities. Fig. 1 shows the percentage of boys and girls in the Rome and Milan events who were very interested in 'science and technology' and who believed they were very informed on that same topic. The data of the Milan students compared with the Rome students show the same percentage interest-wise, but the percentage of those who thought they were very informed is different, to the significant advantage of high school students. Data relative to the other scientific topics chosen (cf. note 1) show similar trends, with the exception of stem cells and space exploration. In the first case, the percentage of boys and girls who were very interested and believed they were very informed was very limited and positive judgements were, in any

[1] Meetings with students of high school in the first phase of the project were related to GMO, "Electrosmog", Space exploration. The issues on wich it was asked the level of interest were: GMO, Food safety, Energy and environmental issues, Stem cells, Relationship between science and society, cf. Reale, 2006.

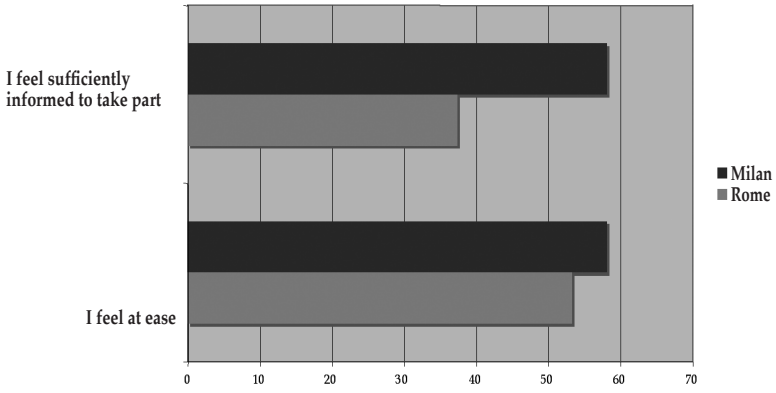
case, more widespread in high school students than lower secondary school students (22.8% vs 13.6% very interested, 5.4% vs 2.2% very informed). In the second case (space) the percentage of boys and girls who were very interested was very high and was higher among lower secondary school students than high school ones (65.3% vs 56.4%), as was their information level (33.7% vs 12.4%). These data confirm not only the relative lower attractiveness of scientific and technological developments linked to stem cells compared with the rather high attractiveness connected with the exploration and use of space (which even inverts the percentages relative to lower and higher secondary school students) but also offered cues on the differences that should exist in science communication based on the view that youngsters have of specific topics and to the perception of their information level. In other words, science communication must not only be tailored to the general public but also to the intrinsic (if we may say so) attractiveness of the contents transmitted.

Fig. 1 - Boys and girls who indicated they were very interested and very informed on science and technology. Rome and Milan events (average % water crisis and greenhouse effect)



However, the students' answers to the questionnaire administered after the events are interesting. A similar percentage of lower and higher secondary school boys and girls replied in the affirmative to the question «I feel at ease discussing environmental issues in a public debate»; however, the percentage of high school students who replied 'yes' to the question «I feel sufficiently informed to take part in a public debate on the environment» was decidedly lower than that of the lower secondary class students. Without claiming to make a direct comparison between the two results, because of the different size of the student groups considered, we can remark, however, that although judging themselves less informed, the younger students felt readier to play an active role in a public debate compared to the older students.

Fig. 2 - Participation in the public debate on the environment. Rome and Milan events (average % on water crisis and greenhouse effect)



Information sources on the environment

We know from different surveys on the topic (Pitrelli, 2003; European Commission, 2005; Reale, 2006; Valente, Cerbara, 2008), that television is the most popular source of science information for youngsters. This does not mean that other sources do not have a significant weight: the Internet and school are also considered

very significant by youngsters, with no significant gender differences influencing these preferences.

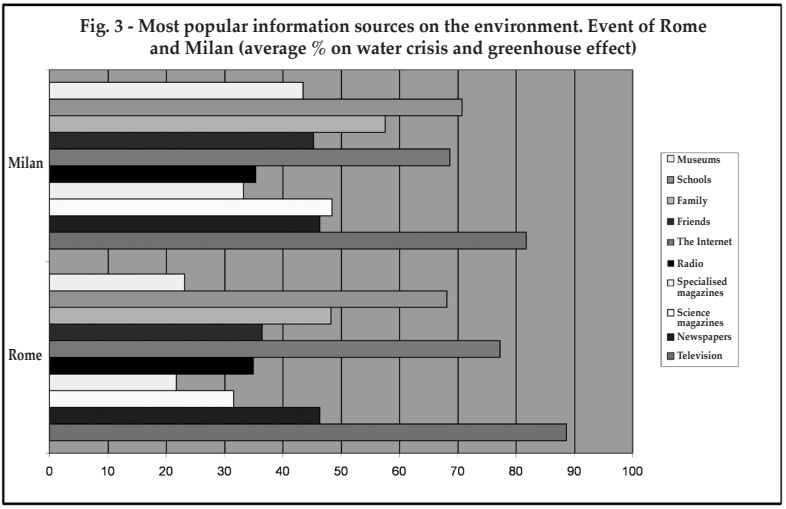
Both surveys carried out in Rome and Milan during the meeting on the greenhouse effect and on the water crisis asked the students which sources of scientific information on the environment they used the most. The results are summarised in Fig. 3. Television, the Internet and school are in a significant position for boys and girls of all schools. Lower secondary school students, however, used a greater variety of tools compared with their high school colleagues: science magazines and specialised magazines, friends and family but especially science museums, which, although not having a key role, which they did not have in the previous surveys either, were identified by a greater number of students in the lower secondary school age group as a more widely-used information source. These data seem to suggest lesser liveliness and curiosity in the search for science information which, in the passage from low to high school, seems to concentrate on the more traditional sources, neglecting, instead, some of the channels that enable a more direct contact with the work that has been concretely carried out by knowledge producers, in particular specialised magazines and museums.

To this end it is interesting to recall the results that emerged from two different and recently developed surveys. The first was carried out in Italy among a few primary and secondary class teachers of environmental education (Caravita *et al.*, 2007), who, when asked which were the most effective methods to teach environmental topics, mentioned laboratory activities in the first place, closely followed by the use of multiple information sources and by visits to museums and exhibitions. Moreover, teachers in the same survey declared that, according to their personal experience, awareness of our relationship with the environment is derived mainly from knowledge acquired from the usual information sources (TV, newspapers and the Internet). The second example refers to the results of a recent survey on the resources and activities of Italy's science museums (Reale, 2007), which highlights that museums, having to classify the importance of the users that their teaching activities are addressed to, largely place elementary and lower secondary school children first, followed by preschool children and, thirdly, high school students. In the case of communication and

participation activities, the main users are children and teenagers.

In short, the picture that emerges from the comparison between the results of our survey and the other studies mentioned underlines the key role of television, school and the Internet as information sources and a reduction in the variety of information sources in the passage from lower secondary school to high school, with a correspondingly low fruition of science museums. But at the same time multiplicity of information sources, visits to museums and content transmitted by the most popular channels are considered by high school teachers the most significant factors for environmental education.

Fig. 3 - Most popular information sources on the environment. Event of Rome and Milan (average % on water crisis and greenhouse effect)



Confidence in environmental information

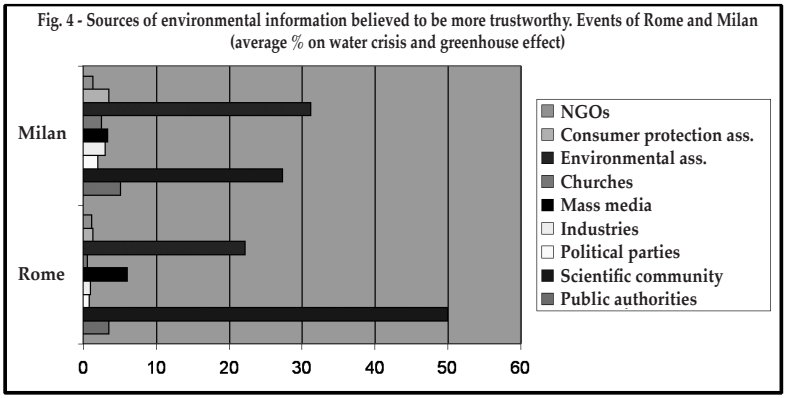
The surveys carried out in the previous years had yielded a few interesting results regarding confidence in information sources. In particular, scientists were granted more confidence than alternative sources, and a clear lack of confidence in political parties, industries and Churches was evident. The comparison between confidence granted and sources used showed an imperfect coin-

cidence between use of and confidence in the mass media, while the consistent use of science magazines and specialised magazines was in line with the high confidence granted to scientists as subjects who should be involved in decision-making processes on the use of the applications deriving from research.

These results are also confirmed by the meetings on water crisis and greenhouse effect, with a significant role played by environmental associations, considered very trustworthy by a large number of students. Maybe because of their manifest trust in the science community and in environmental associations the opinions of girls and boys appear clearer than in the previous surveys and a difference is evident between lower and higher secondary school. Male and female lower secondary school students placed a similar degree of confidence in scientists and environmental associations as well as being aware of alternative sources (public authorities, mass media, industries, workers' protection associations); on the contrary, a strong confidence in scientists is prevalent both in male and female high school students, while the position of environmental associations is reduced in favour of greater credibility attributed to the media (Fig. 4). The differences highlighted are consistent with the answers provided by the male and female students of Milan and Rome on who should take part in the decision-making process regarding the use of research applications and confirm the significance attributed to the science community in both stages of schooling (including scientists directly involved in research); environmental associations are also indicated as very trustworthy.

In the surveys of the last few years a few gender differences have emerged with reference to information sources other than the scientific community: boys showed greater preference than girls for public authorities and mass media, while girls favoured information deriving from environmental associations. In these new surveys, focused on environmental problems, gender differences emerged among the students of Milan with respect to confidence placed in information sources: boys preferred television, science magazines, radio and the Internet, while girls were more strongly inclined towards information coming from school, museums, friends and family. On the contrary, high school youngsters did

not show any gender differences in the choice of the sources they believed to be more trustworthy.



Conclusions

The new communication and participation events of the *Perception and Awareness of Science* Project on the topics of the water crisis and the greenhouse effect confirm many aspects relative to interest, information level, use and confidence in information sources already observed in the course of the previous surveys.

A few important differences seem to emerge between lower and higher secondary school students regarding: a) information level on scientific topics (believed to be lower by lower secondary school students compared to high school students); b) the spectrum of information sources used (wider in lower secondary class students); c) confidence in the sources used (lower secondary school students place their confidence in a greater number of information resources compared with high school students); d) the feeling one's level of information is adequate to engage in a public debate on environmental topics (very high in lower secondary school students compared to high school students despite the latter defining themselves as very informed in a higher number of cases). As we have already stated, these differences should be taken with cau-

tion, because the group of lower secondary school students was not as broad and articulated as the group of high school students. However, lower secondary school students showed an interest in furthering their studies.

Finally, the results of the themes connected to research in environmental topics confirm, on the one hand, the privilege granted by youngsters to information produced by the scientific community and, on the other, underline the significant role that environmental associations play in educating on these themes.

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Science: universal, independent, but respectful of human values

Adriana Valente, Loredana Cerbara

Girls and boys look at science: confirmations and new insights

How do girls and boys look at the science system and at the values of science, and what do they see?

The questionnaire submitted to students also brought ethical and scientific policy issues to their attention. This is one of the ways in which they can be encouraged to take part as citizens in the scientific debate, enabling them to grasp the growing importance of the role of science and its close relations with society.

The Pisa survey showed that the problem was not one of «giving a scientific explanation of the phenomena» but that our male and female students did not know how to «identify issues of a scientific nature» or «use evidence based on scientific data». For this reason it was deemed important to guide the youngsters in building competences based on scientific knowledge but also on the knowledge 'of science' (Mayer, 2008). Indeed, considerations on science, besides identifying its fascinating aspects and those that textbooks do not devote enough pages to, are an integral part of its topicality and of the process of understanding it.

In the first group of questions of this first part of the questionnaire we also included, with the necessary adjustments, three questions from the survey carried out in Norway on the *Public Understanding of Science* in 1999 (Kallerud, Ramberg, 2002), that we believed were particularly suited to understanding and en-

couraging the youngsters' sensitivity on problematic issues of science and society.

These questions (precaution principle, independence of the researchers, human values and scientific evidence), together with our own (speed of scientific progress, autonomy and responsibility, universality and sharing of knowledge, patentability, role of the market), were tested in the first surveys carried out (Valente, Cerbara, 2006) and reused, with a few additions, in the current surveys. This enabled us to monitor the trend of the aforementioned data, confirming the hypotheses formulated and verified in the previous surveys and noting new elements that could lead us to further articulate, examine and change the formulated hypotheses, and, if necessary, bringing out new ones to test.

The first question of the series was about the speed of scientific progress, towards which the interviewees adopted a cautious position: male and especially female students were in favour of a «less rapid development of the applications of scientific and technological discoveries, compensated by dwelling longer on the foreseeable results and risk factors», although, compared with the other surveys, a non negligible percentage of them was «in favour of a more rapid development of the applications of scientific and technological discoveries, since it is not possible to act in the full awareness of all the risk factors» (Table 1). The youngest especially viewed speed as a resource as well as a concern and gave greater space to intermediate positions. However, as the previous surveys showed (Valente, Cerbara, 2006, p. 111)[1], the youngest males had greater difficulty in replying and, besides choosing the intermediate position more frequently, often answered with «I don't know».

These surveys also confirmed the sensitivity towards the precaution principle. Most of the male and female students be-

[1] In the surveys on GMO, "Electrosmog" and Space exploration connected to the same *Ethics and Polemics* Project only the higher secondary schools (and universities) were involved, therefore the youngest were, in any case, students of 14-16 years of age, while in the present surveys on Climate change and the Water crisis the youngest are students of the lower secondary schools.

lieved that «if the consequences that the modern technologies will have on human beings and the environment are uncertain, their use must be restricted». The high number of consensuses attributed to the precaution principle must be considered in relation with the themes treated – climate change and the water crisis. Indeed, the precaution principle was more or less felt by the youngsters according to the environmental relevance of the context in which it was placed, as we were able to ascertain by comparing the three previous surveys on GMO, "Electrosmog" and Space exploration (Valente, Cerbara, 2006).

Regarding gender, in higher secondary schools there remained a slight prevalence of girls who were in favour of the precaution principle compared to their male classmates. Between the youngest male and female lower secondary school students involved in these surveys for the first time, gender difference did not appear, and, in fact, in the survey on climate change it was the girls who moved from unconditional support of the precaution principle towards an intermediate position («I tend to agree with both»). For the youngest we do not have a numerical representativity or historical series available to be able to say whether this phenomenon could foretell a new gender balance in future generations towards the sciences; this aspect will have to be taken into account in the following surveys and tests.

Table 1. Scientific and social values
Cnr data, Science Communication and Education

		High schools		Lower secondary schools	
		males	females	males	females
4.I SPEED OF SCIENTIFIC PROGRESS		*Survey on Climate Change*			
A: I am in favour of a less rapid development of scientific and technological applications, compensated by dwelling longer on the results and by the verification of foreseeable risk factors; **B**: I am in favour of a more rapid development of scientific and technological discoveries, since it is not possible to act in the full awareness of all the risk factors.	I agree with A	39	50	30	42
	I agree with B	27	14	21	16
	I agree with A and B	30	32	42	40
	I don't know	4	4	7	2
		Survey on the Water Crisis			
	I agree with A	35	59	32	46
	I agree with B	27	13	26	18
	I agree with A and B	33	24	19	33
	I don't know	5	4	23	3
4.II CONFIDENCE IN SCIENCE		*Survey on Climate Change*			
A: I believe that today, on the basis of the economic interests in play, it is possible to commission research on any topic, inducing the desired results; **B**: I believe that the scientific community will not allow the topic or the results of their research to be influenced externally.	I agree with A	45	38	35	18
	I agree with B	19	15	39	58
	I agree with A and B	21	29	7	13
	I don't know	15	18	19	11
		Survey on the Water Crisis			
	I agree with A	34	36	29	9
	I agree with B	25	19	26	31
	I agree with A and B	22	23	19	19
	I don't know	19	22	26	41

4.III PRECAUTION PRINCIPLE		*Survey on Climate Change*			
A: If the consequences that modern technologies will have on human beings and the environment are uncertain, we should be restrictive in allowing their use; **B**: It is wrong to place restrictions on the use of modern technologies until it is scientifically proven that they do not cause extensive damage to human beings and to the environment.	I agree with A	51	54	54	47
	I agree with B	31	29	25	22
	I agree with A and B	15	15	15	29
	I don't know	3	2	6	2
		Survey on the Water Crisis			
	I agree with A	41	57	58	55
	I agree with B	32	26	19	21
	I agree with A and B	18	15	10	18
	I don't know	9	2	13	6
4.IV SCIENTIFIC POLICY CHOICES		*Survey on Climate Change*			
A: In the choices of public policy human and social values are important at least as much as scientific results and evidence; **B**: Scientific results and evidence are the best basis for public policy choices.	I agree with A	38	55	34	42
	I agree with B	26	15	18	17
	I agree with A and B	18	15	26	23
	I don't know	18	15	22	18
		Survey on the Water Crisis			
	I agree with A	48	52	26	24
	I agree with B	14	14	23	31
	I agree with A and B	23	14	16	15
	I don't know	15	20	35	30

Regarding human and social values, male and female students agreed that these were important at least as much as scientific evidence is in public policy choices. As in the previous surveys (Valente, Cerbara, 2006, p. 115), the percentage of girls in favour of this principle prevailed, while gender difference among the youngest was not

noticeable in this case either. As for the other questions, the youngest were not inclined to take a position and were slightly more likely than the average of the sample to agree with both the options indicated or to reply with «I don't know».

With the question 4.II, a «major attack on the credibility of science», we asked students if they believed that today, on the basis of the economic interests at stake, it was possible to commission research on any topic, inducing the desired results. As in the previous surveys (Valente, Cerbara, 2006) young people's trust in the research system seemed limited. Both the girls and the boys of the higher secondary schools believed that it was possible to condition the topic and the results of research on the basis of economic interests. This may be considered a factor of mistrust towards science, but it may also indicate the rational acceptance of the influence of economy on the scientific world (Valente, Cerbara, 2006, p. 177). As in the previous surveys, but in a larger measure, the youngest proved to be the most idealistic and did not believe that the scientific community enabled the results of its research to be conditioned externally. Part of the young males (in the water crisis survey) had difficulty replying and tended to answer with «I don't know».

The group 5 questions, consistently with the approach of the previous surveys, highlighted three aspects that can be summarised in as many binomials: 'autonomy and responsibility', 'economic outcome and the market', 'universal sharing and access'; to these questions we added a question on the 'patentability of living beings' (Table 2), in the questionnaire of the last survey.

A very high percentage of male and female students, with no substantial gender differences, expressed themselves in favour of the universal sharing of scientific results and in the full access of developing countries to research and its results, confirming the outcome of the previous surveys. Students of the higher secondary schools, in an even greater percentage compared with the lower secondary schools, expressed their consensus towards these two principles, which in the previous surveys we had indicated as two cornerstone elements (*communal, universal*) of the Mertonian CUDOS model of science organisation (Valente, Cerbara, 2006, pp. 121-122; Merton, 1973).

Even the question relative to the fact that scientists should be autonomous and responsible in their choice of research topics and

methodologies saw girls and boys express themselves in favour, confirming the trend of our previous surveys (Valente, Cerbara, 2006) and of the data of the S&T Eurobarometer of 2005, in which the question was whether scientists should be free to conduct their own research, once compliance with ethical standards has been verified.

Regarding the issue of autonomy and responsibility, our male and female students of the lower secondary schools spread out more among the various possibilities, showing greater difficulty in assuming a position.

Correspondingly, regarding the PLACE model (Ziman, 1990), the two questions inspired by the *proprietary* and *commissioned* principles were asked: «is it right for research to be commissioned especially on the basis of specific market requirements?», «Is it right that researchers have an economic return on patents deriving from their work?». Also in this case the results of the previous surveys were confirmed: the greater adherence to the CUDOS models led to a greater distance from the PLACE model: older and younger male and female students did not regard favourably (slightly or not at all in agreement) the conditioning of research by the market. On the other hand, the possibility that scientists can have a personal gain from their patents was not regarded unfavourably; to this end, students distributed over the different options, substantially in agreement or slightly in agreement and, to a much lesser degree, against it.

The last question of group 5 was present only in the last survey (Water crisis, 2007-2008) and was certainly a tough nut to crack for the girls and boys who were called to express their opinion on whether it is right to envisage the patentability of living beings, whereby genetically modified organisms and stem cells would be equal to inventions, just like any other artificial product. Indeed, abstentions were much higher with respect to the other questions and, among the youngest, this was the only case in which (more than half) the girls did not express themselves, while the boys divided their preferences among the different options, essentially in favour or slightly in favour of patenting living beings. The girls and boys of the higher secondary schools were more cautious, dividing themselves among the various options but avoiding full agreement on the patentability of living beings, a complex topic which is certainly not very present in textbooks and is not much debated in class.

Table 2. Science system patterns
Cnr data, Science Communication and Education

	High schools		Lower secondary schools	
	males	females	males	females
5.1 – It is right that scientists are autonomous and responsible in their choice of research topics and methodologies	***Survey on Climate Change***			
I agree	62	60	58	42
I slightly agree	30	33	25	54
I don't agree	5	5	13	2
I don't know	3	2	4	2
	Survey on the Water Crisis			
I agree	64	49	68	52
I slightly agree	29	41	16	30
I don't agree	4	3	6	3
I don't know	3	7	10	15
5.2 – It is right to envisage the universal sharing of the scientific results obtained	***Survey on Climate Change***			
I agree	83	82	75	80
I slightly agree	11	15	15	14
I don't agree	5	1	4	2
I don't know	1	2	6	4
	Survey on the Water Crisis			
I agree	73	85	65	67
I slightly agree	15	14	16	27
I don't agree	6	0	6	0
I don't know	6	1	13	6
5.3 – It is right that research is commissioned above all on the basis of specific market needs	***Survey on Climate Change***			
I agree	14	18	15	20
I slightly agree	41	54	41	37
I don't agree	43	21	34	37
I don't know	2	7	10	6
	Survey on the Water Crisis			
I agree	24	9	16	9
I slightly agree	30	51	36	40
I don't agree	38	26	16	15
I don't know	8	14	32	36

5.4 – It is right that researchers have an economic return on the patents deriving from their work	***Survey on Climate Change***			
I agree	44	27	33	26
I slightly agree	25	19	24	26
I don't agree	17	30	17	23
I don't know	14	24	26	25
	Survey on the Water Crisis			
I agree	43	27	27	21
I slightly agree	22	30	40	24
I don't agree	12	14	20	12
I don't know	23	29	13	33
5.5 – It is right that developing countries have full access to research and to its results	***Survey on Climate Change***			
I agree	81	78	67	67
I slightly agree	14	16	14	21
I don't agree	3	1	11	7
I don't know	2	5	8	5
	Survey on the Water Crisis			
I agree	76	83	61	52
I slightly agree	12	9	10	33
I don't agree	6	1	16	9
I don't know	6	7	13	6
5.6 – It is right to envisage the patentability of living beings, whereby genetically modified organisms and stem cells would be equal to inventions, just like any other artificial product	***Survey on the Water Crisis***			
I agree	18	18	33	24
I slightly agree	31	27	27	12
I don't agree	22	30	13	15
I don't know	29	25	27	49

Do the developments and applications of the new discoveries in the environmental field generate optimism or concern? As in the previous surveys, we asked students to indicate their feelings on this topic, choosing the words that could better express them from

a precompiled list[2]. The majority of the girls and boys (and in particular the group of the youngest) expresses an optimistic opinion of the developments of the new scientific applications in the sector (except the girls of the higher secondary schools, who were slightly more worried about the development of applications capable of facing a water crisis (Table 3). True to the previous surveys, there is always a not enormous difference between boys and girls, with the latter adopting positions of greater cautiousness and lesser optimism; however, in this survey, the phenomenon takes on lesser proportions compared with the previous ones.

Table 3. Optimism or concern
Cnr data, Science Communication and Education

7. Which of the following words best describes what you feel about the developments and applications of the new scientific discoveries?	*Survey on Climate Change*		*Survey on the Water Crisis*	
	males	females	males	females
Negative opinion (concerned, cautious, pessimistic)	34	32	32	36
Intermediate opinion (contrasting feelings, confused, indifferent)	20	28	21	32
Positive opinion (optimistic, enthusiastic, confident)	46	40	47	32

Who should be responsible for making a decision?

A key question to understanding the actual degree of confidence of students towards science is the one relative to the

[2] This question and the list of terms were taken from a questionnaire drawn up in Great Britain in the genetics sector and changed and adjusted as necessary (Michie, Drake, Bobrow, Marteau, 1995).

decision-making process: finally, among the misgivings and prospects that science offers us, who should be responsible for making a decision? As in the past surveys (Valente, Cerbara, 2006, pp. 128-132), the majority of girls and boys interviewed declared themselves in favour of autonomous decision-making on behalf of the scientists (Table 4). The differences compared to past surveys must be sought in the composition by gender of this datum. Indeed, consistently with the hypothesis according to which the topic treated had a certain influence on the answers obtained, we can say that girls are different from boys in that they grant confidence to all the scientific community (i.e.: doctors, philosophers, historians, sociologists; 24%), although confirming that a decision-making priority should be granted to the scientists of the sectors that are directly involved (i.e.: biologists, physicists and engineers; 43%). Indeed, the issues linked to climate change were seen as markedly multidisciplinary, whereby all the scientific community was called get involved. The issue was downsized in the case of the water crisis, in which the sense of confidence towards the specialists in the sector prevailed, both on behalf of boys and girls, but with greater incisiveness expressed by the latter.

The other suggested options garnered little consensus, as is now customary, except for the ones that concerned citizens in general, who should be able to have their say especially according to girls, and environmental associations, which play an important role here undoubtedly because of the topics treated. Once more the political class was not taken into consideration very much, although some boys were inclined to give credit to it.

All things considered, confidence in scientists was once more confirmed, as was the awareness that the role of society as a whole is not marginal and probably should assist scientists when they find themselves having to decide on the applications of science as a guarantee of a greater social protection against the consequences that these applications may have.

Table 4. Who should be responsible for making a decision Cnr data, Science Communication and Education

6. Who should take part in the decision-making process on the use of the applications of research (…)?	***Survey on Climate Change***		***Survey on the Water Crisis***	
	males	females	males	females
Scientists of the sectors that are directly involved in the technical aspects	50	43	61	66
The scientific community in the broad sense	16	24	9	7
The political class	8	2	6	1
Industries	4	2	3	4
All the citizens	12	15	8	10
Bioethics committees	0	0	1	1
Environmental associations	8	12	10	8
Consumer protection associations	1	2	1	2
Non-governmental organisations	0	0	0	1
Other organisations	1	0	1	0

Conclusions

The surveys considered here take on greater significance if they are viewed from a longitudinal point of view, that is in relation to the other surveys of the same kind carried out in different contexts and times. Indeed, the questions asked, although relating to universally important topics, such as those of confidence in science or the relationship between science and society, also depend on the particular context in which they are dealt with. However, a certain regularity in the results of the various surveys can be noted, leading to hypotheses that are completely taken out of the context of the topic treated. For example, in general, greater caution was noted on behalf of females, which had already been detected in the previous surveys (Valente, Cerbara, 2006) as was a certain idealistic approach that seems to be more present in the youngest students.

The most interesting results of these last two tests were correlated to the convictions of girls and boys regarding the fact that sci-

entific activities may be conditioned by the market: in short, they think that the market should not influence the autonomy and the responsibility of the scientists. Therefore what emerges is a vision of science in line with the Mertonian model of science organization, because the boys essentially believe in the principles of universality and sharing of scientific progress. This must also be read in the sense of opposing to a model exclusively based on market logics restrictive of the autonomy of scientific research, a model towards which girls and boys show greater aversion although considering right the prospect of a personal gain of the scientists from their research. Also in this case, a lower age corresponds to a greater difficulty in replying, which is undoubtedly a synonym of the inability of expressing such challenging opinions, but is also perhaps the proof that adherence to one type of research system or the other matures with age and is linked to the formulation of an awareness that happens by degrees.

Finally, even the results of these surveys show that confidence in science and in the consequences that the applications of the advancement of knowledge can have is rooted in young people, because throughout the survey we found the constant declaration that scientists and the scientific community should be involved more than anyone else in the decision-making process relative to the employment of the applications of their research. Girls and boys, however, believe that society in its broader sense should also have its say in the relative decisions.

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Pathway and prospects. Science as a profession

Adriana Valente, Loredana Cerbara, Maria Girolama Caruso

Images of science and scientists

Some of the questions we asked the girls and boys of Rome and Milan were aimed at examining their perception of science and scientific experience gained thus far, as well as understanding the dynamics involved in choosing their future profession: in short, how probable do girls and boys think it is that they, in some way, will become part of the scientific world one day?

The data at our disposal, besides some direct questions on the topic we were focusing on, was also completed by important information on the socio-cultural context in which these girls and boys live, to help us understand their attitude towards science and scientists. Indeed, the image of science that each of us has undeniably depends on several factors, among which we undoubtedly need to consider one's education and schooling as well as one's family background, in terms of the cultural, economic and also social level in which this education took place. In another paper we had already pointed out the difference between the individual representation of science (image of the scientists) and the collective one (perception of the research system) and were able to verify the distance between these two worlds (Brandi, Cerbara, Misiti, Valente, 2005). Therefore, in the current survey, we took these reflections for granted and formulated our considerations on the basis of them.

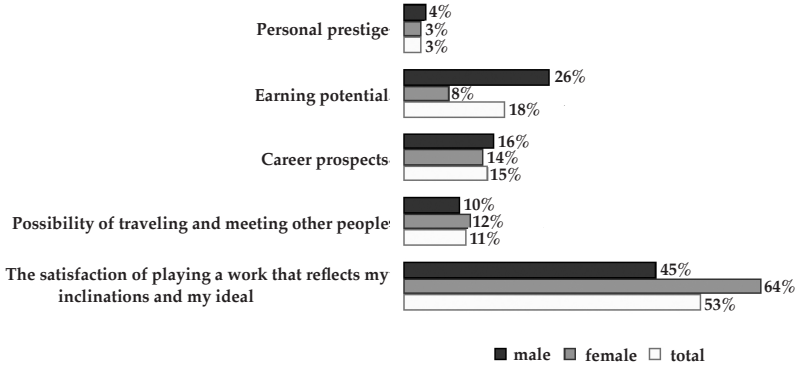
In general, girls and boys affirm that they love studying science (86% of the total of the interviewees). This datum is in line with another survey carried out on male and female students who were taking part in the *Scientists and Students at the Auditorium* Project or-

ganised in Rome during 2007 by the Cnr Press Office, in between our two initiatives on 'climate change' and the 'water crisis' (Valente, Cerbara, 2008).

Slight gender differences exist: counter to popular belief, but in line with the survey mentioned, girls seemed slightly more attracted towards the study of science, with 90% positive statements. Gender differences were evident only in some of the disciplines that we chose to put to the attention of the youngsters. For example, physics was more appreciated by boys, while girls preferred biology.

The choice of one's future profession mainly depends on the satisfaction that it can offer (as 53% of the sample explained), and also on earning potential (18%), career prospects (15%) and the possibility of travelling (10%). Personal prestige is much less important (3%) (Fig. 1). It is interesting to note that the low level of consideration attributed to prestige also appeared in other surveys (Valente, Cerbara, 2008; Brandi, Cerbara, Misiti, Valente, 2005), in which we asked young people and students a similar question: what is the main motivation of people working in science? Even in those surveys, prestige placed last. We will come back to the concept of prestige – and to how much prestige is attributed to people working in science – further on.

Figure 1. The choice of the future profession
Cnr data, Science Communication and Education



Returning to where we left off, the youngest students – those of the lower secondary schools – although largely following this ranking, expressed their desire to grow up by giving great importance

to working trips (20%). The boys showed a marked practical sense since income (26%) was quite important for them (above average), while the girls assigned an absolute first place to personal satisfaction in choosing their future profession (64%). Over 62% would work in a scientific institution (with no major gender or age distinctions) and around 55% thought that he or she would be capable of doing so. This datum is in line with our expectations: in the survey carried out in 2007 within the *Scientists and Students at the Auditorium* Project (Valente, Cerbara, 2008), we found exactly the same percentage of students who would have liked to carry out research activities in a scientific institution and an almost identical percentage of those who felt capable of it.

Vice-versa, in the national survey on youngsters and science carried out by the Cnr in 2004, only 50% wished to work in a scientific institution (Valente, Brandi, Cerbara, Misiti, 2005), even only hypothetically, while few (57% of those who gave a positive answer, that is half of half) felt capable of being able to. Regrettably, the different approach of the current surveys compared with the one carried out four years ago does not authorise us to hope in an increase in possible future scientists, which is essentially due to the fact that, in the first survey, we had addressed the entire population, students and non students, from 18 to 29 years of age. On the contrary, the subjects of our latest surveys were male and female students of secondary schools who had, among other things, very motivated teachers who involved them in extra-curricular hands-on science projects. Therefore the hypothesis that good schooling contributes to the fact that young people consider the possibility of becoming scientists one day seems to take on greater solidity, although they are not always aware of it and schools do not always explicitly show them interesting career opportunities in the scientific sector (Valente, Cerbara, 2008).

It must also be pointed out that, in the ongoing surveys (Table 1), male and female students showed a certain consistency of views because three quarters of those who stated they were interested in working in a scientific institution also thought they could actually do it, while those who would have been interested in a similar job but did not feel capable of it were just a quarter of the total. Vice-versa, 73% of those who did not want to work in a scientific institution did not even feel capable of it.

Table 1: Distribution of the interviewees by percentage according to the replies given to two questions
Cnr data, Science Communication and Education

		Do you feel capable of it?		Total yes
		yes	no	
Would you like to work in a scientific institution?	yes	76	24	62
	no	27	73	38
Total		57	43	100

Girls and boys are aware that becoming scientists entails sacrifices (84%) but is also worth it (84%). Once again, the result of the abovementioned surveys is confirmed and shows that scientific jobs, in the collective imagination, possess a dignity that derives from the sacrifices and efforts of those who devote themselves to them; a commitment largely repaid more by the social usefulness that this profession may have, than by income in the strict sense, because around 45% of girls and boys believed that scientists in Italy earned little.

«Who is more useful for society?» Physicians and scientists win hands down.

The profession that is considered the most useful is that of the physician (57%), especially by girls (70% of consensuses) and a little less by boys (49%), and this confirms the trend recorded by national and international surveys: the first place is taken for granted for all those who work in the medical sector, especially by females (European Commission, 2001; European Commission, 2005). Scientists rank second (26%), and here boys catch up in part (29% for boys and 21% for girls).

Almost no one (less than 35) finds politicians and journalists useful, and even less preference is given to sportsmen and artists. However, some of these professions do have another chance (Table 2). Indeed, in the current survey we decided to distinguish social *usefulness* from *prestige*, that is to say from the consideration one enjoys in society, which bestows authority and which frequently brings with it the privilege of being aware of belonging to a golden

élite that has a certain status or power (political, economic or of another kind); it is some sort of social illusion, from the Latin *praestigium*, but which normally goes hand in hand with the perception that some sort of dexterity has determined it, as is the case with conjuring tricks (*giochi di prestigio* in Italian).

Table 2. Usefulness and prestige
Cnr data, Science Communication and Education

Usefulness and prestige						
	Usefulness			Prestige		
	girls	boys	total	girls	boys	total
lawyer	2	6	4	21	15	17
politician	2	3	3	33	30	31
scientist	21	29	26	12	10	11
entrepreneur	1	6	4	9	9	9
journalist	2	3	3	4	2	3
artist	1	1	1	6	8	7
sportsman	1	3	2	6	20	15
physician	70	49	57	8	6	7
	100	100	100	100	100	100

Thus, if we consider prestige, physicians (7%) and scientists (11%) have to give way first of all to politicians (30%) and then to lawyers (17%), although the youngest Milanese students are less convinced and divide their preferences almost in half between politicians (25%) and lawyers (24%). Sportsmen do not do too badly, but only in the boys' eyes, 20% of which consider it to be the most prestigious profession.

Although we were aware of the difference between the concepts of usefulness and prestige, which is why we posed the two questions separately, we were impressed by such a wide and partly unexpected gap that young people attribute to the two, and to the professions involving one or the other. In our opinion, this is an important datum that should provide food for thought on our society's values and myths.

Finally it must be noted that artists and physicians shared 7% of the preferences, while journalists obtained the least, and their level of usefulness increased only slightly, reaching 3% with difficulty[1].

Imaginary and projections

The analysis techniques available today enable a cross-reading of the data deriving from the questionnaires. This helps us grasp the latent information in the data, which is invisible in the case of a simplified reading. This type of information is often very important and can answer various questions that are the object of research hypotheses. The technique that we considered the most suitable for the available data is the analysis of multiple correspondences[2], a type of factorial analysis that enables the study of the relations between variables, uncovering the significance that derives from their interaction.

The first two factors were considered, which on the whole explain 12% of total variability (that is, of the original information): the first 7% and the second 5% (Fig. 2).

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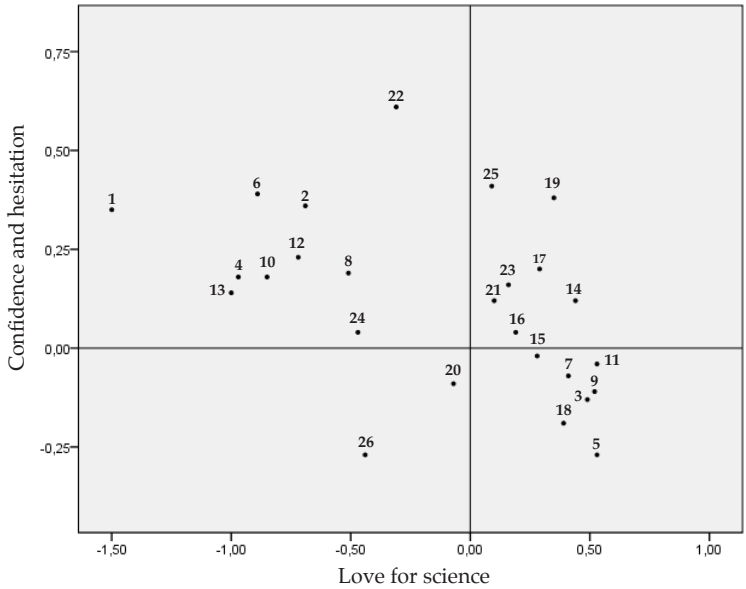
[1] In the 2004 national survey on *Young People and Science* we had asked which was the most *important* profession for society (leaving aside the obvious option of the physician). The consensuses were divided between entrepreneurs and scientists. In the ongoing surveys, in which we distinguished usefulness from prestige, entrepreneurs are considered a useful profession by little over 3% and a prestigious one by little over 9%. The difference between the two results is attributable in part to the fact that in the ongoing surveys male and female students gave answers at the opposite ends of the spectrum, concentrating their consensuses on few options, and partly to the fact that in 2004 we had addressed a higher age group of youngsters and almost youngsters (18-29 years old) which included workers as well as students.

[2] This is a multivariate technique of data analysis that enables a reduction of the available variables on the basis of a specific algorithm. The result obtained depends on the variables added to the analysis as 'active', i.e., which actively participate in the formation of the latent factors. Other variables, defined as 'illustrative', are considered only *a posteriori* with respect to the identification of the latent factors and serve to better determine the characteristics of the individuals to whom latent variables are associable. The validity of the synthesis generated by the factors on the basis of the original data is measured in terms of variability explained by the factors themselves expressed as a percentage. As a bibliographic reference, among all the existing ones, we suggest Greenacre, 1984.

Figure 2. Imaginary and projections



1 Do you like scientific studies? NO
2 Hated scool subject PHYSIC
3 Preferred school subject BIOLOGY
4 Hated scool subject BIOLOGY
5 Preferred school subject CHEMISTRY
6 Hated scool subject CHEMISTRY
7 Preferred school subject MATHEMATICS
8 Hated scool subject MATHEMATICS
9 Would like to work in a scientific environment
10 Wouldn't like to work in a scientific environment
11 Would you be able? YES
12 Would you be able? NO
13 Is it worth making sacrifices? NO
14 The most useful and prestigious profession: SCIENTIST
15 Do you like scientific studies? YES
16 Is it worth making sacrifices? YES
17 Choices determined by: SATISFACTION
18 Preferred school subjec PHYSIC
19 The most prestigious profession: POLITICIAN
20 Male
21 Female
22 The most prestigious profession:ENTREPRENEUR
23 Scientists are underpaid
24 Choices determined by: EARNING
25 The most useful profession: PHISICIAN
26 Scientists are well paid

Love for science

The first latent factor determined by this analysis is a variable that synthesises love for the study of science and the good disposition towards the scientific profession. The higher the values of this synthetic variable, the higher the degree of enthusiasm for the world of science. Indeed, it highlights the contrast between those who are 'reluctant' to study science and those who are 'inclined' towards it: the former are in the negative semiaxis, the latter in the positive one.

Negative semiaxis: the side of those who are 'reluctant' is determined mainly by their negative replies to the following statements: you like scientific studies, you would like to work in a scientific environment, it is worth making sacrifices to become a scientist and includes *hated* school subjects such as physics, biology and maths. Finally, the conviction prevails that scientists earn a lot and that the choice of one's future profession is to be made on the basis of the highest income potential.

Positive semiaxis: on the contrary, on the positive side of the axis we find those whose replies showed they had the most open and favourable opinions of science and a greater knowledge of the difficulties linked to the profession of the scientist. The profession of the scientist is considered prestigious and very satisfying but underpaid. The people in this group are also convinced that it is worth making the sacrifices that a scientific profession entails and believe they will be able to undertake it themselves. They obviously affirm to be very gifted for scientific subjects.

These illustrative values help us to better determine the characteristics of girls and boys who identify with this latent variable. For example, boys are better represented on the negative side, especially if they are younger or if they go to a technical school, while girls are more frequently on the positive side, especially older girls and those who go to a scientific high school. Often they are sons and daughters of teachers.

Confidence and hesitation

The second factor is a synthetic variable that represents the level of confidence that youngsters boast of towards their future. The greater the values of this factor, the greater the conviction

that they can determine their own future by making the most advantageous choices for themselves, from the financial and personal prestige points of view. Therefore, this factor divides those who are aware of their own capabilities and choices from those who are still immature and unable to decide.

Negative semiaxis: this is where a lack of replies prevails, signifying the impossibility of taking a stance even though a certain fondness for school subjects such as chemistry is expressed.

Positive semiaxis: this is where a wide-ranging confidence in one's own future is expressed. The profession of the entrepreneur, but also that of the politician, are considered prestigious while the most useful profession is that of the physician. They are against the study of scientific subjects and believe that the most important factor for choosing their profession is personal satisfaction. They are convinced that becoming scientists entails a number of sacrifices that they would not like to make, because they believe they are not capable of them.

The structural information at our disposal tells us that the negative values of this latent variable are characteristic of the youngest students, especially boys, and those who are still immature and incapable of making decisions on their own future. Positive values are generally associable to the oldest girls who go to classical and scientific high schools and belong to double-income families.

Conclusions

This investigation has confirmed, in good part, the results of our previous surveys, but has also highlighted some contradictions that stimulate new ideas for reflection. One of these is the different perception of *usefulness* and *prestige* and the negative meaning attributed to the latter. Moreover, a breathing space is introduced, related to the motivation that leads young people to a professional choice.

Considering the criteria for choosing the future profession, the young put first the satisfaction of playing a work that is suited to their own inclinations and their ideals, and only in the last

place the prestige. The factorial analysis adds new elements for reading the data, showing the contours of two sub-groups, which are limited in quantitative terms, but which clearly connote with respect to a set of features revealed by the analysis: in fact, the components of the two sub-groups answer on a fairly consistent way to a number of questions. Those who give more importance to earnings as a factor in the professional choice, and who at the same time believe that the scientist gains a lot, are also those who wouldn't work in a scientific institution and for which it wouldn't be worthwhile to support the sacrifices to become a scientist. Conversely, those who love the study of science and who believe that the scientist gains little, but nevertheless consider useful and prestigious the profession of scientist, are the ones who would work in a scientific institution. The apparent contradiction of the former shows that even if they consider the earnings as a prerequisite in the choice of profession, it is not sufficient, and the lack of love for science is the great obstacle to the choice of the scientific profession. The latter, especially girls who love science, they are available to undertake the profession of scientist, although aware of the low gain and the sacrifices which they encounter. Therefore, a subset was identified consisting of girls that, in spite of being traditionally hardly enrolled in science and engineering, are highly motivated on the basis of interest and attractiveness exerted on them by the science and on the basis of some contextual factors – school and families. This is in line with what was outlined in the comparison between countries performed by the International study Rose in terms of social significance, that is the image and the role that science plays in society and the possibility of finding in science the values of each.

Aspects related to social significance seem to have an impact in both cases: for the former, in fact, the most prestigious profession is the entrepreneur and the most useful the athlete, while for the latter the scientist is the most useful and prestigious profession. Our survey shows the importance of the concept of social significance, even when referring to specific contexts: in fact, increased provision for the sciences is found in students whose parents are teachers and in girls who attend "liceo scientifico" high school. Do not think however that these considerations are sufficient to

explain the so-called 'crisis in scientific vocations', as the awareness of low income as well as all other considerations related to science as a system – health well-being and competitiveness of the research system – (Brandi, Cerbara, Misiti, Valente, 2005) in practice will affect the choice of the future profession: moreover, if we consider that this choice is made very often in the family context (Cerroni, De Lillo, 2007).

Moreover, our analysis clarified that one has to have reached a certain degree of maturity to begin to have a clear opinion on science, because, for example, it is the youngest who are the most undecided and incomplete in their replies, especially when these require consistency. However, growing up is not enough. Even in high schools we met with cases where unfounded confidence was boasted, especially in contexts of particular social disadvantage (parents with low schooling and therefore employed in socially weaker professional positions). Of course, we should not expect to find consistency or confidence in future expectations among the characteristics of adolescents, since it cannot be considered normal at an age in which education is still incomplete. And we are not only talking about schooling, but also of that combination of experiences that leads to the formation of an individual personality at a crucial stage of growth.

Therefore, asking girls and boys to project themselves forward and see themselves as future professionals was also useful for them, and revealed to us the fragility with which they confront this stage of their lives. It is clear from the results that we gathered that much depends on the context in which one lives, on the stimuli that one is exposed to, although gender differences lead girls to adopt a more sensitive and precociously mature attitude. All this confirms the hypothesis that it is indispensable, as well as useful for individual development, to be able to expose boys and girls to positive experiences in terms of study, reflection and debate, for instance by using certain communication and participation techniques that are starting to be tested successfully. Therefore, these two surveys provided our working group with a small but positive experience in the vast landscape of adolescence, but it would be desirable to broaden the scope of this kind of initiatives, which would help boys and girls to

reflect on themselves and on their future in a useful way, thereby increasing their critical sense and probably preparing them for a positive transition into adulthood.

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SECOND PART

Communication, science and…

learning, passion, science cafes, creative writing, epidemiological research, radio, blogs, anti-science, ethics, ethology, collaborative environments, not just festivals, observatories, media, institutions, press offices, museums, the publishing industry, open access, bioethics, teaching, feelings

Like the button game

Adriana Valente

One day, Anna Baldazzi, a friend of mine who is an expert in documentary sciences, told me that every classification is like the button game: give a child a jarful of buttons and ask him or her to try and divide them into groups of similar buttons: can you be certain of how the child will group them?

Indeed, the child might divide them by shape, size or colour but also by number of holes, material or type of finishing according to their use (jacket, evening gown, shirt or pinafore buttons). He or she might even classify them by age (old fashioned, out of fashion, vintage, new or trendy buttons) and so on, in a crescendo of more or less objective criteria but also markedly subjective ones which, if considered (at least in part) as a whole, would generate a tight network of buttons, developing over several levels, rather than the hoped-for little piles of similar buttons.

In actual fact, these are the limitations of the hierarchic representation and of the linear organisation of knowledge, the same things that I find myself dealing with now. The game seemed simple enough: it was a matter of gathering short contributions by experts summing up their points of view around three keywords. The first two keywords, *communication* and *science*, were the same for everyone, while the third was specific to the field of study and the scientific and professional experience of each. In my imagination the process was very clear, as was the order to follow in presenting the contributions.

Once I had gathered the contributions, however, I felt like the child with the button jar and realised that the metaphor of the but-

ton game, although afflicting every taxonomy (or brightening it up, according to the different points of view), did not spare other forms of the organisation of knowledge, not even the necessarily linear, sequential presentation of rich and articulated contributions on science communication.

Indeed, some issues, other than those I had originally envisaged, sparked very interesting reflections that generated collective themes spontaneously spanning several contributions. One of these is *affection*, the explicit subject of Romeo Bassoli's contribution, who makes us wonder where the 'major questions' have gone (and why, and what will be the consequences of this). The same topic also appears, with varying significance, in several other contributions (Nadia Rosenthal, Pio Cerocchi, Silvia Caravita and Elisabetta Falchetti). The other topic is *the audience*, directly and provokingly dealt with by Claudia Di Giorgio in «What if the audience of science were a myth?» and analysed from different viewpoints by Pietro Greco, Nadia Tarantini, Marco Ferrazzoli, Romeo Bassoli, Manuela Arata, Anna Parisi and Tommaso Castellani. The relationship between *scientific citizenship* and *scientific knowledge*, present in many contributions on education (Francesco Polcaro, Silvia Caravita, Emilio Balzano, and Sylvie Coyaud), goes beyond that and overflows into the field of ethics (Enrico Alleva and Augusto Vitale, Fabrizio Rufo, Daniela Luzi and Rosa Di Cesare, and Giuseppe Sangiorgi).

Reflections on the *evolution of science and of scientific thought*, and the relative consequences in terms of science communication, are present like a starry sky in various parts of the book, starting with Rossella Bonito Oliva, who takes us all the way back to the common root of the terms *ethics* and *home*, and asks us to join her in defending the «meaning of communication» by searching for «what remains incommunicable in science»; to this end, Francesco Polcaro points out the damage created by the «barriers between the humanistic and the scientific culture» and suggests how to overcome them by using specific fields of knowledge; Elisabetta Falchetti shows us how museums and the products and artefacts of the cultural world contained in them have created «changes in the scientific thought and in the relations between science and society», while Silvia Caravita explains how the vision of a con-

flict between «science and knowledge» has influenced research on learning processes.

Finally, Andrea Cerroni's tale of a «neighbouring» country, in which at a certain point everyone shirked degrees museums and «television programmes, journals and websites where the word SCIENCE was even slightly visible», is *inter-thematic* par excellence and celebrates the «scientism/anti-science» antithesis.

The search for connections among the contributions could be endless but, since this is not a hypertext, I will present the papers in a strictly sequential order, according to the three main branches originally envisaged: *ethics*, *media*, *education*.

Rossella Bonito Oliva opens the theme of the *ethics communication* with an etymological reflection, which is necessary to «let go of the conventional use of the terms»; thus the concept of ethics/familiarity as opposed to segregation/secrecy takes shape. Enrico Alleva and Augusto Vitale, intervening in the emblematic case of the studies on animal behaviour, return to the topic of the responsibility of science, which has to provide information and communicate it to citizens so that they can «choose one side or the other».

Then come the papers on educational and sectorial frameworks, in which ethics and the meaning of communication take on a paradigmatic value: bioethics and its relevance in public debates, introduced by Fabrizio Rufo; the methodology of epidemiological research, regarding which Liliana Cori raises ethical issues relative to the communication of uncertainty, in the context of which participative practices involving citizens take on particular significance. Rosa Di Cesare and Daniela Luzi introduce us to the ideal of «science as the common good for society as a whole», reaffirmed by the Open Access movement, which aims at implementing the free circulation of scientific knowledge: on closer inspection, it is a «subversive proposal» since its implementation requires the redesigning of «the roles and functions of the actors who are part of the chain of production, diffusion and assessment of scientific knowledge». Giuseppe Sangiorgi, from the point of view of institutional communication, also stresses the requirements necessary to be able to speak of «substantial democracy», starting from «digital formats» and the normative evolution of «virtual communication».

Andrea Cerroni's contribution paves the way for the subsequent topics and reflects on the science myths that seem, in turn, to encourage its communication, to avoid it, to preserve it, to marginalise it and to sanctify it, in an endless crescendo of which Cerroni shows the futility.

Pietro Greco opens the theme of the *media* with a paper on radio and on its capacity to correspond to «highly popular goals». Claudia Di Giorgio underlines the chronic fragility of scientific information in the Italian media. This vision is partly shared by Pio Cerocchi, according to whom science can never be but a «guest in the media». It might be because of the need to place science in «the context in which it was born, grew and developed», as Nadia Tarantini points out in her contribution on creative writing. In any case, its role as «a bridge between citizens, media, institutions and science» must be dealt with, in contrast both with the tendency towards isolation and that of «standing out by raising one's voice», as Marco Ferrazzoli reminds us from the «front office of a press office». The topic ideally ends with the enthusiasm of Romeo Bassoli and Nadia Rosenthal, who offer us simple and ingenious recipes: more room for affection, the major questions, anticonformism and, of course, passion, keeping in mind that the history of science is «a history of human discoveries» and that a good piece of advice to give to young people is to keep a «sense of freedom to pursue their curiosity».

Thus we come to the third theme, *education*, which includes both the formal and informal frameworks of education in its widest meaning, among which is *edutainment*, a concept found in community documents aimed at highlighting the blurry borders between school, curricular and extra-curricular education, and entertainment. The major open questions, regarding which I ask you to turn to the introduction to this book, raise their heads: whom should scientific information be addressed to? What is the goal of scientific education?

Silvia Caravita points out that «it is not only knowledge that is in play but also personal and social identities under construction»; therefore, it is not enough to develop knowledge but «attitudes connected to knowledge». However, it is possible to learn science also outside of the classroom, and Elisabetta Falchetti shows us

that museums are places «to teach science […] and educate» and «in which to make interesting and amusing discoveries». Francesco Polcaro raises interest for science *to the stars*, introducing schools to the appeal of astronomical observations. Further science communication projects involving schools are presented by Emilio Balzano, who stresses «the potential of an integration between teaching and communication» and by Claudia Ceccarelli, who underlines how collaborative systems can also provide the chance to redefine methodological choices in the teaching of science. Manuela Arata gives a powerful boost to the process that began in the 17th century to bring science out of laboratories: all this and more is the prerogative of science festivals, which envelop the senses and provide a «full immersion» in which various forms and ways of communicating science are concentrated in a festive climate. Another whirlwind is that of the heterogeneous universe of blogs, onto which Sylvie Coyaud opens a window, showing us «lively and educational» phenomena that mirror and magnify the great ethical and cultural queries linked to the communication of science.

Let us end with a virtual cup of coffee in Anna Parisi and Tommaso Castellani's science cafes. Several years have passed since our Cnr research group organised a science cafe on assisted reproductive technology with the British Council, on the occasion of the referendum on the same topic. Meanwhile, Anna Parisi and Tommaso Castellani with FormaScienza have turned science cafes into an extremely pleasant meeting place, in which it is possible to «enter into a direct debate with the researchers», but also to reverse the roles of experts and audience and so on.

These and other collective themes emerged from the contributions: there is still room to discover more. I am satisfied with my treasure, like the child with his button jar.

…ethical issues

Ethics

Rossella Bonito Oliva

The word *ethics* has a longstanding tradition in our culture and, like any word become common language, it has lost resonance. We might even add that it has lost its background, which is what enables each term to express a meaning because it is backed by a signifier. In short, we could say it is an overused term, a corollary of medicine, science and all that is linked to a human being's theoretical and practical activity. Yet ethics is not law, it is not morals, and it certainly is not science. Therefore it is a sticky term, almost a risky one. The risk is for ethics to become trapped by codes, rules and grids. The term *ethos* in ancient Greek has a root in common with *oikos*, home. And the word *home* reminds each one of us of a familiar, safe place, one that possibly allows greater freedom than a public place. So why are we now asking ethics to play a formal, institutional role? How can we avoid the risk of slippage, preserving ethics archaic root in familiarity? *Ethos* is also certainly present in the term *ethology*, which is closely connected to animals, but concerns it in the sense that animal behaviour is observed by the only animal for which language and communication are essential. Man, according to Aristotle, is an animal capable of language, and immediately specifies its meaning: man is a political animal. However, even language and politics have lost their background for us, reinforcing the meaning of communication or community instruments. It is worth remembering that language derives from *logos*, which means debate, but also link, connection and welcome, just as

politics derives from *polis* which indicates a community of people united in equality and with an equal right to make decisions. Maybe something has been lost, but maybe something can be recovered by trying to abandon the conventional use of the terms to avoid the risk of missing the sense of communication, seeking a familiarity among human beings in view of establishing mutual exchanges while recognising their specificity.

All this serves to introduce a reflection on the ethics of the communication in science. Whereas it is undisputed the scientific progress and the possibility for everyone to benefit from it, it is not equally evident the possibility for everyone to understand and to become familiar with scientific knowledge. All this creates the first ethical problem. Possessing scientific knowledge and communicating it can appear a simple operation. Science is built on objective data, on experimental evidence, on what is made immediately available. Yet, beyond the usefulness of the results, science seems to encounter ever-greater obstacles to its communicability. What does it persist incommunicable in science? Certainly not an obscure part that is intangible for everyone, certainly not something related to fantasy or imagination, or at least very little. The problem does not only lie in the specialisation of scientific language, but rather in the impact of its contents. Today science does not only study celestial or terrestrial bodies, but it enters into these bodies, it builds artifices and intervenes on them. In the pragmatic instance of technology they are made available not only data but future scenarios, other spaces, other times, other kinds of human life. In the minds of ordinary people the science becomes closer and closer to a disturbing and obscure exploration. One can share the spirit of adventure inspired by space missions, rejoice in human being's ability to reproduce life or heal it, but all this is accompanied by a sense of disorientation. Everything seems going too fast, forcing individuals to continuous accelerations, leaving them with a sense of inadequacy. In short, despite an increasingly wider participation to scientific results – thanks to specialised media and also to the popularisation of science – science remains rather extraneous to those who tries to approach it. This distance or remoteness not only produce a temporary uneasiness but also a sense of fear which, like all fears, can generate indifference or even panic. Best example is

the continuous and almost instantaneous communication regarding the danger of epidemics, global warming and impact of the greenhouse effect. While the ability to predict might be reassuring, every piece of news falls onto the shoulders of an audience that the more is informed, the more is defenceless. Even science seems to be suffering from the effects of globalisation: everything is within arm's reach or, better, within the news' reach, but to individuals it appears ever more elusive in magnitude and boundaries. We are forced to look at what we cannot see or we cannot yet see, like in a movie with special effects. But, it is the spectator's role, which is tolerable for a show with an end, that is becoming gradually less reassuring for the human condition. We can no longer feel like Lucretius who watched the sea storm safely from the shore. What to do? Leave science alone, nurturing a peaceful ignorance? To quote Pascal, we have now «embarked» on this, and the problem has turned into an ethical one. Since communication is radicated in human nature, communicating in an ethically correct way can only mean encouraging familiarity between human beings and science producing a sort of humanisation of science instead of a scientific communication that places itself above, ahead and, in any case, beyond the people. Human beings are the ones who bring forward knowledge, experimentation and coding, but protection or even defence barriers are being created between labs and common people. This sort of segregation, which verges on secrecy, often has repercussions on scientific communication itself. Winning back both the confidence and the connection between science and people through communication can only mean to working on the risks of this condition in order to build up trust, before worrying about creating an effective form of communication. Thanks to an ethically correct communication it will be possible to make available not only the contents of scientific communication but also what lies behind them and what makes them interesting for and sharable by all. This is a form of communication that, even though with difficulty, each of us can relate to, even without possessing it, in a scenario which is not only teaching-oriented. Science itself, perhaps proceeding at a slower pace, can benefit from this approach and, along the way, take charge of the question of solidarity between technological progress and human life conditions.

Behavioural ethics

Augusto Vitale, Enrico Alleva

The study of the behaviour of animals, called ethology, finds its application in different areas of biological research. Researchers can be interested in investigating particular aspects of the behaviour of particular animals both for basic studies, such as evolutionary questions, and applied studies, such as the use of animals in biomedical research. Although the level of invasiveness varies depending on the kind of research carried out, the relationship between the human observer and the non-human animal observed in behavioural studies can raise a series of ethical issues. If the scientist goes to the field to study the behaviour of a particular species she or he can, with her or his presence, disrupt the normal activities of an individual in the wild. Furthermore, if it is necessary to handle wild animals, for example to mark different individuals for later recognition, the disturbance can be of a greater entity. If the researcher operates in a captive environment, ethical aspects can be very relevant. This applies, in particular, for the use of animals as models in toxicological and biomedical research.

Communication within the scientific community is provided by the sharing of published data and through the distribution of specialised scientific journals. Furthermore, congresses, workshops and symposia assure a less formal, and often more stimulating, circulation of research and ideas. However, the communication between scientists and general public can be more challenging, and perhaps requires a particular analysis. The times in which scientists considered themselves as untouchable in their ivory tower of knowledge should be well past. Scientists are the product of the society they live in, and they have to respond to the general public on the implications of their work. When it comes to the use of live animals these implications, as mentioned above, are ethically relevant. In the past decade the concern by the general public about

the welfare of experimental animals has increased, thanks also to the activities of protectionist associations. Although the general situation has slowly improved in the past years, the creation of two opposed stereotypes is precisely the result of a lack of communication among the different actors involved in the issue of animal experimentation. On the one hand, some still see scientists as mindless torturers of caged animals; on the other, protectionists are considered enemies of scientific progress. The public is generally left without any kind of useful information that could help it choose one side or the other through an informed choice. It is obvious to us that scientists, with all the due precautions for their safety, must accept the responsibility to go out and explain to the general public the 'whys' and 'hows' of their activity involving the use of experimental animals. Communication must be not top-down, but open to discussing the moral responsibilities that such activity implies. The scientific community and the general public must act reciprocally, in order to allow the possibility of influencing each other's opinions. This result can be reached only by offering clear and transparent information.

Bioethics

Fabrizio Rufo

Bioethics is a relatively young discipline but it poses a problem as old as the history of human knowledge: which moral principles should guide scientific research and its applications in the field of the life sciences. This topic has become ever more central in the political debate of these last few decades during which the increasing ability to plan, programme and manipulate the biological profile of living organisms at all stages – birth, development, and death – has imposed a wider essential freedom as a focal theme, with completely new and often indefinable borders as the subject matter for an ethics debate. Therefore, the birth of bioethics, its quick growth and its popularity in the media cannot be dissociated from this reshuffling of scientific acquisitions, political cultures and social subjects that require the formulation of new morals suited to the challenges and changes produced. Because of this intrinsic characteristic, bioethics has immediately had to face different disciplines and define fields of interest that not only concern situations linked to individuals at a personal or interpersonal level, but also produce moral reflections within the framework of public ethics.

An example of a bioethical topic is human cloning. The prevailing opinion is in favour of cloning cells and tissues for therapeutic reasons, but is against cloning for reproductive purposes, arguing that this technique, by excluding randomness in gene combination, restricts individual freedom and leads to genetic predetermination. Those who are in favour of reproductive cloning maintain that human beings are always, more or less, largely predetermined, since they are born in a given country, in a given era, in a given social class and family. They say that if a person's fate is to become a social, cultural and moral clone, why should genetic cloning not be allowed?

The opposite argument consists in affirming, once the many conditionings – spontaneous or compulsory – that exists are acknowledged, that human freedom and self-determination should prevail over all limitations and obstacles, whether due to social and gender injustice, caused by mind bending or introduced by the biotechnologies. The use of science should not deny or discourage everyone's daily efforts, which are in any case addressed to building one's future autonomously.

Bioethics has not only dealt with issues on the frontier of scientific research (cloning, gene therapy, biotechnologies) but also with 'day to day' problems such as disease, physician-patient relations, man-woman relations, future generations, suffering, overtreatment, and equal access to health care, thus providing new food for thought to applied ethics.

The new discipline has progressively defined itself as the grounds for an intense political and cultural debate, determined by the presence of a consolidated but ever more inadequate morality, and of the drive to renew it. Public debate in Italy is distorted and often inadequate because it does not address the use of rational arguments capable of facing and solving, although not definitively, the ethical-scientific conflicts fuelled by the contrast between the ethics of the sacredness of life and the ethics of the quality of life. On the contrary, the persistence of rhetorical and ideological positions pervaded by a moralistic concept of man, where individual freedom and autonomy are marginalised and compressed, blocks every effort in that direction. Overcoming this situation implies a generalised intellectual effort contemplating the inclusion of bioethics in school programmes and forms of public debate and deliberation aimed at overcoming antiscientific prejudices belonging to idealistic philosophy that still pervade Italian society. This is the only way in which it will be possible to accommodate the necessary wealth of elaborations and interdisciplinary connections necessary to implement a mature reflection that measures up to the issues posed by bioethics.

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Epidemiological research

Liliana Cori

With the sharp increase in information circulated and in the possibilities of *communication*, questions and possible replies multiply. This is ever more topical even in many fields of science, which become common knowledge and leave the halls reserved to scientists. Epidemiological research has recently come to be among these. This biomedical discipline helps to understand how states of health and sickness distribute within the population, why diseases appear as well as to find their causes and assess health care and prevention aspects.

More and more individual citizens or associations want to know whether diseases, sometimes among family members or friends, are due to pollution, traffic, factory plants near where they live, or whether they are attributable to hereditary problems (genetic causes). Authorities planning territorial, environmental and energy production management activities are increasingly being asked what might be the consequences for people's health of new activities and projects. Epidemiology is an 'observational' scientific discipline, based on a planned and systematic observation of what has happened. This observation takes place after a hypothesis has been drafted and a 'study design' capable of verifying that hypothesis by analysing the information gathered with the appropriate statistical methods – has been defined.

What is considered the first epidemiological observation took place in London in 1854, when physician John Snow understood the environmental causes of cholera, enabling to intervene on drinking water and block the epidemic. He achieved this by systematically observing that most of the 500 people who had died in a short lapse of time lived in the area served by one of the city's three aqueducts. At that time it was particularly difficult to understand something of this kind, because it was thought that diseases were caused by 'miasma', i.e. mysterious poisonous vapours, and

that the only mechanism was contagion and direct transmission. Today the effects of microbes and parasites are much better understood, but there are new difficulties, because many diseases of our times are due to multiple factors, that is, they can be explained by a series of different causes that are connected to a person's lifestyle, the environment in which he or she lives and his or her genetic heritage.

When, for example, an epidemiologist wonders what causes the respiratory illnesses of the children who live in the imaginary town of Trisillo, he or she will be faced with many possibilities: traffic, a factory, cleaning products used at home, chemically-treated parquet floors at school or reasons connected to the children's sensitivity, such as allergies already present or the interaction of a variety of these factors. The epidemiologist will thus have to properly define the area to study and understand which might be the possible sources of pollution. In seeing a major highway with intense traffic, he or she can hypothesize that the disease is due to the road, but will not be able to exclude individual, occupational, social and economic cases and thus the interpretative model of reality will not have to be oversimplified.

The epidemiologist will have to gather information on where each of the sick children of Trisillo lives, and if the majority live or go to school near the highway he or she will have found a 'proximate risk factor' and will be able to give indications on how to limit the problems. In this case an hypothesis exists that is confirmed by data, supported by statistic calculations: nevertheless it is not a certainty, because respiratory diseases are typically due to many different reasons. Over time it will be possible to check the following factors: if traffic diminishes and the disease lessens it will be possible for the epidemiologist to say that his or her hypothesis was correct and that he or she contributed to solve the problem.

Therefore, there is a lot of information to transmit to those who are interested in research, in order for them understand the different scientific disciplines available, and their limitations and margins of uncertainty, and how one can make a decision although some uncertainty still exists. Research on the *communication of epidemiological research* is developing especially to solve these problems.

On the one hand we the need to give information on research

and on its results so that they are understood: it will be necessary to know the situation, create a climate of trust with the people involved, understand their points of view, their expectations, what they need to know, what they still do not know and the ways in which research can give answers or pose new questions.

On the other hand we need results that can be used to make decisions, that can be debated and compared and that fall within the working hypotheses, and which can then be supported by expert opinions on different issues.

Once we know that those children who go to school near the major highway get bronchitis in greater numbers and more often than those who go to country schools, and once we know that the situation can be improved by building tree barriers to isolate the road, by moving the school or by moving the road, it will be up to the Mayor and the town councillors of Trisillo to decide how to improve the situation.

By promoting the citizens' participation, they will be able to make decisions also on the basis of what the citizens think, and will be able to discuss the scientific conclusions with the goal of making a conscious and informed decision.

Open Access

Daniela Luzi, Rosa Di Cesare

Scholarly skywriting calls to mind a scholar communication model without time and space barriers. However, according to Harnard's 1991 formulation, it refers even more to a continuum that is a *live* recording of the evolution of scientific research, which is made up of various kinds of contributions, not necessarily complete and/or published. Therefore, it is both a constantly evolving, participated form of science and a model that merges formal and informal communication. According to Harnard, who considered the Internet to be its ideal channel, it is a «subversive proposal», since it radically changes the way in which scientific communication is carried out (going from paper-based to digital communication), but especially because it drastically transforms the ways knowledge is produced and diffused.

We cannot say that Harnard's dream has come true. However, surprisingly, the open communication models tested in those years within specific scientific communities (e-print archives) were widely accepted by international organisations and prestigious scientific institutions, but also by individual researchers and libraries. This consensus is expressed by the Open Access (OA) movement which encourages and supports free access to scientific information via the Internet, removing all kinds of barriers: economic ones, those that generated the 'serial crisis', legal ones linked to copyright and user licences and technological ones connected to proprietary hardware and software systems. The OA movement thus reaffirms an ideal of universal science and common good for society as a whole, as supported by Merton and De Solla Price in the 1950s and 60s.

The originality of this movement lies, in particular, in the fact that, besides issuing statements of principle, it identified development and success strategies for the creation of examples of

the free circulation of scientific knowledge. Such strategies, from developing open Archives to implementing institutional Repositories and increasing open access electronic newspapers, suggest communication models tailored to specific disciplinary contexts and respond to the needs dictated by specific research practices. Open disciplinary Archives are one of the most efficient channels for scholars to rapidly and freely communicate the results of their research to their entire scientific community of reference. Institutional Repositories enable Academies and research institutions to document their activities in ways that are visible even to a wider public while also highlighting the work of their scientific community, thus earning visibility and prestige in a civil society that demands an ever more active role in the choices and values of science. Open access electronic newspapers, produced by scientific communities and research institutions but also by small publishers, make available peer-reviewed articles, thus going against the oligarchy of the big publishing groups. Following the example set by the OA movement, the latter have been forced to offer hybrid models of publication and access to scientific publications (*pay per view*, *author pays*, *institution pays*, articles made available at a set time after their date of publication in commercial magazines, or time-limited access), which, in any case, are concessions towards the elimination of certain types of access barriers. In turn, by supporting OA examples, libraries recover their role as disseminators of research results and, among other things, support researchers in self-storing their works in open archives and repositories. Moreover, they support the spread of open access journals, thus trying to contain the increases in subscription prices (*serial crisis*), which are not justified by the increase in the production and distribution costs of scientific journals. In other words, these experiences are redesigning the roles and functions of the actors who are part of the chain of production, diffusion and assessment of scientific knowledge, and, in particular, point to the fact that the producers of scientific knowledge, be they authors and/or institutions, are regaining possession of the activities connected to the communication and diffusion of knowledge, which in the past had been delegated almost completely to commercial publishing.

The affirmation of the principles of the free circulation of knowledge, supported by the Open Access movement and contained in the BBB definition (Budapest, Bethesda, Berlin Declaration), beyond the different interpretations, are currently a strong example of the change and democratisation of the system of scientific communication, which it will be difficult not to take into account in the near future.

Institutions
Institutional communication and the Internet, the new frontier of law 150/2000

Giuseppe Sangiorgi

Today, virtual communication is the way in which institutions communicate more and more, although qualitative characteristics and standards are often still not homogeneous. As far as the technical aspects are concerned public administrations, at least central ones, are required to join to the national connectivity system, the PA network managed by Cnipa (National Centre for Public Administration Information Technology), while the set of rules regarding content and its transparency is contained in the Code of digital administration. According to this code, as of 1st September 2006 all public administrations had to obtain an institutional email address and a PEC (certified email) address to legally certify communications. All these processes must be supported and implemented with effective, pro-active encouragement policies, because the Internet is changing the entire network of relations between citizens and institutions, if not downright revolutionising it. Rur[1]-Censis surveys periodically take stock of the degree of digitalisation of at least part of the public administrations.

A proposal should be made, involving the University and the Cnr because of the competencies and professional skills of their researchers, to create a browsing system and digital format system to guide citizens through what is now the IT labyrinth of the Public Administration, which to date is not standardised.

Within this new context, 'institutional communication' is an expression fraught with ever-greater meaning and implications. First

[1] Rur (Urban network of representations) is the association promoted by Censis to draw up and promote innovative proposals for the transformation of cities and territory.

of all it has a strong constitutional value. The first reference is to article 21. We are currently witnessing a progressive hyperextension of this article: it is no longer about freedom of thought, press, information, but about freedom of communication, understood today as a new macroarea that includes the traditional publishing industry, audiovisual media, telecommunications and the new digital media. Institutional communication also means turning to article 3 of the Constitution for those aspects relative to the equal opportunities of citizens to actually participate in the life of their country. And it also means article 4, the citizens' right to know which opportunities can enforce their right to work.

All this poses the problem of overcoming the 'digital divide', which is understood as a factor that alters the citizens' equal opportunities. Today, broadband must be considered a new global service that must be accessible to everyone in all areas of the country. Thus a technical problem turns into a political one. A specific Broadband Committee was established by the government in January 2007 with the aim of bridging the digital divide within the following four years, also by coordinating the ongoing investments of the local authorities and of the central state. Then there are the expectations raised by the NGN, the new generation network, the network of the future, the hub of all further development of the information society in our country.

When speaking of institutional communication the topic is the relation between citizens and public power: a topic of equal opportunities and, therefore, of substantial democracy concerning the citizens' fundamental rights.

This relationship has changed a lot over the years thanks to the development of the democratic processes in the country and to the progressive awareness that such a development has engendered in the citizens *vis à vis* what we may call citizenship rights. In the past public power – understood in its wider meaning – imposed itself on citizens. The definition of state was that of an entity that was greater by goals and means than the sum of the citizens composing it. Today the situation is different: over time from a relationship of subordination we have passed to a condition of progressive recognition of the citizens' rights and dignity. Institutional communication is a major test-bed of this change, and of how far or close this

change is to being achieved. Citizens have duties but they also vociferously demand their rights. This causes a series of consequences, starting from the relationship with that branch of the central or local state with which each of us has to do with greater daily frequency: public offices.

This is the framework in which law 150 of 7 June 2000 was born, entitled *Disciplina delle attività di informazione e di comunicazione delle Pubbliche Amministrazioni* (Regulation of the information and communication activities of Public Administrations). For the reasons we have stated thus far, the Internet is the new frontier of this law compared to which law 150/2000 needs to be updated, taking into account the greater value of the Internet compared to all the other media: besides being a medium, it is also a service in itself that the Public Administration makes available to its citizens.

The website of the ministerial Department of Public Function contains a March 2006 survey of the citizens' opinion of the quality and quantity of the information made available by the public administration. This communication is considered insufficient by 24% of the citizens, mediocre by 56%, adequate by 19.4% and exceeding expectations by 0.6%. Thus we still have a long way to go to reach a level of excellence and the Internet can do a lot to improve this situation.

Anti-science
The viscous glue of past modernity

Andrea Cerroni

A short fairytale has lately been going around among *the initiated*. Here it is.

Once upon a time, in a not so 'Far Far Away' country, there lived a population of many many scientists (and also true lovers of science and great reformers, *civil servants* and far-sighted statesmen, free spirits, cultural anti-conformists and so on) who all believed Science was the queen of knowledge. Honours, glory and conspicuous commissions were bestowed on researchers (but also on all kinds of intellectuals and noble souls, indeed), so that they were able to tell the world that their country «had placed them in the best possible conditions to carry out their universally valuable work». Education was the universal drive of social mobility, and highly reputed scientists often became influential politicians. The greatest corporations fought over the best science graduates, especially those with PhDs, well aware that the best investment was in human resources, knowledge, research and education. Then, one awful day, a man appeared, out of nowhere. He looked meek and was then even more dangerous, even devilish (please note the irony at his being known by many as, *Sir Blessed*); in a short time, he spoilt everything. The details are not completely clear or even direct, but they are truly and patently diabolical, as everyone knows.

The Reader (and the Eurobarometer, the OECD and many others) is obviously well aware of what happened afterwards: teachers rapidly unlearned how to teach science *attractively*, students became so lazy that too often did learning become too *tough a matter* for them; eventually, even society began to form a *negative* opinion on science. The boys soon started to realize that it was far far better to become a professional football player compared to the demanding tasks of being a researcher (e.g. in self-assembling nano-balls). The girls started to consider the advantages of becoming a «barely-

dressed-starlet» compared to the demanding tasks of being a researcher (e.g. in dwarf-stars). University degrees in such subjects as maths were carefully shunned, such places as museums forgotten, as well as television programmes, journals and websites where the word SCIENCE was even slightly visible. Every one soon started to ignore such elementary notions as *what causes the night to fall*! So, obviously, since no one knew how to stop it any longer, night did fall down on them all, and it was pitch black. The following day, that country which, until then, had been *luminously* in favour of scientific culture and resolutely oriented to the *magnificent and progressive fate* of modernity (with the profusion of connected *categories of modernity* it had been given by history) woke up to meet with *decline*.

However, it was clear whose fault it was, and it certainly was not the scientists', entrepreneurs', politicians' and *ruling classes'*. Remedies were available, and would have been welcome to (almost) everybody, if only somebody had ever even tried a cure! But, as it always goes with fairytales, they all lived happily ever after, no matter how. That's the end of our fairytale.

Please do not label me a follower of Benedetto Croce, and do not accuse me of being in denial as to the real state of our country and its actual prospects (quite the opposite, unfortunately!); but, alas, if it is Italy we have been depicting, then this is truly a fairytale. This is another typical Italian affair which actually is, like our more or less… *divine* biographies, *slightly more complicated*. Leaving aside the *vexata quaestio* of the (so called) *crisis of* (so called) *scientific* (so called) *vocations* (cf. Cerroni, de Lillo, 2007), the presumed *golden age* of science and Italy's entire *modernization* (cf. any good textbook of Italian history) and even the issue of this country's ruling class (cf. Carboni, 2008), let us deal with the *Scientism-Anti-science* topic (cf. Cerroni, 2008).

Modernity, not just in Italy, is characterised by the indissoluble *Enlightenment-Anti-enlightenment* duo (cf. Sternhell, 2006), which strongly resonates with it. There really seems to be a deep-seated specularity between the positivistic and romantic visions, which are still very widespread in Italy, and are, in fact, largely dominant in Italy but also elsewhere. Therefore, the problem today is how to undo once and for all this perverse knot inherited by modernity,

in order not to enter the *knowledge society* 'backwards'. Indeed, we risk creating pairs of mirror-like myths, which, instead of fighting each other, pair up and replicate and whose mortal embrace is ever more difficult to escape from, like a strong glue.

The myth of knowledge being reduced to mere 'objective and universal informative content' (bit), goes hand in hand with the myth of daily life 'knowledge'. The idea of our body, reduced to a sequence of 'elementary and universal genes' goes hand in hand with the myth of *natural essences*. The 'atomistic' myth of physical systems goes hand in hand with the myth of the universal laws of 'complexity'. The myth of our intellectual activity based on 'neuronal units' goes hand in hand with the myth of the 'personal mind'. The myth of society as a sum of 'isolated individuals' (*homo clausus*) goes hand in hand with the myth of 'holistic structures'. A medicine that has turned extreme specialisation into a myth or goes as far as reducing doctors to 'machine operators' goes hand in hand with the idealization and the new business of a presumed 'holistic medicine'. Quantum-phrenia goes hand in hand with quantum-phobia, techno-phrenia with techno-phobia, late positivist scientism with late Romantic anti-science, and on we go with endless, vain disputes.

Therefore, Reader, the friendlier we are with science, the more careful we must be with the trend to channel it along culturally myopic *mainstreams* which seem to have been created on purpose to be effectively criticised by Anti-science. Moreover, the more worried we are about both the old and new risks that will tend to develop in the society of knowledge without a democratic *governance*, the more we must bring democracy and science together, so that they may invigorate each other, thus defending the former from the dangerous quagmire of proceduralism, the latter from scientism and both from false friends as well as from explicit enemies (which they often share and, Reader, wonder whether this is really accidental).

While the turned-to-the-past face of our identity torn us, its face looking into a future shareable and shared is made by Science *and* Democracy, tightly joint. These two are the highest values of what we call our civilization, and we have so much to work on them in Europe and even more in Italy, where modernity started and it still

remains today paradoxically, perilously unfinished. As you see, it becomes vitally important for communicating science at the beginning of a new era to free itself, once and for all, from the contradictory, viscous glue of past modernity.

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…media issues

Radio

Pietro Greco

Radio plays a very unique, original role in the public communication of science for three reasons that were pinpointed by Walter Benjamin already in the 1930s[1] and which are even more valid today.

«Before radio – wrote Benjamin – we didn't know any form of diffusion [of culture] which would correspond to highly popular goals». Seventy years ago radio was the true major mass communication medium. Today, despite the competition of new media, its ability to reach the masses in countries with mature economies – as well as in those with emerging economies and in developing countries – is once again confirmed.

Radio is unusual, because, as Benjamin added, «it is not sufficient to attract the interest of the listener […], the listener must feel that his personal interest has a substantial value». In other words, radio does not address passive receptors of information, as other mass media do, but co-protagonists of communication. Radio not only demands attention, but also involvement, at times even of the

[1] Walter Benjamin, article written for the monthly magazine "Rufer und Horer", quoted in Mazzonetto M., Merzagora M., Tola E., *Science in Radio Broadcasting*, Milano, 2005, p. 27.

factual kind. It is not by chance that radio invented both active and interactive participation thanks to the listeners' direct involvement in programmes.

Radio has its own specific, original ability within the framework of science popularisation. Benjamin added: «Because radio […] is no longer a popularisation which moves science towards the public, but also the public towards science». And indeed radio, seventy years after Walter Benjamin's intuition, enables direct, real dialogue between scientists and the non-specialised public more than any other medium of mass communication (including the Internet).

In short, radio anticipated and still contributes to the evolution of science communication to the general public. If the first cracks in the walls of the great ivory tower separating science from society started showing in Benjamin's time, today those walls have definitively crumbled. Communication between scientists and the general public has gone from being a slight possibility to an essential need.

Scientists and the general public are forced to speak to each other. Communication by scientists becomes richer and more effective when it is not a one way affair but manages to involve non-expert listeners.

What's more, communication between scientists and the general public is really fruitful and useful for the cultural growth of society when it is not a monologue but becomes a dialogue with the main characters.

This is why radio, having preserved and even improved the characteristics that Walter Benjamin already acknowledged seventy years ago, remains one of the media's most important tools to build up a scientific citizenship and a democratic society of knowledge.

Magazines

Claudia Di Giorgio

What if the 'audience of science' were a myth? What if the presumption on which our communication models are based, i.e. that there is a 'popular' demand for scientific information, were false? This is the question I've been trying to answer since, having gathered all the data, I happened to piece together the experiences of scientific magazines in Italy in the last few years.

About ten years ago, more or less in conjunction with the new millennium – which made wondering about the future trendy – four magazines appeared in Italian newsagents with many differences but with a common goal: bringing science to a vast, non-specialised audience. This was a television audience, both as far as numbers and as far as tastes were concerned. Indeed, it was not accidental that two of these four magazines, i.e. "Quark" and "La macchina del tempo", were connected to as many successful television programmes and their hosts. However, "Newton", born in 1997, also had a 'popular' style, not to mention "Focus", the Italian edition of one of the most successful German magazines, which had been introduced in our market already in 1992.

In fact, it was probably because of "Focus"' huge success, which came to sell up to 800,000 copies, that major publishers such as RCS ("Newton"), Mondadori ("La macchina del tempo") and Hachette-Rusconi ("Quark") decided to try their hand at scientific information, a topic that the Italian media as a whole had never paid particular attention to (just to give two examples, a prestigious newspaper such as "La Repubblica" has never had a science page, while "L'Unità" scrapped theirs during one of their first restructurings in the mid-Nineties).

At first this gamble seemed to pay off. In 2001, according to ADS data on annual media, "Focus" sold 614,367 copies at the newsagents, "Quark" sold 205,979, "La macchina del tempo" 103,507 and "Newton" 136,214 between newsagents and subscriptions. In com-

parison, "Le Scienze", a 'highbrow' scientific magazine, which was not very inclined to bow down to the requirements of a popular audience, that same year sold 67,407 copies on average.

In my opinion it is important to point out that, in the same period, in Italy it was the concept of the 'communication of science' that took hold, as opposed to the concept of 'popularisation', which emerged in the Anglo-Saxon world when it became clear that the relationship between science and civil society was critical: it was a confidence crisis that the model of the so-called 'Public Understanding of Science' did not seem capable of overcoming. The suggestion was and still is to replace the paternalistic model of information transmission with a dialogic model, based on a dialectic exchange between two subjects on an equal footing (scientists and civil society), and summed up in the definition of *Public Engagement with Science and Technology*.

Very many reflections were inspired by this new model, which Italy subscribed to with a slight delay but very enthusiastically, so much so that even in Italy the study of the communication of science has become a profession in itself or is trying to. Hand in hand with those reflections, university and post-university training courses for scientific communicators have since multiplied in Italy. Moreover, during the last five to six years, science festivals have flourished and their success has contributed to inspire an optimistic view of the Italian public's attitude towards science.

Regrettably, the facts tell a different story. Of the four abovementioned 'popular' science magazines, only "Focus" is still in existence, having, however, lost over 200,000 copies at the newsagents compared with 2001. The other three closed down between 2006 and 2007, with numbers that give food for thought. The last issue of "La macchina del tempo" (October 2006), sold 41,128 copies; "Quark" closed down in December of that same year with a little over 64,000 copies; "Newton" published one last special issue in January 2008, featuring a collection of old articles, after its sales had fallen by -54.7% between 2006 and 2007.

What about "Le Scienze"? Its circulation remains below five figures, albeit with a slight constant increase (around 7% in the last 24 months), which might also be attributed to an overspill of readers from the magazines that shut down, despite the major differences

in style and language. Furthermore, "Le Scienze" is interesting from another point of view, in that it allows an analysis of the readership of scientific magazines. Fifty percent of magazine sales has always come from subscriptions, an absolute anomaly in the Italian publishing world, whose readers by far prefer newsagents, but which, in this case, points to a precise trend of the readers growing fond of the magazine and considering it an investment 'good'.

This is an extremely synthetic overview of the facts that led me to wonder (without finding the answer, let it be clear) whether the conviction that 'popular' models do exist to communicate science is in fact a tragic misunderstanding. Scientific information has always been very fragile in the Italian media, and the current revolution of our mass communication system, in particular concerning printed media, obviously affects the science sector more than others. Furthermore, anti-scientific viewpoints such as creationism (an almost absolute novelty in Italy) are gaining space and authority. In parallel, the Italian political world's chronic disregard of scientific research has risen in parallel with funding cuts.

Rather than proposing new and often muddled models for the communication of science, in Italy today it might be necessary first of all to defend conquered positions, reconsidering, with a dose of humility if required, the merits and disadvantages of the approaches undertaken so far.

Mass media

Pio Cerocchi

Science in the media, that is, its communication by the media, is, let us say, like squaring a circle. Indeed, it is hard to imagine two entities so distant from each other: science is everything man studies with a critical method independently of the consequences that his or her studies may have, while the media, in order to survive, must focus ever more on emotional impact to the detriment of that tiny part of reason with which and for which they were originally born. In short, we should try to understand how and the reason why, i.e., the conscious use of rationality aimed at expanding the field of human knowledge, apparently needs such an ephemeral, banal type of communication.

Very well. If we wanted to continue with this paradox, we could easily find many arguments in favour of the idea that science as such does not really need to be popularised, since the results of its own research satisfy it. In short, every science has its own language (i.e. the history of a journey undertaken, goals achieved but also failures, etc.) and the language of reason is sufficient for each of them. However, since we are in the communication age, no one – apparently not even scientists – can afford the luxury of ignoring the main communication rules. Even without employing the usual hyperbole of «video therefore I am», it is a fact that non-communicated research can end up mired in the disinterest of those who, on the contrary, might be able to support it. And if you will allow this comparison, non-communicated science is like poetry that is never read or recited. It is possible both for poets and for scientists to exist without anyone knowing but – we wonder – is it imaginable to spend all of one's life in the shadow cast by the large and too ephemeral communication edifice?

It is evidently impossible; we must thus seek and find the means to establish the correct form of communication between researchers and the general public. After this long premise I would like to offer

a few short considerations on the existing form, which may serve to generate a better idea that many are now longing for. The structural impossibility of a narrative *continuum* of the media obliges scientists to pay a certain price to the trivialisation of the message, which inevitably tends to be channelled along two 'logical' pathways: one is «the first time that…» (indifferently followed by anything else, almost as an attribute) and the other is based on future predictions, such as «in a century's time…» etc. (see above). This is how we learned how and when man set foot on the Moon for the first time, and that the melting of the polar ice caps will raise sea levels, causing the disappearance of entire territories and cities etc. Besides, it is a well known fact that catastrophism is closely linked to predictions. Indeed, how much interest would be generated by the fact of knowing that tomorrow will be, if not the same, at least very similar to today or yesterday? In order to sell, science needs threats, neither more nor less than news needs crimes instead of non-newsworthy good news.

Hence, before my short paper starts having the same effects as 'Scamander's banks', where the poet Carducci bowed his head in sleep, let me point out a few simple prospects. First of all science must remain what it is, and accept the risk of not pleasing everyone (which, in any case, is an impossible task). Many people, therefore, will find science incomprehensible and (*propter hoc*) boring; others – perhaps not many – if science is not distorted by the obligations of appearing what it is not, might appreciate it for what it is, thereby producing that effect of involvement which what is desirable always arouses.

We might thus conclude that science will never be but a guest in the media. It is useless to delude ourselves further. Besides, when we say 'science' we have to be aware that we are speaking of an indefinable (perhaps unlimited) number of different arguments which are not even related to one another, including those that, unlike others, cannot even be bent to the logic of doom or of «the first time that…».

Therefore, what should we ask the media in exchange for hospitality? First of all not to turn science into a divination method, which, instead of bringing it closer to common sense, would end up alienating it even more. On a positive note, it might be easier to

make two requests: a little more continuity in communication, trying to present both a before and an after; and greater attention for the biographies of scholars and researchers. Indeed, a life history many times communicates more than the subject of the research. Scientists are well aware the histories of those who preceded them, paving the way for new knowledge. There is a lot to tell about science, but it is still an unwritten story.

Creative writing

Nadia Tarantini

At times the worlds that appear farthest away are actually contiguous. Often, by changing our point of view we can transform distance into closeness. We consider science to be the world of rationality – the North Pole – while creative writing is the world of intuition and imagination – the South Pole. And yet the most effective way of communicating science – as many similar experiences show – draws precisely on the methods of creative writing. It's not by chance that the first brilliant scientific documentaries were born in the Anglo-Saxon world – the same world that was the first to study and theorise creative writing. *Creative writing* has been taught in universities for decades both in New York and at Oxford and many other countries have no other way to call it except by its English name.

The path towards creating a story can offer useful hints to those who want to divulge a scientific discovery or the report of a more or less lengthy research process. When we sit in front of a white sheet of paper, anxious to create a story, the first thing we need, the first tool in our 'tool box' (to paraphrase Stephen King), is an idea. The *big idea*, as Hollywood screenwriters call it; the *concept*, as the copywriters say. Every novel, film or opera libretto can be reduced to that 'idea', which is simple but so difficult to formulate if our creative goal is not clear. *The Betrothed*: two 17th century youngsters love each other but a powerful, arrogant local baron tries to prevent their marriage. *Gone with the Wind*: a young Southern belle survives defeat in the American Civil War thanks to her attachment to the land. *La Traviata*: a courtesan renounces love to redeem her meaningless life with a noble sacrifice (and dies). We can also use the same thing to begin our science communication project: what is the *big idea*, the essential concept of the event, of the story or of the research that we want to divulge? It might be the discovery that the Earth revolves around the Sun (Copernicus); but

also, or vice versa, the previous failed attempts to prove it. What is important is to be able to write a line or a line and a half about our starting point.

In order to flesh out an idea we need an environment and some characters. And a measure of time, the factor that keeps environment and characters tidy when weaving the plot originating from the idea. Before you start writing, you need to know who will be the lead characters in your story (possibly not too many). As the great Ernest Hemingway used to say, when writing about a character you need to apply the *iceberg theory*: you must know everything about him or her (iceberg), although you are aware that only a small part of them will be revealed (visible iceberg) in the tale; the greatest part will remain unknown to the reader (submerged iceberg) but you must know everything, even of the cashier handing you the receipt who only appears in a very small scene and doesn't say a word. Because if you don't know who the cashier is, what he or she thinks and what he or she has done in life how can you imagine that gesture, the uniqueness of that personal gesture? And you must know everything about the environment. No idea – not even a great scientific discovery – can hold up without the context in which it was born, grew and developed, in which it met with consensus and opposition, in which it took root or was forced to migrate… Painting the context should not be difficult for a divulger of science: in fact, it should be a familiar concept. And then we have the time factor. How do we want to build this story now that we have an idea, an environment and some characters? It has to be done scene by scene, as creative writing teaches us. Each scene, as Raffaele La Capria writes, has two main tasks: it must be self-conclusive, it must have a meaning even when it is detached from everything else; and it must bring the story a step or more forward. We can modulate the timing of a story in a linear way: beginning, development and end, as in a fable, and indeed the Russian formalist linguists named the chronological development of a story *fabula*. Or we can weave past, present and future in a more dynamical way, in order to increase the story's interest and passion. We can begin with the main point: Albert Einstein writing that small, magical formula on the blackboard: $E=mc^2$, and then flash back to the moment in which the journey leading him

there began. We can interrupt the story's linearity again with an anticipation (*forward back*) of where his activity as a scientist will lead him (Nobel Prize). If necessary, we can even *digress*, and write something about the city in which he lived for a long time, Berne.

To this essential, skeletal writing approach we must add the yeast of *conflict*. The tales that captivate us ripen, like good cheese, thanks to the humid shadow of the contrasts that oppose the main character to the antagonist; and both to *fate*, which shuffles the cards of our dreams and goals, to society that thwarts their success, and to enemies always waiting in ambush, even among one's friends. But I think that scientists and science divulgers know more about these topics than us writers and teachers of *Creative Writing*.

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The Press Office
A bridge between citizens, media, institutions and science

Marco Ferrazzoli

What kind of scenario in the relations between science and communication is revealed up from an observation point such as the Press Office of Italy's National Research Council? From an insider's perspective, what is evident is especially the greatest Italian research institute's major institutional and territorial presence (over one hundred institutes throughout Italy) and competencies (11 Departments for macroareas covering almost the entire sum of human knowledge), an ideal supply chain ranging from pure research to technological application in enterprises. For those who are animated by the curious 'Socratic' ignorance – the only possible approach to managing such a huge, complex cultural mass – it is satisfying and amusing to deal with food farming one day, health another day and climate and environment yet another, or to create links between apparently opposite disciplines such as the protection, conservation and enhancement of the historical and artistic heritage and innovative diagnostic techniques.

However, the difficulties are not just related to the 'luxury' of having to make a selection. One must also counteract the scientific network's tendency to isolate itself in the ivory tower of specialised and peer-reviewed publications, haughtily refusing contamination with the global village, of which, in any case, the structural defects are evident: rushed timeframes (concerning analysis and synthesis), non-existent qualitative evaluation (the incompetence of those who mediate, in this case, is not a motivating force but a limitation), and the tendency to stand out in the chaotic and crowded mass media world simply by raising one's voice.

The Press Office must operate within the gap between two different textualities bordering on opposite cultural autoreferentialities.

On the one hand we have the language – proof of a profound mental, psychological and epistemological attitude – employed by a researcher who addressed the Cnr Press Office in these terms: «I am contacting you to inform you that in the next issue of 'XYZ' there will be an article on […]. In short, the epigenetic modifications induced by estradiol on chromatin in the regions regulating target genes are analysed, demonstrating in particular that hormone stimulation, by inducing the demethylation of lysine 9 of histone H3, causes […]. I apologise for the generic nature of my email».

On the other hand we have journalists who often do not conceive of scientific interest if not in alarmist or thaumaturgic terms, refusing to treat anything other than apocalyptic scenarios of pandemics and natural catastrophes, or illusions of lab-engineered panaceas. This shallowness, which often borders on the unprofessional, is caused in part by the deluge of news items, even important ones, issued each day by the mass media, in part by a few irritating attitudes. For example, the attitude of the assignment editor of a national newscast, who, inquiring about a two-year-old press release, ignored at the time and probably recovered by chance in a pile of email, asked: «Is it still a scoop?»

The Cnr Press Office tries to bridge this corporate miscommunication gap by adopting a rather simple strategy: minimal institutional autoreferentiality and maximum attention to 'already achieved' research goals; utmost translation effort, without the fear of discussing national mainstream topics such as the conservation of buffalo mozzarella and shopping bags made with tomato processing waste, and 'extreme' research at the vertices of the ideal triangle formed by the two Poles and the Himalaya; great attention to content validation, which the scientific network guarantees, but also to the requirements of the news industry, to which the Cnr provides experts daily for explanations and comments.

Information given by the press is only a part, and perhaps not even a large one, of scientific communication, which is, as a whole, an extraordinarily important element. First of all for the gratification that those who deal with it derive from their own work, when it is successful. In part because of contributing to promote an institute that carries out a key mission for the country's cultural, social and economic development.

But, above all, informing, mediating and spreading data through press releases and articles means bridging the gap between citizens, institutions and science in order to make people understand that research is a major, not-to-be-missed opportunity for our future and an essential, unavoidable element of our present. This is proved by the great issues which we are ever more often called to speak about: global warming, the comeback of nuclear energy, alternative energy sources, agricultural policies, defence of Italian-made products, genetic engineering, increase in life expectancy, health protection… No matter what problem society is facing, we are right in affirming that greater, improved knowledge is the only means to make choices which are more respectful of the common good and of individuals.

This is the challenge and the strongest motivating force for those who deal with science and communication from the 'front office' of a Press Office.

Affection
Major questions are like narrow neckties

Romeo Bassoli

Like waves crashing ashore, the scientific communication/popularisation market ebbed towards the end of the 1980s. Then the foam of various magazines such as "Focus", "Quark", "La macchina del tempo", "Explora" and "Newton" flooded the beach of the 1990s and of the first few years of the new century.

However, low tide is back again. Many magazines have shut down and their hundreds of thousands of readers seem to have vanished into thin air.

Does this mean that the readers' interest is a pendulum? The interest of marketeers certainly is. But, beyond this fluctuation of the printed science market, what is the demand for culture, knowledge and close contact with the discoveries and facts of science?

There are very few signals that can help us understand this. Surveys paint Italians as both trusting of scientists and wary of their ability to express ethical judgements. They are interested in science but a worryingly high number of them lack the basic knowledge to understand what is being discussed.

Therefore, the 'fine print' of widespread scientific culture is, at least for me, difficult to interpret.

However, thanks to my job I can closely observe the changes in the culture of those who package information products to sell to people, i.e. the managers of the media and of the Italian publishing world.

The curve drawn by these last twenty years is clear (to me) here.

In the 1980s and at the very beginning of the 1990s, a twofold vision of science was still prevalent. On the one hand there was the demand for outcomes – especially in the fields of energy and of medicine capable of combating infective diseases such as AIDS. On the other there was an (ever weaker) concern for the major ques-

tions: the beginning of life, its meaning, the essence of the Universe and the rules that regulate all that exists.

When the triumphant hedonism of the 1980s ended its cycle even within the higher levels of the media, major questions completely lost their attractiveness. No feeling related to existential issues was acceptable. Actually, one was: boredom.

It was considered that, since scientists did not have to deal with major questions, it went without saying that they did not even have an ethical authority. And they had no reason to, because their research did not have to address fundamental, momentous issues. Others would have their say, but not the knowledge-seekers, because the latter were no longer justified by Major Answers.

The obvious corollary is that scientific research (and therefore news) nowadays only makes sense if the knowledge it implies intends to lead to something practical, concrete and more or less immediately usable. Scientists have lost what distinguished them from technologists and now form a single entity that can only be justified by the direct relation between curiosity and (application) motivation.

Therefore, scientific culture cannot have an ethical value (and point of view) within the media culture, because it must only produce objects, methods and substances. Trying to understand the laws and mechanisms behind these has lost its significance.

Is this science's divorce from 'natural philosophy'? It certainly is in the minds of the media managers. And it translates into a substantial disinterest both in basic research (the idea that it is disinterested resembles a perversion) and in space research, considered as passé as a 1960s western.

This is true unless, in either field, disasters, black holes, explosions and risks for people are involved. In short, these sciences seem to arouse more interest because of the damage they can cause than because of the discoveries (considered negligible) or performances (lacking any type of practical interest) they can achieve.

Of course I am being extreme in my analysis but not that much. During these years spent collaborating with various national newspapers first and then as head of the press office of the particle physics institute, the message that has reached me almost unanimously from the media managers has had a consistent ring to it: we do not

want stupid, major questions. The only good question is the one beginning with «what is it for…».

I would like to return to the beginning of this short paper and to the ebb and flow of the science market. Has this view of the scientific culture percolated from the media to the general public? I am not sure. What I do know is that it perfectly coincided with the marketeers' view, who were convinced that the only magazines that could be sold all had to cater to this practical idea of science. Which meant that there were no alternatives ready when this type of offer saturated the market. I do not mean to say that the market existed and was not exploited. I intend to say that they did not even try, convinced as they were that philosophy, Major Questions and Major Answers were out of fashion just as the rules for creative finance, market transparency, the centrality of the material production of goods and narrow neckties.

Passion

Nadia Rosenthal

The master painter disposes the colours for the sake of a picture that cannot be seen in the colours themselves.

The Buddha

I never thought of myself as a scientist, at least not in the way scientists are conventionally portrayed to the public: solitary dishevelled figures working late, bending over bubbling beakers, with calculators in the pockets of their labcoats, oblivious to their surroundings. Of course that probably is exactly what I looked like as a molecular biology graduate student at Harvard in the 1970s, but inside my head I was exploring a world most people never have a chance to see. My childhood in a family of artists had prepared me for a different obsession, but this new world, opened up by an inspiring high school teacher, was even more compelling. She showed us how awesome was nature in its detail, beautiful and unpredictable. And I was hardly solitary. I felt I was swimming in a broad stream with all the other biologists who had worked before me and the ones who will come after. The history of science is not a history of humans, but of human discoveries, measured not against each other, but against nature itself. That was what gave me strength during the times when the going got rough later on. The promise of a truth that would stand up to nature's scrutiny made the hard work and endless obstacles of no particular consequence to me.

Decades later, I still feel this way, and I do whatever I can to foster the same excitement in my own students. As scientists, we are all bitten by the same bug of universal curiosity and have the same dread of personal failure. There are a thousand subtle and not-so-subtle ways to discourage a young researcher, to distract her from

the joys of discovery and dissuade her from demanding more space or more support when she clearly needs and deserves it.

It's important to identify our own impediments. We are not all well enough equipped to deal with competition – for positions, promotions or papers – and competition is a constant in research. Above all, we need to recognise the power imparted by external research funding. I once sat on a committee to analyse the plight of women (or lack thereof) in senior research positions at my institute and was mortified to discover that female laboratory heads were receiving, on average, 40% less NIH funding than their male counterparts. For years I had served on NIH grant review panels – how could I have missed this blatant discrimination on the part of my colleagues? The real horror struck when we examined the data in detail: the women had asked for 40% less money on their applications. I repeat this tale to every young postdoctoral fellow leaving my laboratory. They understand the message: «Male or female, you won't get what you do not ask for in this world».

How then, do we promote a sense of entitlement amongst our young scientists? It's a multifaceted problem that requires much more attention than it has received. Young scientists need guidance on aspects of training, mentoring, networking, and communication so essential to a successful scientific career. But the most important common denominator among successful scientists has been a personal passion for science, of which they never lost sight.

Though it hits everyone differently, the feeling of infectious curiosity is unmistakable. My own obsession with science sprang, unexpectedly, out of an early passion for art. I began drawing as soon as I could hold a pencil. I'd draw anything I could. I wanted to see if I could get it just right. Every detail in nature raised persistent questions about general form and the forces that shape them, and convinced me that the biology of pattern formation would satisfy my curiosity more than painting ever could. In my ignorance, I was sure that nature would reveal her morphological secrets to me.

Of course, I never found those morphogenetic charts at university, nor anywhere else for that matter. It wasn't until I came across a popular science magazine in my university library that I realized how limited the collective knowledge was at that time. A picture of a child's outstretched hand was on the cover. The caption read: «How

Does a Hand Know to Become a Hand?» but the article didn't shed much light on the actual process of limb patterning, and instead posited the presence of hypothetical morphogen gradients and reviewed current concepts of positional information. I was fascinated, and rushed off to do more reading, but emerged disappointed by the lack of mechanistic detail in the articles I found. My professors only affirmed what I suspected: the field was awaiting the molecular revolution that would take another two decades to unfold.

During the interim, I found other satisfactions: first in the revelation of evolution at work as we caught our first glimpses of mammalian gene structure; then in the pursuit of illusive molecular interactions underlying the new genetic code of eukaryotic gene regulation; later in the excitement of testing our hypotheses of transcriptional control in living animals through transgenic and gene knockout technologies. It has been a capricious path, but peopled with marvellous colleagues, and the synthesis of collective discovery is a joy for which nothing I learned from my textbooks could have prepared me. Despite the practical difficulties and psychic pitfalls, I have maintained a sense of freedom to pursue my curiosity – not only because of some lucky breaks along the way, but because I found I just couldn't put up with anything less. I tell my students to do the same when they enter the laboratory, and it has paid off over and again. Thirty-five years after my original epiphany, I am finally returning to the problem of vertebrate limb morphology, thanks to a brilliant student who showed me how to approach the subject in a novel way, using all the wondrous tricks of the trade we now have at our disposal.

As I reflect on the characteristics that help scientists realize their dreams, I am impressed by the resilience we need to withstand the tribulations of the profession in order to keep focused on discovery and on the promise of epiphany that originally drew us into the field. It takes clever strategizing to keep doing what you're interested in doing, in the face of shifting fashions and inconsistent funding. The politics and practicalities of research are necessary parts of the game, and can work just as well *in* your favour as against it. But the centrepiece has to be the science. If you are truly obsessed with a magnificent question, nature never lets you forget it.

…education and edutainment

Learning

Silvia Caravita

Science education is the target of specific studies within the framework of international psycho-pedagogical research. Although marking the distinction between learning as memorisation of information or procedural routines, and learning as understanding, as the capacity of using and generalising knowledge, makes the starting point for the design and evaluation of any didactic action, this problem takes on particular relevance in the teaching of scientific disciplines. It also triggers different approaches when it is tackled within the framework of the communication or of dissemination of science. Within the school context, in fact, explicit and implicit 'pacts', goals, motivations and schedules are specifically conditioning the relations among the participants in the knowledge building process (the learner with the other learners, with the 'object' to learn, with the teacher, with the environment).

Modern societies need to continuously raise the quality of technical and scientific development and this can be ensured only by young generations capable of innovating, reorganising and transferring knowledge in new and unforeseen contexts. These competences presuppose that the learnt notions have been transformed into culture and into the construction of a person as far as all of his/her potentialities are concerned. The attainment of this goal becomes all the more necessary when education is ultimately aimed at enabling the students to enact citizenship rights and duties and to envisage the future by taking a long-term view, as it should be intentionally pursued by the School according to what is frequently stated in the institutional documents.

Why are scientific subjects, even more so than mathematics,

such a weak point of basic schooling? The main cause is attributed to the special epistemological status of scientific knowledge in opposition to common sense, because science is built up through different thought and empirical procedures distant from daily life. The phenomena which scientists (or maybe school books?) talk about seem to belong to a 'different' reality than the one familiar to us, the descriptions of facts seem counter-intuitive, the undisputable 'truths' seem to respond to questions and offer solutions that sound foreign to the way in which we commonly perceive and formulate problems.

This focused view on the conflict between science and common knowledge has dominated the research carried out on the learning/teaching processes but the many and deep observations collected in school contexts enabled the science educators to better understand in which terms the conflict emerges and which are the conditions to create for preventing it as a real obstacle. I will try to 'throw a flashlight' on the main achievements of current research, which has also received important inputs from the development of philosophy and sociology of science. I will list and reduce to a nutshell some of the statements that have characterized important branches of research and that also emphasize current ways of dealing with the problem.

Children discover how the world works by applying the same thinking procedures that scientists use.

Science and knowledge proceed through the structuring of mental models on reality and their more or less radical change (sometimes up to their replacement) in relation to the experiential evidences.

In the actual practice in the laboratories as in the historical development of the disciplines, the making of science is not a linear process, it does not sequentially apply principles of hypothetic-deductive logics, it is not a rational process only, it is contextually determined.

Individual cognitive processes evolve in social contexts through the interaction with others and communication through symbolic languages. The abilities of argumentation and of knowledge representation in ways suited to its content are essential components of scientific knowledge.

Learning takes place within culturally defined practices, as a process of progressive more competent participation and appropriation; these practices include those pertinent to science, which are also conditioned by the intellectual and material artefacts that are made available to the students.

Teaching is not only defined by the didactic discourse but by the learning environments that it creates, which are not only places but systems of components and conditions mediated by the teacher; science labs and field activities are a specification of these environments.

Teaching strategies must be able to build contexts for the learner in which the 'objects' of learning acquire a meaning in relation to the learner's own experience and personal history.

It is impossible in this short text to go deeper into each of these statements to define the concepts that are mentioned and to highlight the relations with the theories on cognitive development and on learning, even pointing out the dissenting points. The relations that exists between contents, processes and contexts of knowledge acquisition, and also the interconnections between cognition and emotions continue to be critical issues in the cognitive sciences that, in the last few decades, have explored the problems of representation and memorisation of knowledge (both by psychological and artificial systems).

Research in scientific education has carried out many investigations on *naïve conceptions*, i.e. the theories that each of us builds up about the facts and phenomena of the world ever since early childhood.

The results of these studies effectively contributed to a more precise understanding of what is shared and what distinguishes common thought from the 'expert' thought of science. Not the nature of the cognitive tools is different, but the ways of using them and the reality to which they are applied: scientific practice specialises and systematises methodologies of action and of reasoning which are aimed at freeing, in part, from the subjectivity of human perception and from the concreteness of details. The reality that is the object of experimental procedures is a reconstructed and conveniently simplified reality. The motivations of people and of scientists to understand and interpret the world in order to be able to anticipate events and to act effectively and safely are not substantially different, but their goals are: scientists search for explanations that may enable the construction of consistent models that have a general scope, people instead need sufficiently inconsistent and flexible theories that can be adapted to the variety and complexity of the everyday situations and to the ways in which each individual experiences them.

The surveys concerning the students' mental representations of the key topics taught in the science curricula and about the *organizing concepts* of the disciplines have been followed by the study of the factors that in schools can promote the evolution of these conceptions to bring them closer to scientific culture. The relevance of the psychological and social aspects of the interactions that develop in classrooms quickly made itself clear: it is not only knowledge that is in play but also personal and social identities under construction. However, the nature of the conceptions and of the theories on single aspects of reality, together with the processes of their elaboration, depend both on the contexts in which they are used, and on 'naïve' theories concerning knowledge, its nature and the rules of its organisation (epistemological beliefs). Therefore, it is not sufficient to develop knowledge: it must be integrated with beliefs, motivation, and attitudes connected with knowledge.

I will end on a critical note concerning us as researchers.

> *After 100 years of systematic research in the fields of education and educational psychology, there is, in the early 1990s, still no agreement about whether, how, and under what conditions research can improve educational practice. Although research and educational practice have changed substantially since the beginning of the twentieth century, the question of how science can actually contribute to the solution of real educational problems continues to be controversial* (E. De Corte, *Learning and Instruction*, 10 (3), 2000, p. 251).

The *unproductivity* of educational research is attributed to the lack of strong theoretical models, to the complex nature of the phenomena it studies, to the difficulty of generalising results and to the obstacles encountered in school teaching,…

…but might it not depend on the way in which research and researchers approach their relationship with the school?

Museums
Between conservation and change

Elisabetta Falchetti

Science, communication and museums: these three words are spontaneously associated with science museums. In the most common social representations, museums are still places where collections of natural objects and scientific instruments are preserved and exhibited to «teach science… and educate», thus playing a didactic role. However, science museums are ever more viewed as (and expected to be) places in which to make interesting and amusing discoveries and that are also suitable for pleasantly spending one's leisure time. Other ideas will probably widespread as new museums are born, historic ones are renovated and institutional roles and communication methods are reshuffled to respond more efficiently to the pressing requirements of the popularisation and democratisation of science. Today, when we speak of Science Museums in the plural, we refer to the great variety of institutions – with different contents, characteristics and missions – that are the expression of current scientific knowledge, with its wealth of ideas, many fields of application and possibilities of interpretation. In historic natural science museums divided by discipline, such as zoology, palaeontology, geology, and chemistry museums, but also in botanic gardens or zoos, the collections are the soul of research and communication activities. Next to them, several museums, sometimes even without collections, have made their mark as *interpretative centres*, *science and technology museums*, and *science centres*. They are inspired by the cultural goal to provide practical and explorative activities in parallel with the experimental aspects of science, as a means of building up the visitors' scientific knowledge.

The link between science and museums is old (and well established) and the popularisation of science is not its only aspect. Science's *life history* is mirrored in the history of its museums: indeed, they were born in the same period and co-evolve. Collections and

cataloguing methods, types of research, professions, exhibition criteria, communication choices and even buildings have changed over time in parallel with changes in scientific thought and in the relations between science and society. Natural science museums, for instance, were born at the end of the 16th century and consolidated in the 17th and 18th centuries, *for* and *with* a new science that chose objectivity and experimental approach as its statute. This science needs to observe, describe, name, compare and document in order to improve its investigation and knowledge criteria; this is why natural objects are collected, classified and preserved in museums, in glass cabinets or drawers, such of Aldrovandi in Bologna or of Cuvier in Paris. Continuity of ideas and great scientific revolutions can be perceived from laboratory and museum techniques; nowadays, historic investigation methods are supported by biomolecular technologies and complex electronic instruments, which open the door to other knowledge prospects. New facilities, such as the Darwin Centre in London's Natural History Museum, render conservation more efficient and make everyone more aware of the role and irreplaceable nature of collections: specimens do not lose importance, nor are they static or dusty; on the contrary, they always tell something new and nourish science, which restudies and reinterprets them today in the light of new theories, new research needs and new epistemologies, built around the objects themselves. The museums of scientific instruments document the co-evolution of knowledge and technology: new discoveries generate new instruments and vice versa.

Museums have been (and are) the context for the construction of science and for its consolidation in society; indeed, they disseminate results and thought processes, affirming their cultural and practical value implicitly or explicitly. Communication methods tell of other stories of change. Today museums are not limited to the 'pure, naked' exhibition of objects, which were presumed to speak for themselves, but present knowledge and methods of a complex, systemic science which not only describes but also studies origins, causes and relations among phenomena. The narrative style is engaging, the exhibition techniques inspiring, the education strategies well planned and open to dialogue with a wide, varied audience. The possibility of discovering science autonomously

by means experimental paths through exhibitions and educational labs is also provided. Finally, communication also reaches outward through websites and local events and activities.

What are the potentialities and prospects of science museums in an ever-changing society whose relationship with science is currently difficult? Museums are evolving cultural centres, but their connotations and resources are capable of laying the ground for change and providing references and stability: the stability of the cultural value of the collections as research, study and documentation tools; the stability of the historical value of thought, artefacts and scientific events; the stability of the educational role played by exhibitions and cultural activities. At the same time, museums are open to transformations deriving from changes in scientific culture and from the various social needs, and even from continuous exchanges with an ever more conscious audience. One of the most significant results that museums can achieve is to convince the public that science can be interesting for everyone, even in one's spare time: they should portray science as comprehensible, close, gratifying and advantageous, both *culturally* and practically. The goal of modern museums is not only to be efficient mediators of contents, but also generators of encouragement, motivation and openness towards science and culture in general.

Finally, today, in such a strongly disenchanted society, we discover that museums can be re-enchanting, astonishing, amazing places in which imagination and creative thoughts can run free. The museum environment, the objects and methods of communication that enhance the emotional components of learning, generate many types of cultural experience. We can leave a museum having gained new disciplinary knowledge or we can leave without reading a single information card or using a single software programme, but bringing with us the positive effect that the museum has had on our interests, states of mind, values, attitudes, and awareness. And this is an unique prerogative of museums.

Astronomic observatory
The dissemination of Astronomy: a bridge between science and society

Vito Francesco Polcaro

Astronomical phenomena have been observed since the dawn of civilisation and the attempts to interpret them have been a driving force for the development of human thought. Astronomy paved the way for most of the 'scientific revolutions' of all times (from the roundness of the Earth to the 'Copernican Revolution', from Newton's Laws to the Theory of Relativity).

Astronomy is thus an activity that is justified first of all by its own enormous ability to increase the cultural heritage of humanity, placing the human being in relation with the entire Universe: for this reason it has an uncommon appeal compared with other disciplines. Indeed, it is one of the few sciences that are practiced not only by professionals but also by many 'amateurs', who often devote to it more intellectual, physical and financial resources than they devote to their paid jobs, at times even reaching valuable scientific results: even just the members of the Italian Amateur Astronomers Union (UAI) are around 40,000. Moreover, amateur astronomy magazines sell more copies than all the other science magazines put together (excluding archaeology ones) and schools, cultural associations and local authorities continuously ask professionals, but also expert 'amateurs', to give conferences.

However, the fulfilment of these requests for astronomical knowledge is, in our country, almost completely entrusted to the goodwill of the individuals working in this sector. Indeed, Italian school programmes incredibly do not pay any attention to this discipline, notwithstanding its enormous formative value. After the rudiments learned during the first cycle of compulsory education, students must wait until the last year of high school to receive further training in astronomy. However, according to an outmoded

approach dating from over a century ago, this task is entrusted to the teacher of 'Natural Sciences', who is usually a biology or chemistry graduate. Therefore it appears that Astronomy (or rather, as it is called in the ministry's programmes, 'Astronomical Geography', a discipline with a Ptolemaic ring to it that only exists in Italian schools) should be taught by people who have never studied it at university level and, apart from a few praiseworthy special cases, have never even had any interest in studying it. Moreover, the school programmes for this subject are not only based on a completely outdated view of astronomical knowledge, only marginally touching upon the current frontiers of the knowledge of the Universe, such as stellar and galactic evolution and cosmology, but also totally ignore cultural astronomy (the history of astronomy, ethnoastronomy and archaeoastronomy) which, on the contrary, could be essential in overcoming the barriers between the humanities and scientific culture, which, quoting Geymonat «have caused humanity so much damage».

Indeed, the analysis of the astronomical orientation of monuments and burial places is often the only method to obtain any information on the religious beliefs of peoples of the prehistoric and protohistoric period. The documented coincidence with significant and identifiable astronomical events (eclipses, transit of known comets) enables the exact dating of historical events. The comparison between the descriptions of the same astronomical phenomena written by observers belonging to different cultural environments within the same historical timeframe enables us to highlight the differences and analogies of their respective 'world visions', while the study of astronomical phenomena that may be connected with the origins of myths enables a less ambiguous interpretation of them. Cultural astronomy, therefore, shows that scientific knowledge is the offspring of the society that generates it and of its needs, proving the falsity of the statement of the 'neutrality of science'.

Astronomical dissemination today must therefore close these two gaps in the Italian school system: on the one hand it must give young people a vision of the evolution of the Universe as it can be effectively deduced from the current state of our knowledge and, on the other, it must make sure that astronomy is considered a

branch of knowledge that is attentive to human beings and to their more general social and cultural problems.

In order to respond to the first of these needs, the ROADr (Rete di Osservatori Astronomici Didattici remotizzati – Network of Remote-Controlled Educational Astronomical Observatories) was founded in collaboration with the IASF-Roma of the Italian National Institute of Astrophysics (INAF), the associations of amateur astronomers based in the Lazio Region and the Planetarium of Rome, and funded by the Lazio Regional Government and by the Ministry for University and Scientific and Technological Research following the Law on the Dissemination of Scientific Culture. It aims at providing schools in the Lazio Region with a new tool for the teaching of science, by employing new technologies capable of allowing students and teachers to have access to a real astronomical observatory, enabling them to make personal remote-controlled astronomical observations from their own schools, to visit amateur but high level astronomical observatories, and to attend seminars and astronomy lessons both in the classroom and by teleconference. With the completion of the first two telescopes' remote control system, the ROADr Network is ready to become operational.

In order to respond to the second need, various initiatives are starting up, such as the Center for Astronomy and Cultural Heritage of the University of Ferrara and the Master's Degree in Cultural Astronomy organised by UNLA-UCSA and by the Italian Archaeoastronomy Society, which also complies with the decision made by UNESCO to include, in the list of monuments that have been declared 'World Heritage', a subgroup devoted to 'Properties of Astronomical Interest'. This decision spawned a UNESCO initiative called *Astronomy and World Heritage*, aimed at conducting a census of this special cultural heritage. This group includes both monuments of archaeoastronomical interest, ancient observatories (such as Ulugh Beg's in Samarkand, Tycho Brahe's in Hven, etc.) and ancient astronomical instruments and, in general, any kind of material expression of human creativity connected with Astronomy. UNESCO has proclaimed 2009 as the 'International Year of Astronomy': this might be the chance to haul the dissemination of this science out of its pioneering stage and assign to it its proper role as a bridge between science and society.

Education
The relation between communication and teaching

Emilio Balzano

«…It interests me as a citizen, that's why I'm learning it!». This is what a Portuguese civil engineer told us in an interview during an informal activity on seismic risk assessment developed within the framework of the CIS Project (www.cisproject.eu). In this activity the engineer debated with his colleagues and experts on how to streamline communication in a civil protection programme. Communication in the scientific field is considered very significant today and concerns more and more fields beyond the journalistic one. In particular, I will try to offer a few suggestions that are at the basis of my experience matured in borderline situations between communication and teaching and between formal and informal contexts. These situations, in which it is necessary to experiment with unexpected contaminations, new strategies and languages avoiding banality, superficiality and improvisation, are becoming more frequent. The topic of science communication has only recently been imported into our country: good experiences exist in the training field, communication models are actively studied but not much is done in the experimentation field and in the implementation of resources and materials. There are multiple causes for this and some of the factors are the prevalence of a sociological approach over a commitment of those who *make science* which is still not decisive, the scarcity of a new generation of museums and the lack of funds destined to field research. Thus, for example, there are no initiatives such as the ones organised by the Nuffield Foundation – which has recently launched *Science in Society* (www.scienceinsocietyadvanced.org) renewing *Science for Public Understanding* which has been active since 1998 – and museums, even new ones, find it hard to become forums for the debate on *science and society*. Despite the numerous initiatives, the promised 'new

agora' as a meeting place between citizens and scientists, citizens and institutions mainly translates as a series of museum activities addressed to schools. And, in the absence of examples of teaching materials, and of guidelines on how to develop cross-curricula and interdisciplinary pathways, they remain isolated 'extra-curricular' activities. And yet, there is no lack of examples of initiatives to get the general public involved. The first editions of *Futuro Remoto* in Naples, the *Science Festivals* in some cities, family visits to science parks and museums at weekends and some engaging activities within successful scientific exhibitions, offer a chance to reflect on the potential of initiatives and strategies capable of attracting and captivating citizens. So what can we do in our country to create non-sporadic opportunities for citizens and science to meet?

The question is obviously a challenging one. I do not have an answer to it but I will try to give a few suggestions by referring to two experiences that, in my opinion, are significant.

In Naples the first editions of *Futuro Remoto*, even before the Città della Scienza was born, were based on scientific exhibitions centred on a topic of great interest (the body, the sea, sustainable development…), on educational exhibitions and very differentiated activities (conferences, show-conferences, dramatisations, etc.) addressed to the general public. The event's success certainly went beyond the expectations of the originator himself (Prof. Vittorio Silvestrini). The world of culture and civil society represented by various communities, institutions and associations (of researchers, teachers, actors, volunteers and administrators) actively and creatively took part both in designing and in implementing the event, proving it was able to involve the most interested subjects. Thus, a series of events mostly aimed at specific audiences (teachers in exhibitions and conferences on teaching methods, young people attracted by role-playing games involving their peers or by new technologies, etc.), all capable of attracting the general public by arousing their curiosity and creating an interaction between different experiences and sensitivities even on complex topics.

The ENVIRAD Project (www.fisica.unina.it/envirad) involves a few dozen high schools in the Campania Region of Italy on the topic of radon exposure. The study on radon concentration is very important not only to choose the measures to adopt to mitigate

consequences on health but also to gain information on seismic and volcanic events. Young people at school, together with their teachers, work to measure the radon concentrations in schoolrooms, laboratories and offices. By interacting with university researchers in the processing and sharing of the results, these young people contribute to the creation of updated maps on the distribution of the concentrations useful for research on environmental radioactivity and for the teaching of science and mathematics with the possibility of revisiting and improving study programmes. Motivation and interest are very high and schools enable the inhabitants of the territory (starting from the young people's parents) and, in particular, the administrators to get involved in risk management.

In short, although it is necessary to learn from experiences gained in other countries (where there is a tradition in this field), the potential of an integration between teaching and communication, formal and informal, which is the foundation of a few significant experiences, seems to show us the way our interventions should follow. Rather than mechanically importing models that work in other cultures we must take into account our specificity, the backwardness of our citizens' scientific education, our available resources and, at the same time, the worthiness of certain initiatives that flourish in our cities.

Collaborative systems

Claudia Ceccarelli

Nowadays many technological tools, more and more sophisticate, are available to make better our work or studies or just to communicate with the other people. In the last years the continuous technological evolution led to an innovative method to increase our knowledge: 'online learning'.

The application of these new alternative educational systems is quite more convenient with respect to the individual training and have completely crashed down geographical barriers. Web, in fact, is a large box where we can find millions of information, in every moment and in every place.

Training systems based on pc tools were introduced with e-learning methodologies and their common use was running up with the increase of the pc use; now they are gaining further advantages by means of the resources available by the Internet. These systems are able to elaborate and organize the training support on a specific learning activity, providing private accesses to users; furthermore, it's very easy to create and use a customized 'training path'.

The progressive changing of users' needs and the developing of new products, caused a significative improvement in the modalities used to supply training activities with online systems. In fact, in addition to the well known systems based on the traditional e-learning methodology, which allow a good level of flexibility but are quite restrictive in the interaction among users, there are now some tools with a different approach based and dedicated on the groupware work. Groupware systems allow a user-to-user autonomous co-operation, joining them to a 'community' where they can participate directly in the creation of new content and contribute as well to modify the on-line content already existing.

Some activities carried on by National Research Council of Tor Vergata (Rome) are dedicated to these actions. Specifically, the *EDEN project – Educazione Didattica per la E-Navigation* (http://eden.saferinternet.it/) promotes a safer-surfing for kids getting them more aware about the Internet use; in order to do it, EDEN realizes a virtual classroom on the web with protected accesses, where young people can meet one another and with teachers to share their experience about the Internet. The project adopted a wiki-wiki platform to encourage the groupware activity, giving the possibility to create new hyperlinked wiki pages on the web, where young people may express their opinions.

This participation to a 'virtual community' persuades kids to 'think before act'; the aim of the EDEN Project in fact, is to transmit some behavioural 'rules & values', that they should apply into a specific context to know the real potentiality of available resources.

In this context kids are invited either to elaborate and to gain from the others' experience, or to express their needs and ideas as authors of the content; this 'self-management' conceived into a safe place, allows some educative mistakes that are fundamental for self-formative progress and, at the same time, it's a good training to know the 'little tricks' that will be useful for surfing the web.

Groupware systems allow to create organized contents and result particularly suitable to manage technical and scientific contents.

The use of these tools is relevant in order to introduce an innovative action of co-operation among users; on the other hand, groupware systems could report several problems in their application because many people are not yet familiar with them.

Very often users are demoralized in dealing with unknown tools, therefore they consider them as a further obstacle to overcome instead of a potential means to get advantage from. To make easier their use, groupware systems, like wiki, have usually a similar look of the pc software packages most commonly used.

The application of this new modality of work into a wider area, for example the school environment, could be a good way

to overcome worries about their use, employing them in a current activity. Now, the best ambition should be to emphasize users' curiosity, moving their attention from the tool to the result.

Not just a festival
Dissemination as a means to lay the groundwork for the society of knowledge

Manuela Arata

With over one thousand Festivals organised in many Italian cities throughout the year – on topics ranging from music to theatre, from literature to philosophy, to economics and many more – Italy seems to have definitively chosen this method of dissemination as the best way to communicate ideas and implement debates. The reason is easy to understand: spanning several days, Festivals enable a sort of full immersion in a given topic, analysing it from many points of view in the presence of especially invited national or international experts; at the same time, they create a festive climate which attracts the public and the media and turn out to be excellent magnets even for public and private investments.

Regarding a complex and delicate topic such as science, the reasons that led us to open it up to the public are undisputable: in a world in which scientific and technological issues permeate most of a society's choices – both public and private – it becomes essential to have citizens who are more informed and better aware, and who can thus play a more active role in the decision-making processes that concern them directly, and a political class that is sensitive to the importance of increasing and improving investment in research as the cornerstone for the country's growth.

Speaking of Europe and Italy in particular, there is also a precise responsibility of the scientific world to stop the tragic fall in the number of students enrolled in scientific faculties and to attract young people to a scientific career to bridge the widening technological gap with countries such as the United States and East Asia.

Our experience, which began in 1992 and has since been dotted with initiatives and events that have convinced us ever more firmly of the need to *bring Science to the public*, and peaked with the

now famous Science Festival held in Genoa since 2003, proved that these are real 'emergencies' for which the scientific community must find an answer that cannot be found without directly confronting society as a whole: workers, students, families and children, men and women, devotees and the plain curious – as well as, obviously, the 'decision-makers' – who must be involved in such a way as to pique their interests: this is where the need arises to *bring Science out of the labs*, offering it up in an original way in those places where people feel most at home.

The 'formula' of the Science Festival, an event that has managed to attract hundreds of thousands of visitors from its first edition onwards (250,000 of which in the successful 2007 edition only) is exactly this: a combination of events for all ages whose common element is the public's direct involvement, with hundreds of initiatives including interactive science exhibitions, hands-on laboratories, conferences and round tables, science cafes, science shows in theatres, a mind gym… and then conference-shows, scientific street performances, clowns and international artists creating a fascinating atmosphere that permeates the entire city.

The 2008 edition, another mind-blowing voyage of discovery and knowledge, focuses on the concept of diversity: *diversity of mind*, *of languages*, *of life*, *of matter*, *of technology*, *of ideas*, in a riveting parallel between art, experience and thought, theatre shows, interactive labs and conferences given by the most important experts and intellectuals, next to young talented researchers on their way to 'the frontier of knowledge'.

It must be pointed out, however, that today's Science Festival is much more than a cultural and edutainment event aimed at disseminating 'knowledge'.

Over the years it has become a melting pot of experiences and cultures from all over the world; a container where new ideas can be gathered, tested and enhanced; a channel for the communication of science which, starting from a 'pioneering' level, has now managed to attract the interest of companies, thus encouraging innovation and technological transfer; a major enterprise with strong financial returns, capable of attracting investments; a lab for new interdisciplinary projects…

In short, the Festival has consolidated as a *common heritage of*

society, proving in its own small way that knowledge is capable of producing value and employment.

An example of this are the thousands of scientific promoters who, over the years, have explained science to the general public: students, college grads e postgraduate students. Thanks to their skills and experience in scientific communication and dissemination, they will form a new generation of researchers possessing within their DNA the capability to transfer knowledge.

And there is also Matefitness, the first Maths Gym, which is a permanent trademark of the Cnr in Genoa but is also continuously touring Italy and abroad to offer training and games in schools, companies and even at the beach. As well as being a very successful dissemination initiative it is a clear example of how culture can benefit at the same time as new jobs are being created.

Of course there is still a lot to do at all levels for the creation of a *favourable environment for research and innovation*, to enable our country to gain lost ground and express itself at the level of excellence that it deserves in many sectors, aiming at science as a real strategic resource that needs to be enhanced, even through a major, continued dissemination of new scientific knowledge.

This dissemination, in an extremely fragmented manufacturing system such as the Italian one, can serve to reach and raise the awareness of many small firms that normally do not focus on technological development as a success factor. It might 'make the difference' in terms of their placement in the global market in which we are now completely immersed.

Blogs

Sylvie Coyaud

Like Charles Darwin before nature, we are filled with wonder and amazement at the numerous, varied creatures of the blogosphere. Having appeared just four years ago, the species *Blog scientificus*, for example, has produced a biodiversity so rich that it amazes the observers for its abundance of niches, disciplines and subdisciplines, languages ranging from the most technical to the coarsest, and observation points, both internal and external. Particle physicists discuss day and night the possibility of finding the Higgs boson in an American or European accelerator. Having appeared just after the Big Bang, maybe in a slim version and in a fat one, it apparently gave mass to the electron thus enabling atoms scattered in the primordial soup to connect to one another and to form all matter existing today, ourselves included. There are, in growing numbers, analysts of political measures ranging from the financial laws establishing the entity of funding to the various bioethics regulations. The Swiss law on biotechnologies regulating experiments on living beings was dissected particularly severely. Plants are certainly living beings and the Swiss Confederation has given them a dignity and autonomy that must not be damaged, just as is the case with the other creatures. Therefore, debates arise on whether it is licit to deprive a petunia, for example, of its 'reproductive autonomy', by manipulating it genetically or otherwise in order to render it infertile.

The ideal blogroll, i.e. the list of sites that one could spend days on, seeking intellectual inspiration, includes announcers of important or strange news, comedians, demagogues, feminists and male chauvinists, students and professors, specialists and those who think they know it all, reporters of abuse, conflicts of interest and badly carried out research, critics and fans, media observers, nomads and people who have settled down, in a word, human beings accumulating and exchanging knowledge.

On the other side we find the opposers. For them, the Earth is 6 or 10 million years old, opinions vary and Noah embarked two baby dinosaurs because a pair of adult ones would not fit in the ark. They organise an online resistance to climate change, which is a farce and a conspiracy of the greens and of the reds against the US economy. What is more serious, in my opinion, is the disinformation that is given on HIV, which, according to them, does not exist and thus cannot cause AIDS, although conspiracy theorists are convinced that the virus was created in a lab by biologists-CIA agents (or the KGB if you prefer), and escaped by accident unless it was not released deliberately.

Opinions almost never coincide.

They do not even coincide in the subspecies *Blog scientificus seriosus*, whose ceaseless conversation is one of the most lively and educational phenomena of the web. Guests are welcome, questions too. It is enough to ask and you will obtain in a flash sources, data, images, video, and sometimes even original publications by email, in defiance of copyright laws. Of course, in the comments to the posts, people quarrel and sometimes even insult one other, but anyone who is animated by sincere curiosity and wishes to better understand the topic of the day will immediately receive updates, explanations, bibliographies and accurate advice.

A word of warning, however: some scientists, even those with an excellent reputation, use their blogs as research tools on the credulity of their readers and, for example, around the first of April, but not exclusively, take advantage of the freedom, informality and limited responsibility of this form of communication to play jokes and put out a piece of scientific news that really does seem true.

Science cafes
Science-tasting nights
Open debates in the company of scientists, philosophers and gourmets

Tommaso Castellani, Anna Parisi

Science cafes nowadays take place in over thirty countries all over the world, in all five continents, and are now regular events even in various Italian cities.

Although based on the common idea of a meeting on a science topic in a café, these debates show considerable differences in their approach, due to the different choices made by the groups organising them.

Ours was to discuss rather general topics (intelligence or chaos, cosmology or language) and to do it in an interdisciplinary way, inviting two researchers coming from different backgrounds, for instance a physicist and a biologist, to speak about the same subject from two complementary points of view.

The two guests who, on a given night, concentrate on one of the aspects of the topic, tell the audience about their jobs and then launch a debate.

After two seasons science cafes in Rome have become places for debate and reflection loved both by the audience and by the researchers. There are several reasons for this success.

First of all, science problems are discussed directly with the people who deal with them in their research, without the filter of journalists or other spokespeople: therefore, myths or outright untruths that reach the audience through newspapers and television programmes are very often debunked. Moreover, people discover that research is much further ahead than they thought, and that answers to their fears have already been given, and that perhaps other questions have sprung up in the meantime or other problems have been raised.

This chance to enter into a direct debate with the researchers is a great opportunity for the audience, but also for the scholars. Indeed, researchers, as well as being given the chance to present their results and points of view without seeing their work disfigured by the sensationalist news given by the media, can personally understand the audience's needs and perhaps even its fears.

Finally, science cafes are one of the rare places where different disciplines come together on the same topic. While research becomes ever more multidisciplinary, researchers become ever more specialised and nowadays even the general public feels a strong need for a wider vision involving different points of view in order to be able to look at problems in their totality.

The perspectives introduced by the different disciplines contribute to enrich the discussion topics and quite a few scientists, initially called as speakers, continue to visit science cafes as part of the audience.

This is an evident sign of the strong need for non-academic spaces for dialogue and debate (guaranteeing, however, at the same time, the presence of high level researchers and soundness of content).

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