Communicating science at school: from information to participation model

Alba L'Astorina[1] and *Adriana Valente*[2]

Abstract: 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 with the insufficient diffusion of scientific culture. The contribution of pedagogues and philosophers of education recently stresses the importance of developing techniques for stimulating students' intrinsic motivation in learning science and participating in the scientific debate. Among other methodologies, inquiry-based learning (IBSE) has been acknowledged as a great potential to the development of scientific reasoning and to the related competences. Enhancing students' participation in the scientific debate is the central aim of the methodology developed by the research group "Science Communication and Education" of the Italian National Research Council (CNR) within the Project "Perception and Awareness of Science" (PAS). The present paper describes the proposal of CNR inspired by the IBSE principles but enriched by some peculiarities. After a brief introduction on the recognition of the importance of improving the scientific culture for the modern knowledge-based society, the paper makes a review of the use of IBSE methodologies and continues outlining a profile of the peculiarities introduced by the CNR-PAS methodology. The essay ends with some results of the surveys that have been carried out during the introduction of the PAS at school.

Keywords: science communication, science education, participatory models, perception of science

[1] Science Communication and Education, IREA - Consiglio Nazionale delle Ricerche (CNR), via Bassini, 15 - 20133 Milano (Italy). Email: lastorina.a@irea.cnr.it
[2] Science Communication and Education, IREA - Consiglio Nazionale delle Ricerche (CNR), via Bassini, 15 - 20133 Milano (Italy). Email: valente@irpps.cnr.it

Introduction

The achievement of a consolidated and disseminated scientific knowledge in European society is one of the objectives set by the Lisbon Strategy of the European Commission in 2000. The Lisbon Program aimed at making Europe the most important knowledge-based economy through focusing on efficiency and quality of "training opportunities, employability, human capital, innovation and research". This requirement is also considered crucial to the quality of democracy, so that every citizen can exercise his right and duty to participate in social life and make choices (European Commission & DG Research, 2007).

Many assert that the process of acquiring a scientific culture must begin very soon, starting with the younger generations. Such a belief is prevalent also in civil society. Already from the 2005 Euro barometer (the survey that is periodically carried out by the European Commission to investigate the opinion of European citizens on science and technology) it was noted that 80% of respondents considered the interest of younger generations towards science essential for the present and future wellbeing of our society (European Commission, 2005; European Commission, DG Science and Society, 2004; European Commission, 2007; OECD, 2007; OECD PISA, 2006; Schreiner & Sjoberg, 2004).

Yet, for years, questions have subsisted about citizens' lack of confidence in science[3], and the lack of interest of young people in undertaking studies and careers in science. With a few variations on the theme, national and international surveys on young people and science also confirmed this. A recent OECD study (2006) indicates that children show a natural curiosity about science and technology - some add that in their approach to the world around them, children act as "little scientists". However, when inserted into a traditional route of science education, the

[3] The cited 2007 report criticizes the alleged public distrust in science and scientists by saying that "the fears of the public are not the result of a *lack* of scientific knowledge, but rather the concerns that citizens have in the institutions". The problem therefore is not scientific knowledge but the way the relationship between science and society and science and institutions is set up. Policies must change in order to provide more inclusive forms of learning that are both reflective and open.

children's interest fades completely from these subjects, affecting, as we have seen, their subsequent educational and career choices.

It is increasingly internationally recognized that the education system holds its share of responsibility. School often emphasizes this distance when it offers workshops, lessons and textbooks presenting a watered-down science, deprived of its dynamic components, conflicting and often taken out of its original context, application and multi-disciplinary comparison (Caravita, Valente, Luzi, Peace, Khalil, Valanides Nisiforou, Berthou, Kozan-Naumescu, Clément, 2008).

A 2007 report by the European Commission attributed to the way science is taught at school the responsibility for an increasing decline in the interest of young Europeans in scientific studies. Similarly, the report by the European project "Form it" on the forms of collaboration between research and education, noted that among the reasons for a lack of interest in science, there were two that directly concern the school: the content of science taught, abstract and far from the daily life of students; and teaching methods, based on lessons that use a deductive method that is rarely participative and which leaves little time for learning the methods of investigation and the contribution of individual students (Murcia, De Haan, Huck, 2008). In both cited reports, two possible solutions to this problem are identified: a more fruitful collaboration between research and education, and a more direct contact between scientists and students.

The contribution of pedagogues and philosophers of education recently stresses the importance of developing techniques for stimulating students' intrinsic motivation in learning science and participating in the scientific debate. Among other methodologies, inquiry-based learning (IBSE) has been acknowledged as a great potential to the development of scientific reasoning and to the related competences.

Bringing into schools the wealth and articulation of the scientific debate, including the "unavoidable uncertainty of science (Trench, 2008) which characterizes the scientific method, is the central aim of the methodology developed by the research group "Science Communication and Education" of the Italian National Research Council (CNR) within the Project "Perception and Awareness of Science" (PAS). The proposal of CNR, inspired by the IBSE principles, suggests a process of study, participation and exchange of opinions between young people and experts on central topics in the scientific debate considering also the economic, social, environmental and ethical aspects of them. The attempt to propose and test various communication models is combined with the intent to observe the situation in which the work is being carried out, in view of a better understanding it and increasing the awareness of all participants. To this aim a survey on the values of science is also carried out. Some results of the survey are also reported at the end of the paper.

Motivating students to science learning through the IBSE methodology

In recent years, many scholars (philosophers, educators, teachers) converge towards the need to develop educational strategies that can stimulate the intrinsic motivation of students who are learning science and the importance of allowing them to participate in the public debate (Kachan, Guilbert & Bisanz, 2006; Brenneman & Louro, 2008; Howes, Lim & Campos, 2009; Murcia, 2009).

These strategies are officially recognized in the teaching method based on the "inquiry-based learning" (IBSE), as defined by authors such as Duschl (1990), Flick (2004) and Moje (2001). Such a method can stimulate rational and critical thinking in students, develop skills that enable them to investigate, select the sources of documentation, analyze a scientific problem, form personal opinions, seek solutions and not simply hold to the original pre-established formulas, and do everything in close contact with the scientific community thus helping to bridge the gap between schools and research centres (Murcia, 2009; De Haan, 2008). In addition, some authors propose teaching practices that encourage teachers to promote the ability "to argue" for students (Jimenez, 2008; Osborne, 2000). This approach implicitly recognizes the "complexity" of the nature of modern science and encourages teachers to develop, in science education, "several alternatives to face the same problem, and students to consider and evaluate the evidence and the argumentation of each of the possible solutions" (Osborne, 2005).

These new methods can be effective both if we want to achieve a "science for all citizens", as claimed by Millar and Osborne (1998), or if we want to invest in human capital, the "Human resources for S & T" as claimed by others (European Commission, 2004).

In addition, IBSE methodologies are also considered important for teacher training. The Talis-OECD report of 2009 has investigated the teachers' awareness of the role and the influence they have on students' education and the difficulties they encounter in their work. The result is that some nations have, as one of the difficulties, a lack of pedagogical skills. 42% of all teachers already declared that the reason they do not require additional training is not only a lack of time but also a lack of adequate support. "Relatively few teachers participate in the kind of training that would seem to have a greater impact on their work; such as certification programs and individual research collaboration" (Gurría, 2009). In most countries, teachers say they use traditional methods to convey knowledge in structured situations rather than to develop techniques to respond and adapt teaching to individual needs; far fewer teachers resort to teaching activities which involve a deeper intellectual engagement by of students (OECD, 2009). These results and other related ones such as, for example, the awareness that the education system - in particular through the textbooks and classroom instruction - participates in the formation of future citizens not only promoting knowledge but also attitudes and values (OECD, 2009), reinforce the conviction that the IBSE methodologies should focus on both teachers and students.

Communicating science at school using information and participation models: the CNR proposal

The CNR proposal is inspired by the IBSE methods described above, but in addition it has several peculiarities[4]:

• it takes into account the *complexity of science* in the sense described, among others, by Latour (1998) as science in process and by Funtowicz, Ravetz (1999) as post-normal, uncertain science: features of modern science, often underestimated in science education, but that have been considered increasingly important in recent years. The growing awareness of the complexity of modern science makes the traditional approach in

[4] The methodology of the project proposed by the CNR has been selected as one of the two Italian good practices by the European project Form-it, which analyzed 160 European proposals, with the intent of creating a set of quality criteria and guidelines to carry out research projects and educational cooperation and to produce documents for policy makers.

science communication, often linear, one-way, inadequate to represent the richness and articulation of the relationship science-society;

• it focuses on *participatory methods* and cooperation by all actors involved in public debate on science: teachers, students, experts, stakeholders and authorities involved in various ways in the theme. A way to reduce the gap between science and society and to follow what Jasanoff (2003) calls the "participatory turn", that is that "participatory turning point" involving teachers and students in a process of cooperative learning that makes them feel and be active in the scientific debate (Midoro, 1994). The participatory methodologies, such as the Metaplan (Valente & Mayer, 2009) and the Open Space Technology (L'Astorina, Del Grosso & Valente, 2009) are used to bring out the "tacit knowledge" of students as defined by Polanyi (1967), and as a basis for shared proposals within the groups. This process builds what Ziman (1967) defines as the "collective wisdom", but also mobilizes different types of competencies and skills that are not typically required at school, nor valued, such as the role of facilitator within the group, the communication skills, the ability to express ideas, the social skills (OECD, 2005). In addition, participatory methodologies are also used in order to redefine the role of the teacher who, besides acting as a facilitator, reflects on his/her practice, acts as a "reflexive practitioner" (Lisle, 2000);

• it promotes an approach to knowledge that begins with a *scientific documentation* which makes an extensive use of ICT, but which also meets strict criteria: reliability and diversity of sources, pluralism of opinions and points of view of technical-scientific and social actors involved, both nationally and internationally (Libutti & Valente, 2006). All this is in line with criteria which Fishkin (2004), expert in theories and practices of democracy, considers the starting point of any deliberative process. The goal is to develop skills able to attract young people to issues of science, and to show that inquiring and asking questions is as or more important than learning how to give answers. In particular, the focus is on the importance of bringing students closer to a true culture of information, helping them to become "information literate"[5] as young as possible.

[5] The American Library Association has defined information literacy as "the ability to know when information is needed and to be able to identify, locate and effectively use information for lifelong learning and problem solving".

Figure 1. The CNR Participative methodology

PAS-Ethics and Polemics methodology is based on a "training path" whose main steps are:

1. Stimulate question on a scientific topic by means of a participative methodology (that is the Metaplan). Group discourse and communication, whether by high school or university students, set in motion a process by which new knowledge is created and consolidated, and thus give rise to what is also known as "tacit understanding" or "collective wisdom", which will not necessarily manifest itself in the form of formal scientific language, yet allows the group to participate more actively and knowledgeably in their engagement with experts. In this process professors play the role of tutors in this process promoting study and discussion activities before taking part in the debate with scientists, experts, stakeholders and administrators.
2. The documentation, which is also explicated and supplemented by teachers, constitutes the first point of contact between the school and the scientific theme in question. Not until this phase and group discussions were complete did the students engage with the experts from the sector. In this way, the selected groups were equipped for active participation in discussions with scientists. To guarantee the comprehensiveness and transparency of the information provided, to all classes further material is given beyond traditional textbooks in which the debate on "in progress science" is either not present or briefly treated in a linear, not problematic style. The documentation is selected with reference to a series of parameters such as reliability, international relevance, pluralism, multiplicity of sources.
3. Stimulate students' own search for scientific reliable documentation on the topic. Since young people find using technology easy, it is necessary to introduce them to a real information culture, helping them becoming familiar with actions such as acknowledging the need for information, improving the quality of the questions to find pertinent information and comparing and evaluating sources, in order to identify the most reliable ones.
4. Experiment different activities to study the topic such as visiting scientific laboratories, reproduce historical experiments at school, use computer simulations/virtual labs, etc.
5. Put students in contact with scientific researchers and experts through the organisation of a public conference/round table/science café conducted by students with the support of teachers.
6. Evaluate the activities and the results through participative methodologies. Participative methodologies (such as the Open Space Technology) allow teachers and students to express their voice feeling active part in project assessment, and to get qualitative feedback. Interdisciplinary vocation of the methodology allows its wide extension. Teachers from different disciplines are invited to participate. In all phases of activities, a multiplicity of actors, such as researchers, experts, stakeholders, local associations, are involved within schools. The final public event lets the different stakeholders interact and cooperate. The involvement of students in the organisation of the public events allows a direct contact between students and scientific researchers, with a high space reserved to students' questions, comments and proposals.

PAS methodology was tested and implemented throughout several international events involving teachers, students and Italian and British scientists who discussed relevant topics such as GMOs, electromagnetic pollution, space exploration, the impact of climate change on cities and the water crisis. As illustrated in the figure 1, each initiative consisted into two main phases: 1) the structuring of the debate within student groups; 2) the completion of a survey on perception of science and its values (with questionnaires before and after each initiative).

In presence of a linear model of public communication of science, where people are only considered as the final part of a unidirectional process, it is difficult to think that young people become aware to be important part in the scientific debate. The PAS Project revealed that to participate in the scientific debate knowledge is indeed important but only when it is critical, problematic and interdisciplinary. Furthermore, active participation implies deliberation/proposal steps, the most important aspects of the interaction between institutions and citizens, and this passage is not easily made for both of them.

Conclusions

In addition to proposing and testing new models of communication, the CNR group always carries out surveys, using both quantitative and qualitative methodologies, aimed at investigating the perceptions of science and its values (Valente, 2009). Generally two questionnaires are submitted to students and teachers at the beginning and at the end of the Project. What emerges from the inquiries? Here we report just some hints from the general results.

Considering the relation between the students and the experts results revealed that young people are increasingly asking to be protagonists in the process of learning and constructing knowledge. Students ask to understand the connection between the scientific culture, to which we want them to approach and which raises increasingly complex and global issues, and the possibility to act in the first person, on a "local" scale, to answer such questions. They feel great pleasure when they discover they also have a sort of knowledge (even if "tacit"), and they can trace the deepest "motivation" that link them to issues which they apparently do not seem to have any relationship with (climate change, water crisis, GMO, etc.). Students seem to appreciate very much the direct contact with experts and think communication be not only a transmission of facts but also a sharing of theories, knowledge and approaches.

Furthermore, a strong link between scientific culture (not intended in its disciplinary classifications) and civic culture also emerges from the results of the inquiries to both students and teachers; they seem to ask to connect their "status" of a student and a teacher, provided with a defined institutional role, and the identities that refer to other "status" (teenager, adult, citizen, parent, foreign, etc.).

Students also ask to find a connection between what they study, discuss and debate at school and what they experience in their everyday life. That is, between inside and outside the school, the subjective and emotional sides of experience, the knowledge at school with that coming from other contexts (different family traditions, television, virtual world, lifestyles, etc.). A link perhaps still too implicit and undervalued, which can become evident within an effective practice of public communication by all subjects of science communication: museums, schools, scientific institutions, etc.

References

Bosetti, G., Maffettone, S. (eds.) (2004). *Democrazia deliberativa*. Roma: Luiss University Press.

Brandi, M.C., Cerbara, L., Misiti, M., Valente, A. (2005). Youth and Science in Italy: between enthusiasm and indifference. *Journal of Science Communication (Jcom)*. June, *4*.

Brenneman, K., Louro, I.F. (2008). Science journals in the preschool classroom. *Early Childhood Education Journal*, *36*, pp. 113-119.

Caravita, S., Valente, A., Luzi, D., Pace, P., Khalil, I.,Valanides, N., Nisiforou, O, Berthou, G., Kozan-Naumescu, A., Clément, P. (2008). Construction and Validation of Textbook Analysis Grids for Ecology and Environmental Education. *Science Education International Journal*, *19*(2), pp. 97-116.

De Haan, G., Huck, J. (eds.) (2008) *Recommendations for Policy makers*, Form-it. Take part on research project, 6° European Framework Programme. Austrian Institute of Ecology.

Driver, R., Newton, P., Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education, 84*, pp. 287-312.

Duschl, R. (1990). *Restructuring Science Education. The importance of theories and their development.* Teachers College Press, Columbia University New York –London economy and society directorate, Brussels.

Del Grosso, E., L'Astorina, A., Valente, A. (2009). Introducing Open Space Technology in schools to educate towards citizenship in science and society. In A. Valente (ed.), *Science perception and participation*, (pp. 57-68). Roma: Biblink editori.

European Commission (2005). *Eurobarometer*. *Social values, Science and Technology*.

European Commission (2007). *Science Education NOW: A renewed Pedagogy for the Future of Europe*, Luxembourg: Office for Official Publications of the European Communities.

European Commission, DG Research (2007). *Science and governance: Taking European Knowledge Society Seriously*. Report of the expert group on science and governance to the science,

European Commission, DG Science and Society (2004). *Europe Needs More Scientists*. Report by the High Level Group on Increasing Human Resources for Science and Technology in Europe.

Fishkin J.S., (2004). Il sondaggio deliberativo, come e perché funziona. In G. Flick, L., & N.G. Lederman (eds.), *Democrazia deliberativa: cos'è*. Scientific inquiry and nature of science. New York: Springer.

Funtowicz, S., Ravetz, J. (1999). *Post-Normal Science – an insight now maturing*. Ed. Futures.

Gurría, A. (2009). *Remarks delivered at the launch of the OECD Teaching and Learning International Survey* (TALIS), Mexico, 16 June 2009.

Howes, E.V., Lim, M., Campos, J. (2009). Journeys Into Inquiry-Based Elementary Science: Literacy Practices, Questioning, and Empirical Study, DOI 10.1002/sce.20297, Published online 21 July 2008 in *Wiley InterScience* (www.interscience.wiley.com).

Ischinger, B. (2009). *Relazione sull'indagine TALIS, Politiche di innovazione per la scuola*. Genova: Associazione Treellle, Lang.

Jasanoff, S. (2003). Technologies of humility: Citizens participation in governing science. *Minerva*, *41*(3).

Jimenez-aleixandre, M.P., Erduran, S. (2008). *Argumentation in Science Education*. The Netherlands: Springer.

Kachan, M., Guilbert, S., Bisanz, G. (2006). Do teachers ask students to read news in secondary science? Evidence from the Canadian context. *Science Education*, *90*(3), pp. 496-521.

L'Astorina, A. (2009). *Ricercare e comunicare*. Indagine conoscitiva sulle attività di comunicazione negli istituti di ricerca del Consiglio Nazionale delle Ricerche, (in press).

Latour, B. (1998). *La scienza in azione*. Torino: Edizioni di Comunità.

Libutti, L., Valente, A. (2006). Science communication and information dissemination: the role of the information professional in the Perception and Awareness of Science project. *Journal of Information Science*, *32*(2) pp.191-197.

Lisle, A.M. (2000). All hail reflexivity, *Annual Review of Critical Psychology*, *2*, pp. 109-129.

Mayer, M., Valente, A. (2009). Expressing oneself in order to participate: tacit knowledge, learning and the Metaplan. In A., Valente (ed.) *Science perception and participation* (pp. 43-56). Roma: Biblink editori.

Midoro, V. (1994). Per una definizione di apprendimento cooperativo, TD. *Tecnologie Didattiche*, *4*, Ortona: Ed. Menabò.

Millar, R., Osborne, J. (eds.) (1998). *Beyond 2000: Science Education for the Future.* London: King's College London.

Moje, E., Collazo, T., Carrillo, R., & Marx, R. (2001). "Maestro, what is 'quality'?" Language, literacy and discourse in project-based science. *Journal of Research in Science Teaching 38*(4), pp. 469-498.

Murcia, K. (2009). Re-thinking the Development of Scientific Literacy Through a Rope Metaphor, *Research in Science Education, 32*(9), pp. 215-229.

OECD (2005). *The definition and Selection of key Competencies* (DeSeCo). Executive summary.

OECD (2006). PISA 2006 *Science competencies for Tomorrow's world*. Paris.

OECD (2006). *Evolution of Student Interest in Science and Technology Studies* – Policy Report; Global Science Forum.

OECD (2007). *Education at a glance. OECD Indicators* OECD, 1.

OECD (2009). *Creating Effective Teaching and Learning Environments: First Results from TALIS*. http://www.oecd.org/dataoecd/17/51/43023606.pdf

Osborne, J. (2005). *The role of Argument in Science Education. Research and the Quality of Science Education*. In K., Boersma, M., Goedhart, O., De Jong, H., Eijkelhogs (eds.). Research and the quality of Science Education (Part 7, pp. 367-380). The Netherlands: Springer.

Polanyi, M. (1967). *The Tacit Dimension*. New York: Anchor Books.

Schreiner, C., Sjøberg, S. (2004). Sowing the seeds of ROSE. Background, Rationale, Questionnaire Development and Data Collection for ROSE (The Relevance of Science Education) - a comparative study of students' views of science and science education. *Acta Didactica 4*. Department of Teacher Education and School Development, University of Oslo.

Trench, B. (2008). Internet, turning science communication inside-out?. In M., Bucchi & B., Trench (eds.). *Handbook of public Communication of Science and Technology*. London: Routledge.

Valente, A. (ed.) (2006). *La scienza dagli esperti ai giovani e ritorno/ Science: from specialists to students and back again*. Roma: Biblink.

Valente, A., Cerbara, L., Caruso, M.G. (2008). *La scienza cos'è e come comunicarla*. Indagine sulla comunicazione della scienza. Parlano i ricercatori del Cnr, (in press).

Valente, A. (ed.) (2009). *Immagini di scienza e pratiche di partecipazione*. Roma: Biblink editori.

Ziman, J.M. (1967). *Public Knowledge: An Essay Concerning the Social Dimension of Science*. UK: Cambridge University Press.