IMPRESSE CONFERENCE, GULPEN 29-30 SEPTEMBER 2006

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Introduction

The poor performance of the Italian students in the PISA 2003 enquiry uncovered the diffuse shortcomings of school learning in Italy and came as a shock to the public opinion. The declared EU priorities for education (Lisbon 2000 and Stockholm 2002) require the participating countries to (a) promote basic competences for active and responsible participation in the knowledge society, (b) strengthen (improve) the study of scientific subjects (maths, science, technology etc.), (c) spread the ability to use ICT.

In the light of these indications science education in Italy is in bad need of radical improvement, starting from the very first school years.

Some of our woes (with special regard to physics) are reported in the AIF document contributed to last year's IMPRESSE Meeting in Rennes.[1] We will now consider the issue from a more general point of view and describe an new initiative that, we hope, will contribute positively to the wished-for improvement.

The problems

1) Aims of Science education

Teaching science in school can (or must?) serve two different but related aims:

- to build the intellectual tools that enable a person to use knowledge, however learnt, in life
- to promote the understanding and appreciation of how scientific knowledge grows and of the logical structures of the different sciences.

We think that both aims are irrenounceable for an informed citizen. The problems are:

- how should the teaching learning sequence be calibrated in order to suit the different age groups?
- what do the pupils retain at the end of their compulsory schooling?

Research in science education has given some answers but the research results are unknown to most teachers and, unfortunately, science lessons in further years often fail to deliver the basic knowledge and abilities that were not acquired before.

The low degree of knowledge and ability at the end of secondary education is documented by the answers given by motivated candidates to the admission exams to degree university courses in science subjects.[2] The admission tests to the two-year specialisation schools (SISS) that prepare new teachers for upper primary (11 to 13) and secondary school science education show that often these requirements are still inadequate even after a three-year university degree.[3]

2) Teacher training and education

Initial education

- Infant and lower primary (6 to 10) schools
  The teachers are educated in the degree course "Sciences of Primary Education". The prerequisite is having finished a five-year secondary school course. Many students have very weak

[1] See http://udppc.asso.fr/info/impresse/IMPRESSE2_FR.htm

[2] A 2004 survey of the admission exams to the university course of Life&Earth Sciences (Scienze Naturali) revealed "a widespread incapacity to reason out of rote knowledge, to interpret schematic graphical representations, to advance arguments pro or con a scientific issue, to evaluate the correctness of an experimental procedure, to discriminate hypotheses from theories". M. Bandiera, "Valutazione di padronanza in ambito bio-naturalistico: i test a scelta multipla", UeS, **1R**, 2005, p.42

[3] In some cases less than 50% of the candidates gave correct answers to items that belonged to the subject matter of their own degrees. G. Anzellotti, F. Mazzini, "Il coordinamento delle prove di accesso alle SISS per gli indirizzi scientifici: primi risltati del test di settembre 2004", UeS, **1R**, 2005, p.72

backgrounds in science and maths and must acquire the basic knowledge and abilities while they learn the teaching competences.

- Upper primary (formerly "middle school")
  The teacher teaches a wide array of subjects, comprising Maths, Science (Life&Earth, Chemistry, Physics) and Computers so the two-year specialisation school is open to three-year graduates with different educational backgrounds. The study mentioned in [3] showed that the science knowledge of the mathematicians was very weak and, viceversa, the biologists and the naturalists were unknowledgeable in maths. These students are required to fill up their knowledge gaps before they graduate as teachers.
- Secondary schools
  The courses are split in the two subspecialties "Physics-Informatics-Mathematics" (FIM) and "Life&Earth-Chemistry" (SN), reflecting the traditional coupling of the science subjects in the Italian lycea. The study mentioned in [3] showed that in the FIM exams (taken by three-year graduates in physics, mathematics and engineering) the mathematicians exhibited widespread weaknesses in all the fields touched in the test while the physicists not only obtained the highest marks in their own specialty but were also superior to the mathematicians in the maths test.
  In the SN exam the mean total scores of the candidates (mostly coming from biology, chemistry, geology and life&earth studies) are practically equivalent and the differences concern the specific specialties: th chemists being strong in chemistry, physics and maths, the geologists and naturalists in the earth sciences and the biologists in biology. Of course the students are required to fill up their knowledge gaps before they graduate as teachers.

In-service updating

- In presence: an effective course could be quite expensive, in terms of money for the school administrators and in terms of time for the teachers. The course effectiveness is highest if it requires active involvement, feedback and e return session after an adequate lapse of time.
- Distant learning: to enhance the effectiveness of this choice some form of interaction and tutoring is required. In Italy the newly certified teachers must participate in web-based discussion groups organised by the state agency INDIRE[4]. The science teacher associations contributed moderators to these groups. Once the course is finished and contacts are broken it is difficult to estimate the practical value and permanence of this form of updating.

3) Assessing the pupils' learning

INValSI[5] is the Italian state agency in charge of measuring the level of the pupils' learning in our schools. The procedures are still in trial and, until now, the testing has been administered only to schools that volunteered.

Past and present initiatives for science education

1) Past

Initiatives aimed at promoting good practice in school science were occasionally promoted by the Ministry. I will only mention one of the most recent and prominent (but dating back to the late '90's), called SeT[6], in which a number of school-originated projects were funded. The funding constraints limited the number of possible participants, that were selected on the basis of their proposed projects. An interesting feature of SeT was that it required the projects to be

- shared by a number of schools, possibly at different age levels and in different geographical regions
- shared also by external partners, e.g. in industry

[4] INDIRE (Istituto Nazionale di Documentazione per l'Innovazione e la Ricerca Educativa)
[5] INValSI (Istituto Nazionale per la Valutazione del Sistema educativo di Istruzione e formazione)
[6] SeT (Science and Technology: National iniziative for promoting the development of products and services for Science and Technology education.)

- co-coordinated by one of the schools and by a partner engaged in research at the university level.
SeT produced very interesting examples of good practice and of deep and insightful thinking about what to teach, how to teach and why teach science at different school levels. The initative is now closed and the products are collected and freely available in the INDIRE website.[7]
A good question is how much are they sought by teachers who, in majority, seem not to be particularly comfortable with the web.

2) Present
The "fuzzy" experiences in the INDIRE discussion groups confirmed what the science teachers' associations knew from the start: distance learning might help but it surely is not enough. On the other hand, the associations' strength, time and resources are limited and the direct disciplinary and methodological updating they are able to promote can only touch a limited number of teachers. It's imperative to offer good in-service help to the teachers *where the teachers are*.
This persuasion promoted the ISS Project, a recent partnership involving AIF, ANISN (Associazione Nazionale Insegnanti di Scienze Naturali), SCI/DD (Società Italiana di Chimica-Divisione Didattica), the Science Museums of Milano (Museo della Scienza e della Tecnologia) and Napoli (Città della Scienza) and the central Ministry.
The project will last (3+3) years. It's aim is to provide an adequate number of suitably equipped science teacher centres, mostly hosted in schools, where the teachers will find expert support.
The main target is science education in the first 10 school years (pupils aged 6 to 14). Foremost attention will be put on lab-based approaches, where the word "lab" is given an extended meaning.
The tutors and facilitators are now being recluted on a voluntary basis and will be prepared for their new responabilities in courses that are scheduled to start in October.

[7] See http://www.indire.it/set/area1_esperienzescuole/cm131/5.htm. Some examples are
- *Scuola di base: i linguaggi della matematica e delle scienze e la razionalizzazione di fenomeni ed esperienze comuni* (Coordinators: an Elementary School and the Mathematics Dept. of the Univ. of Genova)
- *MEMO – macchine, energia, misura e materiali nell'Officina* (Coordinators: a Vocational School and the School of Engineering of the Univ. of Modena - Reggio Emilia)
- *Biotecnologie classiche, recenti ed in classe* (Coordinators: a Scientific Lyceum and the Istituto Internazionale di Genetica e Biofisica of CNR)