

# The perception of science and scientists in the young public

Italian Teenagers and Science: views, beliefs and attitudes toward scientific research

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## Abstract

Common people watching the world through a special glance. This is the image that Italian youth has on scientists, while disagreeing with them on study and commitment involved by work. These are amongst the outlooks emerging by a research carried out by ICS (Innovation in the communication of science, International school of advanced studies, Italy) during 2003, over a sample of boys and girls aged 14-15 in Italian schools.<sup>1</sup>

The interest stands in the need to know public attitude towards science as a first step for communicating science itself in a proper and effective way. In particular, choosing teenagers is requested by the importance of understanding which science image have those ones who bring ideas and reflect debates' core of adult world. The point is that they are next decision makers in the comparison between science and society. In this way, 5230 boys and girls throughout Italy answered 50 questions set in 6 areas: scientist figure, the image of science, scientific thought (the role of mathematic language, of experiment and method), the relationship between science and nature, the awareness with scientist work, confidence on scientific progress.

Outlooks sketch a scenario which can't be taken for granted: scientist emerges as character provided with genius inspiration while descending his ivory tower to carry on his work with other social groups. On the other hand, science has a significant role in our history and it will solve many future problems. Nevertheless, at the same time, it won't win challenges such as poverty, hunger, wars.

Starting from the Italian experience, the description of these outlooks has the fundamental objective of raising a comparison among the participants from other PCST member states.

## 1 Introduction

The circulation and diffusion of scientific ideas are processes which define scientific culture in a society and indicate public perception of science, which in turn shape also science communication.

Our aim is to understand the circulation of scientific ideas, tools and methodology among common people. Such circulation determines the background on which science communication acts, and how science and society interact as well as help to understand the nature of people's interest in science.

We want to investigate people's attitudes towards science therefore archetypes people nurse on science, the circulation of scientific ideas and methodology (hereafter results and concepts) among common people. Scientific culture and individual beliefs determine the relationship between people, society and science which must be viewed as an integrated system within which each individual finds a place. Science communication is fundamental to define the relationship between scientists and the general public. However, communication between people not directly involved in science is often *full of science*: communication plays a role in the making of science, both on a social and on an epistemological level. We want to investigate science communication among a public which is not directly involved in science; communication that is obviously affected by the image that people have of science.

We are interested in individual attitudes towards science, what people understand as science and scientists, which practices and routine are identified with science, which distance people establish between themselves and science.

We have focused on Italian teenagers and started by asking the question: who is a scientist? What can s/he do? Is s/he a special person or not? Do people trust science? Which are the future scenarios for our society in relation to scientific development? What is the role of science communication?

We did not want to measure scientific knowledge and understanding of Italian teenagers; we wanted to analyse in what ways scientific and technological developments are received and assimilated, the channel through which science and society communicate: investigating the image that teenagers have of science involves analysing their attitudes, prejudices, (mis)conceptions, archetypes.

We all learn and negotiate our notions and opinions about science through our everyday experiences, but our idea of science originates mainly from childhood and is confirmed in adolescence. This paper focuses on Italian teenagers aged

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between 14 and 16 (our sample is constituted by pupils born in 1987 and in 1988 attending state schools, which are the vast majority in Italy), and analyses their perception of and attitudes towards science. Teenagers tend to seek answers to the needs of society, and to become involved in the debates which develop in the media and in society in general. Social studies show that, in Italy and Europe, the meaning of sciences whittled down to medicine and technology; furthermore, the scientist's figure is that of a middle-aged man, with glasses, white coat and ruffled hair: such stereotypes seem to be quite deep-rooted. Vice versa, our results offer a view of scientist (and science) which contains contradictions and different points of view.

This study is part of a wider research promoted by the Observatory on Children, Teens and Science, based at SISSA in Trieste.<sup>2</sup>

## 2 The statistical sample and the questionnaire

### 2.1 The selection of the sample

We have submitted to Italian teenagers a questionnaire, which formulation has been fine-tuned through a trial test. We did not ask students what science they knew, but how did they relate to the various meanings that the word 'science' assumes in everyday language.

A pilot group of teenagers filled a temporary version of the questionnaire, and we discussed with them and their teachers our choice of questions. We were confirmed in our conviction that the role of the scientist should occupy a central position (our questionnaire revolves around the figure of the scientist) so as to avoid abstract generalizations. The questionnaire was administered to a sample constituted by pupils attending years 1 and 2 of the secondary school (14-16 years old).

Our aim is not to discuss Italian teenagers. Secondary schools provide a sample which is randomly selected, but in Italy attendance to the first year of secondary school is compulsory, therefore the pupils selected are in many ways representative of the whole population.

Sampling was done by asking every teacher subscribing the web site *Ulisse - nella rete della scienza* (<http://ulisse.sissa.it/>)<sup>3</sup> if classes in years 1 and 2 of their schools were willing to participate. About 60% of the teachers who volunteered received the questionnaire returned it filled. We interviewed pupils in 289 classes belonging to 54 different schools. The complete procedure was undergone by 250 classes (86,5 %) of 47 schools (87%) with a total of 5,230 teens, an average of 21 students per class.

Since pupils are random samples of the population, we feel the results might also apply, more in general, to the teenager population of the same age. The only *caveat* is that the rate of answers is not 100%.

The population of students attending the first two classes of Italian high schools is constituted by 1,155,816 pupils: 598,725 in class 1 and 557,091 in class 2 distributed in 49,529 classes (24,959 class 1 and 24,570 class 2).<sup>4</sup>

From a quantitative point of view, in order to obtain a confidence level of 99%, with a maximal error of 2%, we need a statistical sample of 4,091 replies. Our sample of 5,230 students is therefore amply sufficient to obtain a 2% error with probability of 99%, which is fully adequate for the purposes of the research.

### 2.2 The structure of the questionnaire

The image adolescents have of the scientists, which occupies much space in our questionnaire, has the scope of shedding light on the links between the social and the epistemic dimensions of science, moving from events which are close to the public being questioned. Such image is transmitted not only by the school, but also by the media and therefore it is heavily influenced by cultural stereotypes: many protagonists of movies intended for a young audience are scientists and more often than not such figures substitute the real scientist in the perceptions of adolescents.

The questionnaire includes also a wide range of questions concerning social issues linked to science and leaves room also for personal opinions.

The questionnaire is arranged by themes:

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<sup>2</sup> See also <http://ics.sissa.it>

<sup>3</sup> Ulisse is a website entirely devoted to science and its popularisation. Visitors subscribe to it only if they want access to the interactive services. As a consequence, teachers who subscribe to the site are probably very interested in science.

<sup>4</sup> Data supplied by the Ministry of Education, University and Research, Servizio per l'Automazione Informatica e l'Innovazione Tecnologica, EDS - Servizio di Consulenza all'Attività Programmatoria, "Sedi, alunni, classi, dotazioni organiche del personale docente della scuola statale Anno scolastico 2003/2004", Roma, September 2003, 77-78

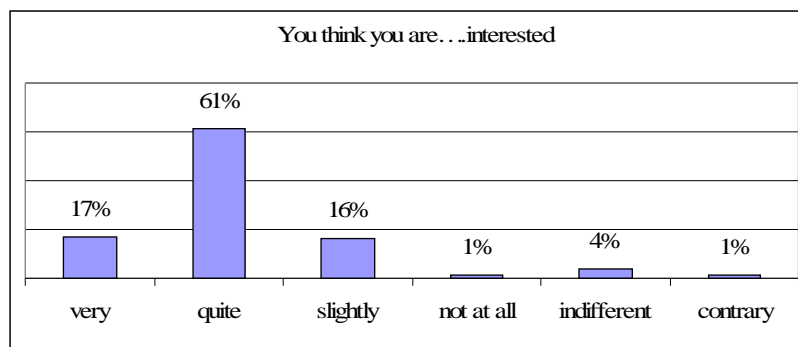
- The definition of the scientist: do young people think that being a scientist is a job open to everyone or do they reckon it is only open to an elite; which personal characteristics are required to become a scientist; is it a job to be carried out on one's own, or is it a group work; does it have a connection with society, etc.;
- What does a scientist do: inventions/ discoveries, observations/ experimentation, calculations, writing, transforming/manipulating, helping/taking care of things.
- What are the timings and routines of research; which is the average age of a scientist;
- What tools are needed by a scientist (intellectual and material); what is the relationship between science and animal life.
- The places where science is exercised: the lab, the office, open air, etc.
- What is the motivation of teenagers to enter the scientific profession, what are – in their opinion – its aims and objectives; what role(s) should competition and co-operation play.
- Understanding scientific methodology, hypothesis and deduction, error, etc.
- Analysing the possible interactions between science and society; individual and collective feelings (fear, faith, exclusion, IAC, etc.).

The questionnaire consists of fifty questions. Three questions are left open: we ask to describe a scientist and his/her skills, and we ask about pupil's interests and hobbies. The other 47 questions offer multiple choice answers.

The close questions have two standard formats for replying: either a selection between several choices, or a scale from 1 to 4 (only one question has a scale from 1 to 6), allowed the expression of opinions and evaluations on science and scientists. To complete the questionnaire students need approximately two hours.

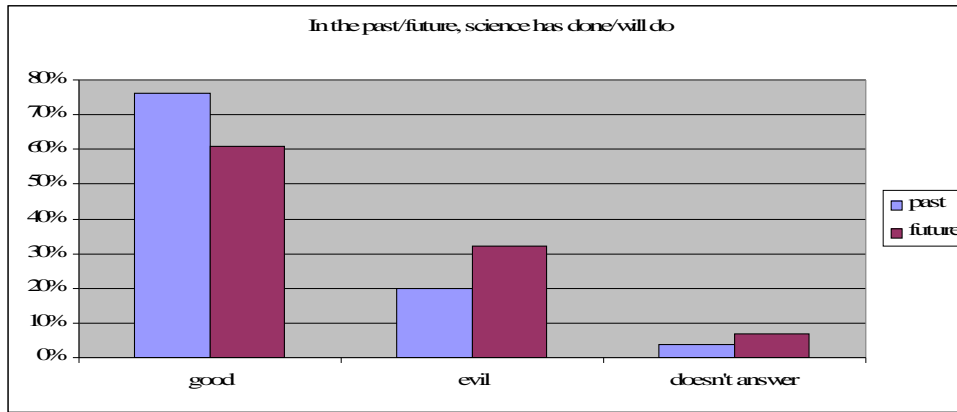
### 2.3 Some relevant subgroups in the sample

At first, we evaluate two significant parameters: the *interest* in science and the *attitude* to science: we ask explicit interest (Fig 1) and cross the replies about hypothetical uses of science (Understanding, knowing | Solving practical problems | Doing evil | Improving the quality of life | Having influence |Curing |Doing good) and the ones which describe *impressions* about science in the past and *expectations* about science in the future. These are summarized in Fig. 2.



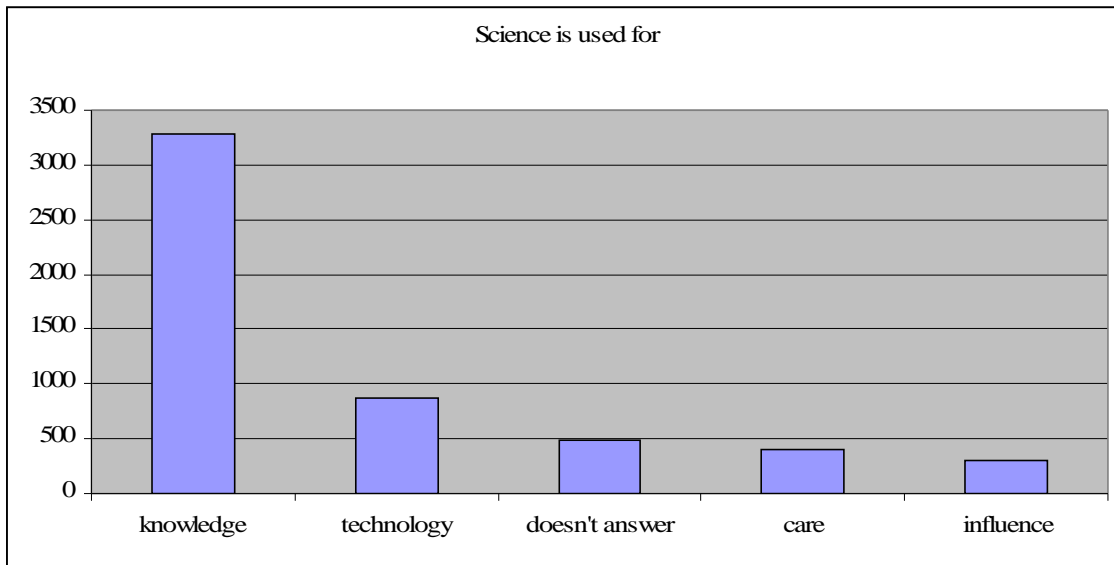
**Figure 1** Pupils' interest

Students have, in general, a positive view of the past (76 % think that in the past science has done more good than evil) but less optimistic views about the future (the percentage, however high, in this case goes down to 61%). It is interesting to note that among pessimists 20% are critical about the past and 32% about the future. (Fig 2)



**Figure 2 Pupil's expectation**

Putting together all replies, we arrived at five classes, proceeding as follows. First of all, we compared replies about impression on the past/future. 424 pupils didn't answer at least one of the sub-questions. The other 4,806 divided were divided in four groups, according to their impressions and expectations. On the other hand, four classes emerges from the replies on the aim of science (Fig.3)



**Figure 3 The aim of science**

Putting together all replies relating to the aims of science, the evaluation of the past and expectations for the future we arrived at five classes:

- **SciOriented** pupils are those who think that science is used for knowledge and that it will not do evil in the future. To this class also belong students who do not have an opinion about possible uses of science in the future (52%)
- **SciTeched** pupils are those who think that science is the basis for technology, regardless of the past and of expectations for the future. To this class also belong students who think that science in the future will do more good than evil and that it is used for improving people's conditions (23%)
- **Disheartened** pupils are those who think that science will do evil in the future and think that science is only the basis for technology (14%)
- **Uncritically confident** pupils are those who think that science is used for improvements but they don't know what it will succeed. To this class also belong students who have positive expectations for the future or think it is use to acquire power, or do not have an opinion on the matter (8%)
- **NoWay** pupils are those who don't find any use for science and they think that in the future it will do evil. They don't know what it will do, they have a negative impression about the past and they think that science is used for the acquisition of power (3%).

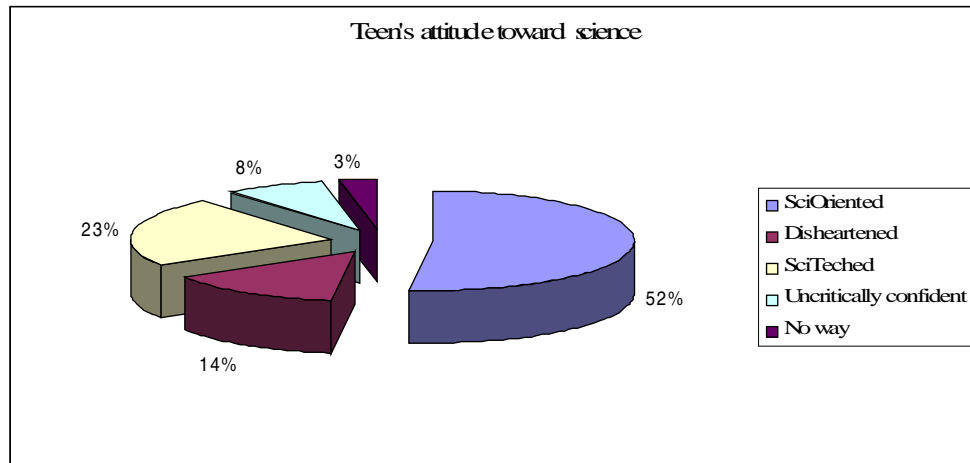


Figure 4 Teens' attitude forward science

From a quantitative point of view, students seem to have a surprisingly positive attitude towards science, albeit with some concerns. This tendency becomes a “faith”, which is at times unjustified, contradictory, with a fatal attraction for technology.

### 3 Beliefs and contradictions about science (some results)

#### 3.1 A portrait of the scientist

Common people watching the world through special glance: this is the image which teenagers have of the scientists. S/he is: an adult, middle-aged, male or female; very curious and, at the same time, diligent; tidy and neat; no other special *personal* characteristic are indicated. A scientist may be both altruistic or egoistic, pleasant or unpleasant; with or without a family, friends and social connections, as everyone else. On the other side, scientists have some peculiar *professional* features: they are curious rather than boring, tidy, diligent rather than absent-minded.

Finally, scientists are more interested in achievements than in profit; they like their results to be published and quoted.

Generally speaking, according to the adolescents in our sample, in order to be scientists people must have a mix of will and talent, intelligence, self-sacrifice and must be hard-working students. An interest for wildlife and animals is not an essential prerequisite.

A scientist needs to interact with other social figures. Boys believe this more strongly (70%) than girls (61%). Both groups, however, think that the work of a scientist should be of benefit to everyone. Some doubts about this role are shown by teenagers of *low cultural level* and by those with *little auto-declared interest*. These categories do not agree with the image of science as a collective enterprise. In particular, one teenager out of three in the *against science* category believes that a scientist is totally isolated from society. We may say that this is one of the factors with which one can measure disapproval of science.

According to our students a scientist is either a chemist or a physicist, an astrophysicist, a biologist a mathematician or a geologist. Doubts have been expressed whether the qualification of ‘scientist’ should also apply to palaeontologists, zoologists, botanists, medical doctors and immunologists.

If the judge, the jurist, the economist and the wizard are surely not scientists, there are categories for which there is some uncertainty: should the software developer, the historian, the philosopher and the statistician be defined as scientists? Only teenagers whose parents are of low cultural level consider them all as such.

A relevant role in the definition of a scientist's image is played by the most famous scientists, real and imaginary, dead and living. Furthermore, there are people classified as *famous scientists* who are actually not scientists. Such answers, however, give very useful information on the way science is perceived by young people. In fact, to the question "*write the first three names of scientists that occur to you*", nine in ten teenagers gave only one reply. The total number of replies is 15,697 because there are replies including more than three names. Altogether 499 different scientists were named, quite a number for 14-16 year olds.

Top of the list come Einstein, who received 3,615 votes (more than seven teenagers out of ten chose him) and who emerges from this research more like the icon representing science itself than just as a scientist. Pupils don't actually

know much about his achievements and theories, but they know *him*. His name is spelled in 30 different ways in the replies:<sup>5</sup> this might mean that his actual name is less known and less important than the symbol he seems to represent. Students have named 5,517 physicists, 1551 biologists, 1234 natural scientists, 368 chemists and 360 mathematicians, which somewhat reflects the relative fame of the various scientific professions.

Archimedes and Darwin, chosen by 90% of the sample, show a generalised and deep-rooted knowledge of their scientific activity probably coupled also to a knowledge of them as historical characters. Rita Levi Montalcini and Enrico Fermi (both over 65%), confirm the interest roused by 20th c. by physics and biology.

There are some contradictions: the scientist's image is a mix of ambition, selflessness, co-operation, competition and egoism. In particular, competition does not have any positive meaning: in fact, it has been chosen in greater percentage by those classified as *against* and *disheartened*. On the other hand, faith in co-operation increases between *girls*, those with a *great interest*, and *sciOriented*.

Another contradiction emerges from the identification with the scientist. Only a third (37%) of our sample thinks that, in the future, it is possible to become scientists; many of them think that this is surely impossible. Students from comprehensive school are, in this respect, the most positive and optimist.

Identification with the figure of the scientist is not influenced by cultural level or by attitude, but by gender. Boys consider that scientists may be both female and male, but girls are more puzzled and have a greater difficulty to identify themselves with a scientist.

### 3.2 How does the scientist work

Teenagers seem not very well informed about science: for instance, those with *great declared interest in science* do not seem to assign importance to scientific method. And this incomprehension coexists with the belief that science studies and investigates any event. Teenagers belonging to the *great interest* category seem to have a rather naive view of science: a methodology which achieves knowledge without having any rules, which is far from the Galilean "*provando e riprovando*": in short science for them seems to be made only of discoveries and results.

When answering a direct question almost half of the sample states that a scientist's work consists prevalently in thinking and evaluating hypotheses: s/he is involved in a speculative activity. The hypothesis constitutes a starting point for scientific research, regulated by scientific methodology and logical deductions. From other questions emerges, however, a different story: the scientist's work consists mainly in observing: this statement goes together with the 'classical' iconography where the scientist is characterized by spectacles; the microscope and the telescope also hint at observation as the main activity of the scientist.

On the other hand, teenagers seem deeply convinced that thought is essential in scientific work. It consists of mathematics, abstraction, observation, capability of formulate hypotheses, models, methods, theories, etc., but in their perception, observation is the tool which mostly characterises science. In fact, scientists work through observation and experimentation: they study animals and nature; and travel in order to observe phenomena which cannot be reproduced. Scientists, like in the stereotype, wear big glasses to observe reality.

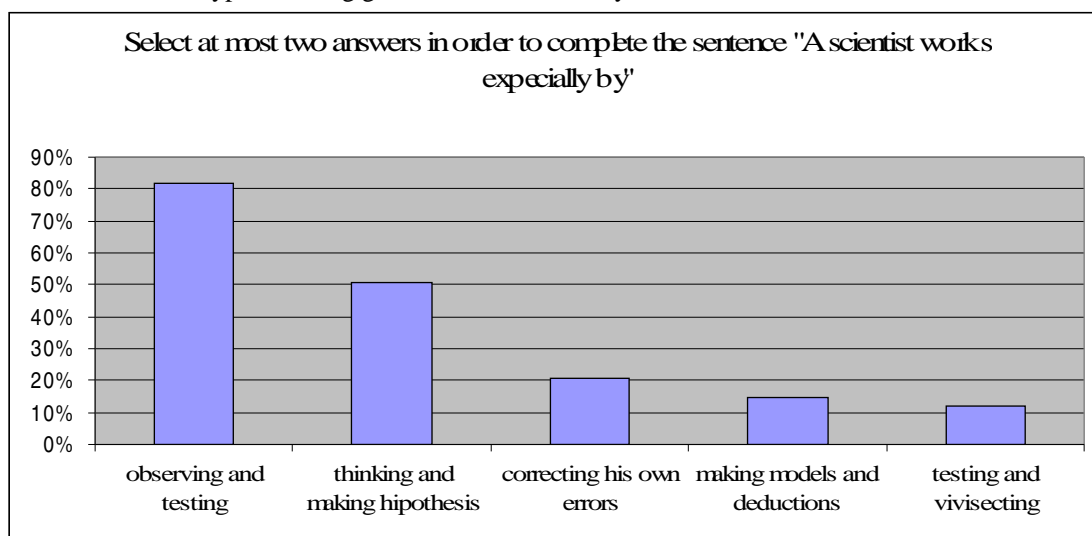


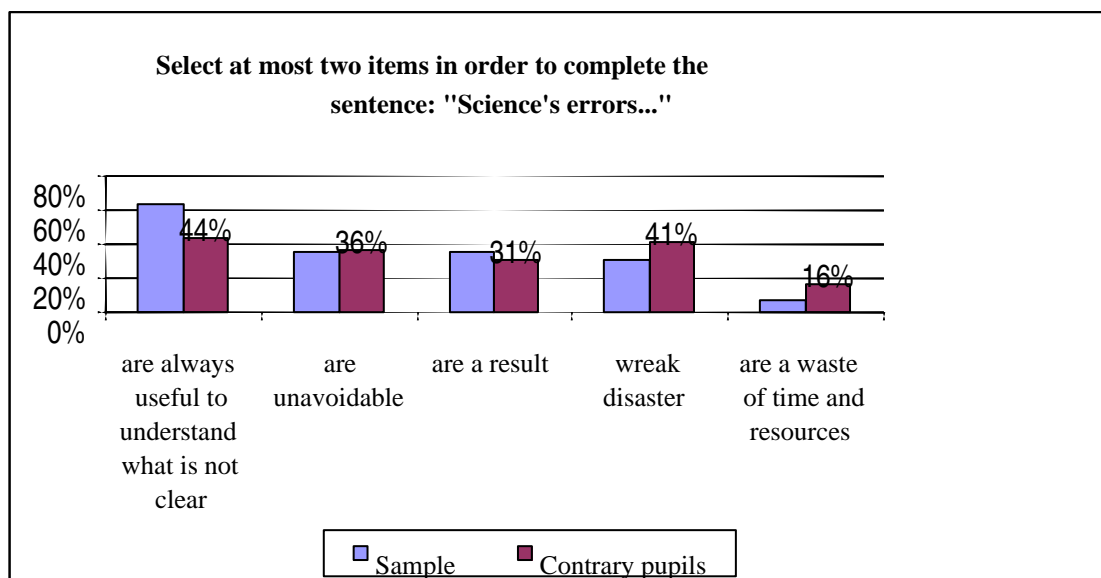
Figure 5

<sup>5</sup> Ainstain, Ainstein, Ainsten, Aistain, Aistein, Aistong, Alfred Einstein, Angela Einstein, Einchting, Eindtein, Einestine, Einstain, Eintain, Eintein, Eintstein, Eistain, Eistine, Hainstain, Haintatin, Haistain, Haistein, Heigstain, Heinstain, Heinstein, Heinsteing, Heintein, Heistain, Heistein, Heisten

Boys are more convinced than girls that a scientist works mostly through observation and testing (boys: 88%, girls: 78%, mean: 82%).

Scientific thinking is characterised by the attitude through which scientists aim at obtaining results. Science is used to investigate hypotheses, in order to see if these produce contradictions; but it is also used to: deduce results from a very limited set of initial data, induce a general regularity from a series of particular cases which existence was not known.

Teens know that all of these are a consequence of two abstract tools: interpretation of the errors and formulation of hypotheses. Only the *contrary* teenagers do not think that errors may have a positive role in a scientist's work.



**Figure 6 The errors' role in scientists work**

Most of the students in the sample consider experimentation as the core of scientific activity. Thus, the lab becomes one of the sources of scientific thought: in the laboratory, ideas originate and develop, and that may contribute to the formulation of a new theory.

In a lab, abstractions may become reality: it is possible to isolate and study only some peculiar aspects of a natural phenomenon. The lab allows the scientist to put him/herself in the exact conditions s/he desires, without any distraction not relevant to the research. Such an interpretation of the laboratory's role is more typical for boys than for *girls*, for the students from comprehensive schools more than for those from *technical and professional schools* and for those with a *great interest* and by the *sciOriented*.

The lab allows *the scientist to repeat many times a particular situation and invent completely new situations and worlds*. Through the instruments, the scientist aims at *confirming what s/he knows through theory* (57%) or, on the contrary, to *prove that a theory is wrong* (25%). Furthermore, pupils think that s/he may decide to go beyond the simple verification and to use the instruments in order to exceed the theory itself. In this case, the instrument becomes a guide for the thought, it is used to make abstractions possible.

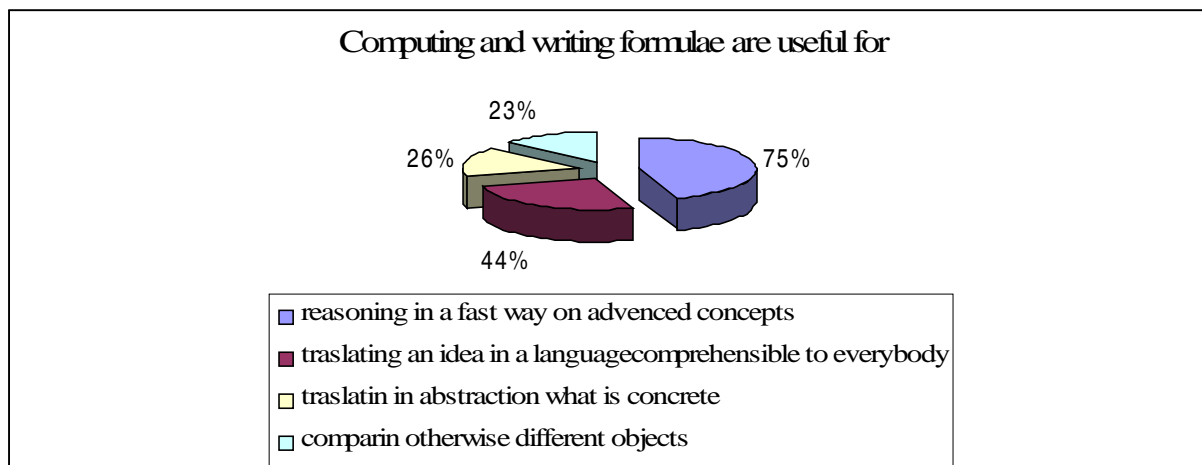
### 3.3 The role of communication

Once an experiment is carried out, or a theory conceived, the scientist needs to communicate it to other scientists, to her/his peers, but also to the public of a journals, magazines, and television. From this point of view, scientific activity also entails the organisation of thoughts in words, sentences, numbers, formulae, graphs, images. Convictions like these emerge from many open replies which refer to *explaining, speaking and making discoveries public*.

The expressive potentialities of scientific language are based significantly on the possibility of realising images: this is the communicative counterpart of the relevance of observation as a scientific practice. Since *a scientist cannot work in isolation from the rest of society* (53% of the sample believe in this), a scientist feels satisfied if a result is published and quoted (46%).

Relevant tools for science communication are computations and formulae, and 75% of our sample thinks that they are used in particular to *argue on advanced concepts* and, to a lesser degree, to *translate an idea in a language*

*comprehensible to everybody*. Thus, scientific language is seen as a mathematical language, based on formulae, symbols and numbers. Such a belief is spread among the sample without exceptions of gender, culture, interest and attitude.



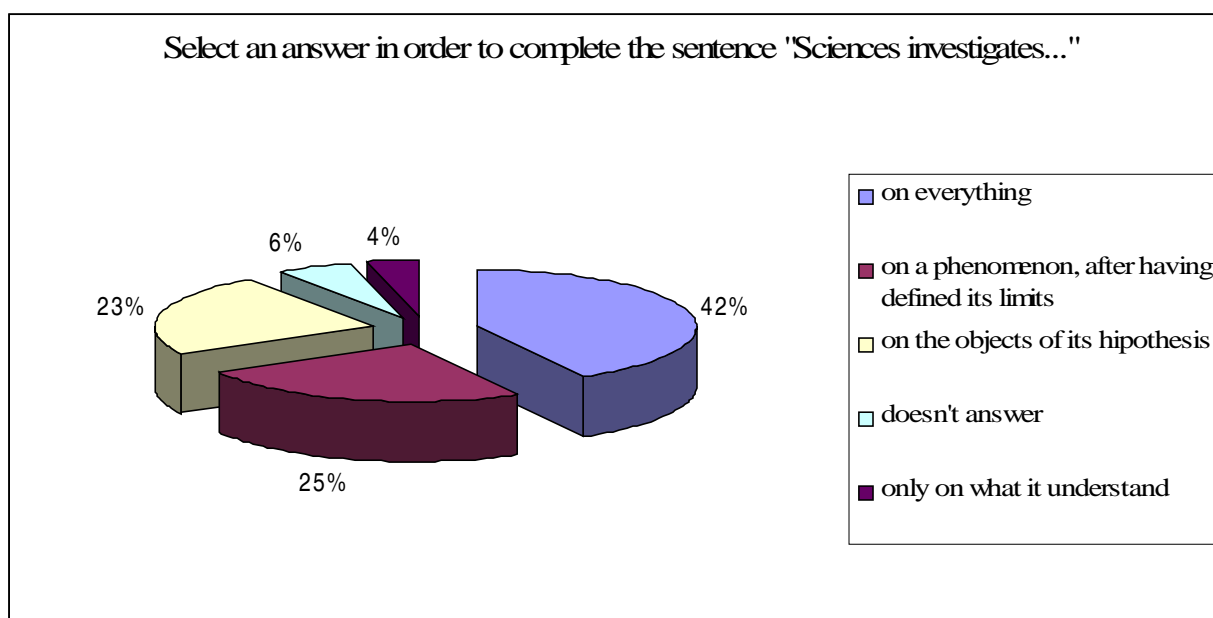
**Figure 7 computing and writing formulae**

### 3.4 Scientific approach and the global problems

Scientific thinking is important also outside science and is of help in a lot of situations. For more than half of the sample *observation and experiment are an approach to all human problems* (55 %) and are able to *solve all evils* (23%). They think that everybody is able to think scientifically. No particular capability is necessary. Scientific thinking is available to everyone, and therefore the relationship between science and society proceeds in both directions.

Science is a social activity: society needs science for its progress, and science needs society in order to advance (just 19% thinks that *a scientist is a stranger to society*, while 53% that *a scientist cannot work in isolation from the rest of the society*). In relation with society, science is, first of all, a cognitive practice, which gives the whole society the means to evolve. Technology, medicine and other applications follow.

Science is prevalently perceived as a tool for knowledge. Its aims are understand, know and become aware. In this direction, the most popular opinion is that science can investigate anything.



**Figure 8 Science can investigate anything**

A crucial point is to understand how science carries out investigation. Observation and experimentation represent, first of all, a test, but they are also a way to look at human problems and at natural phenomena.

Ethical concerns are also present. 32% of the teenagers in our sample think that transformation and manipulation are neutral tools, *an efficient and controlled instrument to understand how things change*. All the others are divided

between three opinions: a positive opinion (*transformation is the realisation of rightful and just attempts*, 20%), a negative opinion (*transformation is a dangerous and witchcraft-like activity*, 22%), an ambivalent opinion (*transformation is a possibility to create new beings and objects*, 22%).

The ambivalent choice is refused by the *boys* (19%) and appropriated by the students of *technical institutes* (26%) and by those of *low cultural level* (25%). Furthermore, *disheartened* and *noWay* teenagers are troubled by transformation and manipulation, while the *sciOriented* do not offer any open criticism. In this context, the risks for mankind and nature are present but not in a relevant way. The expectations are neither catastrophic nor euphoric.

Another relevant question is to understand what science does and in what it consists of: 50% of the sample thinks that *helping and curing* are the real aims of science, but very few teens are confident that science is really able to help and cure. Such a deviation, between the foreseen aims and the actual use of science, is not casual: it is related with the corresponding deviation between the impressions of the science's past effects and the expectations for its future results. In fact, scientific discoveries should improve the quality of life, but they will not solve global problems (poverty, hunger, war).

### 3.5 Confidence, quality of life and media

Despite all reservations teenagers trust science, and they are sure that research has to be financed, even if it does not obtain direct benefits (79%); even if the trust in future progress is (61%) inferior to the consideration for past results (76%)<sup>6</sup>. Teenagers are persuaded that positive social role of science is going to decrease: science will be able to help us at an individual level, but it will not be useful to win the global challenges. Moreover, there are some social actors (the military, industrialists, etc.) which may use science in a wrong and bad way.

This confidence held by teenagers is based on a very well-balanced auto-perception about their own information: they can be divided in enough and little informed. The latter are slightly prevalent. *Girls* perceive themselves as informed, more than *boys* (there is a difference of ten points between them). Students of *medium-low cultural level* and those with *little interest* think to be little informed, as do those belonging to the *contrary* and the *disheartened* groups.

As media concern, teens are persuaded that some media treat science better than others. They prefer television to the internet (in fact, on the web you have to take choices and choices, in their mind, reduce meaning and weight of information), magazines to daily papers, books to comics, etc. They assign a crucial role to authorities: a chat with a friend is not a means of comparison and learning about science – that is a situation in which nobody has an authority to spend, and hence no science is possible.

Only those with *great auto-declared interest* prefer comparison to authority and are able to do without an authority *ex cathedra*: they indicate as source of scientific knowledge the options: *friends, not scholastic books, comics*. And they are able to use the web to obtain information, as are the *sciTeched*.

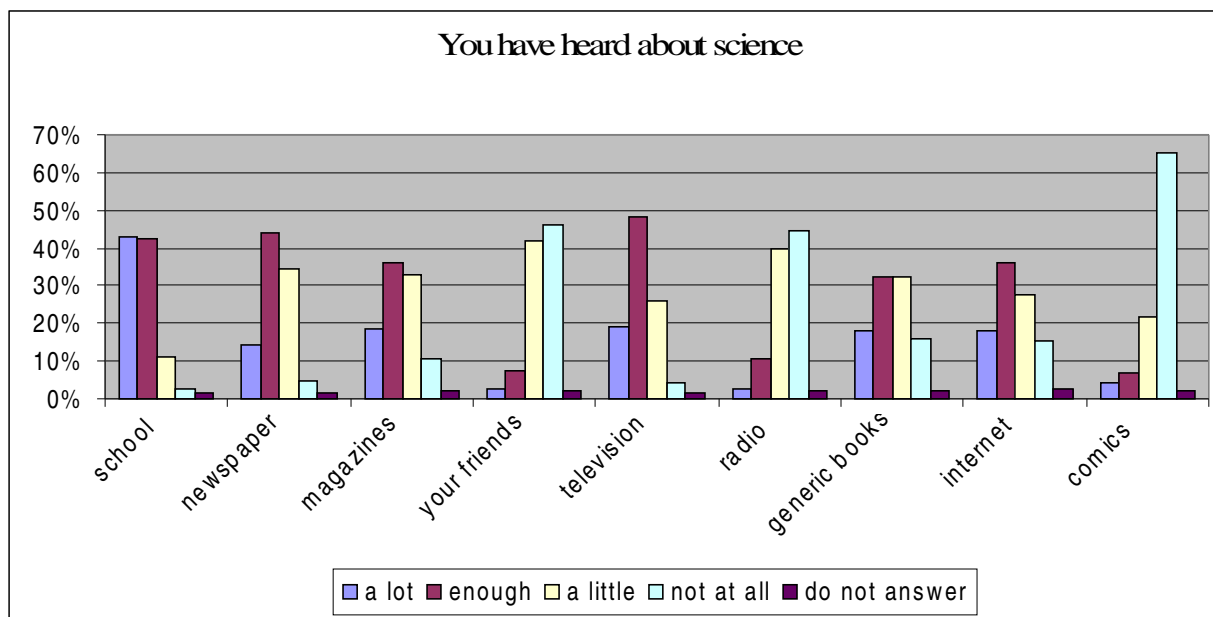


Figure 9 Science and the media

<sup>6</sup> If one separates the data according to gender one notices that 15% of the boys are critical about the past a percentage rising up to 24% for girls. As regards the future girls are more optimistic than boys: 63% as against 59%.

## 4 Conclusion

### 4.1 *The social representation of science*

As science is part of culture, it is characterized both by concepts, notions, models and by metaphors, stereotypes, beliefs, conceptions and misconceptions. Individual and collective beliefs inform the social representation of the scientist's figure, of science's role, objectives and methods. We approach scientific culture as a social issue.

Teenagers may represent the beholders of the idea of science in the social imaginary; this idea coagulates under the action of different influences: school, family and mass-media, the continuous exchange of knowledge and beliefs, peer-to-peer. Our study is a contribution, limited to the Italian context, to shed light upon the teenagers' social representation of science and the scientist.

### 4.2 *Teenagers' identification and interest*

For a teenager, a scientist may be whoever, but s/he thinks they may not become scientists themselves because of the sacrifices and hard work involved. To be a scientist entails reaching fame and glory and therefore it is an unobtainable goal, rather than a profession.

On the other side, science catalyses a lot of interest, which does not depend on the kind of school attended, or on the subjects teenagers learn at school, nor on the ethical discussions - which are present and which are faced without prejudices. It may be defined as a *pure* interest.

The subjects teenagers like most are astronomy, genetics, medicine and psychology, which charm them; while they are not so fascinated by chemistry, mathematics and physics. A complex and articulated vision of the science emerges from this study, studded also by contradictions: teenagers seem to think that different scientific work may have different goals: knowledge, solution of global problems, medicine, technology, ethics, theory, etc. Consequently, science produces expectations and hopes which may be not fulfilled; but this disappointment is not sufficient to reduce them. So hope and distrust may be present, at the same moment, in the same person.

A great realism emerges: science must try to help men, but a positive result is not guaranteed; even if science can help, care for people is not its main goal.

Also in order to 'do' science, communication between science and society is necessary: science and its image are determined by all the acts of communication in a society, not just by those directly devoted to science. Science exists in strict relation with society; it needs suggestions coming from extra-scientific situations.

Obviously, science and scientists are under the eyes of the mass media, they are at the core of a rich and multi-faceted activity, which influences our minds. In particular, the presence on the media addresses the interest to not formalized topics. Moreover, even if the position of the media is negative, in contrast with science, the support does not reduce in a significant way: actually, teenagers think that science has to be supported, independently on its results.