

Science: universal, independent, but respectful of human values

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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		<i>Survey on Climate Change</i>			
<p>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;</p> <p>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.</p>	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
	<i>Survey on the Water Crisis</i>				
	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		<i>Survey on Climate Change</i>			
<p>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;</p> <p>B: I believe that the scientific community will not allow the topic or the results of their research to be influenced externally.</p>	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
	<i>Survey on the Water Crisis</i>				
	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		<i>Survey on Climate Change</i>			
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;	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
		<i>Survey on the Water Crisis</i>			
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	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		<i>Survey on Climate Change</i>			
A: In the choices of public policy human and social values are important at least as much as scientific results and evidence;	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
		<i>Survey on the Water Crisis</i>			
B: Scientific results and evidence are the best basis for public policy choices.	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
<i>5.1 – It is right that scientists are autonomous and responsible in their choice of research topics and methodologies</i>	<i>Survey on Climate Change</i>			
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
	<i>Survey on the Water Crisis</i>			
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
<i>5.2 – It is right to envisage the universal sharing of the scientific results obtained</i>	<i>Survey on Climate Change</i>			
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
	<i>Survey on the Water Crisis</i>			
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
<i>5.3 – It is right that research is commissioned above all on the basis of specific market needs</i>	<i>Survey on Climate Change</i>			
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
	<i>Survey on the Water Crisis</i>			
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

<i>5.4 – It is right that researchers have an economic return on the patents deriving from their work</i>	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
<i>5.5 – It is right that developing countries have full access to research and to its results</i>	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
<i>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</i>	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 list². 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 (...)?	<i>Survey on Climate Change</i>		<i>Survey on the Water Crisis</i>	
	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.

Bibliographical references

KALLERUD E., RAMBERG I., *The order of discourse in surveys of public understanding of science*, in "Public Understanding of Science", 11, 2002

MAYER M., *La competenza scientifica degli studenti*, in INVALSI, *Le competenze in scienze, lettura e matematica degli studenti quindicenni*, Roma, Armando, 2008

MERTON R.K., *The sociology of science. Theoretical and empirical investigation*, Chicago, University of Chicago Press, 1973

MICHIE S., DRAKE H., BOBROW M., MARTEAU Th., *A comparison of public and professionals' attitudes towards genetic developments*, in "Public Understanding of Science", 4, 1995

VALENTE A., CERBARA L., *Ragazze e ragazzi guardano la scienza: distacco, obbedienza, fiducia?*, in *La scienza dagli esperti ai giovani e ritorno / Science: from specialists to students and back again*, Roma, Biblink, 2006, http://www.irpps.cnr.it/com_sci/pubblicazioni_pdf.php

ZIMAN J., *Research as career*, in COZZENS S., HEALEY P., RIP A., ZIMAN J. (eds), *The Research System in Transition*, The Hague, Kluwer Academic Publishers, 1990