Chapter 12

Public perceptions of science: methodological review and survey findings for São Paulo

1. Introduction 12-3

2. Public perceptions of science: developing a new discipline 12-3

2.1 International and national context 12-4

2.2 In search of indicators: a conceptual and methodological challenge 12-5

2.3 Use of research on public perception of science as policy-making input 12-8

3. Public perceptions of science in São Paulo: case study of three municipalities 12-11

3.1 Objectives and methodology 12-11

3.2 Discussion of results 12-12

3.2.1 Social representations of S&T 12-12

3.2.2 Public understanding of the content of scientific knowledge 12-17

3.2.3 Social communication of science 12-18

3.2.4 Public participation in S&T affairs 12-22

4. Convergences between findings of surveys in São Paulo and other countries 12-22

5. Conclusions 12-23

References 12-25

Figures & Charts

Chart 12.1
Three dimensions of public understanding of science 12-6

Chart 12.2
"Deficit model" of public science communication 12-8

Chart 12.3
Spiral of scientific culture 12-10

Figure 12.1
Responses to statement "Applied S&T will increase the supply of jobs", by age group 12-13

Figure 12.2
Responses to statement "We attribute too much truth to science and not enough to religious faith", by education & age 12-14

Figure 12.3
Responses to "Many people think the development of science presents problems for humanity. Do you think that is the case?", by education level 12-16

Chart 12.4
Comparison of findings from São Paulo State survey with results of surveys conducted in U.S. (NSF) & Europe (Eurobarometer) 12-18

Figure 12.4
Responses to "The main cause of improvements to the quality of life for humanity is scientific & technological progress" cross-tabulated with grades for general knowledge about science 12-19

Figure 12.5
Responses to "S&T in general are not concerned with people's problems", by level of exposure to mass media 12-20

Figure 12.6
Public knowledge about S&T, by level of exposure to mass media 12-21

1. Introduction

Public perceptions of science and technology (S&T) are a relatively new item on the academic research agenda but are increasingly coming under scrutiny, not least to support policy making for the sector. A better understanding of S&T's complex dynamics and interactions with society, taking the opinions of the general public into account, has also been found useful for the endeavour to increase access to knowledge and move towards more democratic management and social control of S&T.

The inclusion of this chapter in this series of *Indicators of Science, Technology & Innovation in São Paulo*, published by FAPESP, is extremely relevant if, instead of being considered merely a phenomenon to be controlled or changed, public opinion about science is to be understood as a significant indicator for the formulation of public policy. Any society that claims to be democratic must investigate and comprehend this phenomenon. The demands, concerns and expectations of the citizens, as well as their discontents, must be discerned and should be part of the policy-making agenda in S&T, along with other areas.

In the last 20 years governments and researchers have gradually taken up the challenge of developing indicators that gauge public perceptions of S&T and the degree to which the citizenry participate or take an interest in related issues, thereby building up a picture of scientific culture in its various facets. Nevertheless, the opinion surveys that have been conducted, the indicators proposed and the analytical models used have proved insufficient to provide an adequate description of public perceptions of science. There is no international consensus in this field today, and no standard methodology or set of metrics. But there is a universal awareness of the need for a theoretical framework and the importance of collecting and analysing empirical data on the subject.

The aim of this chapter is to review the most widely used concepts and methodologies in research concerning public perceptions of science; to set out a critical discussion of the indicators developed and surveys conducted to date; and to contribute to conceptual refinement in this field (Section 2). Case studies of three municipalities in São Paulo State are discussed in Section 3. These are of an exploratory and preliminary nature but may nonetheless lay a basis for the future development of indicators that reflect the specific characteristics of the state while also allowing for international comparisons and contributing new elements to the formulation of public policy throughout Brazil. The case studies analyse responses to a questionnaire by 1,063 residents of Campinas, Ribeirão Preto and São Paulo City in the period February-September 2003, including cross-tabulations focusing on certain aspects of public perceptions and comprehension of S&T.

Lastly, Section 4 highlights the main findings shared by international surveys of public perceptions regarding S&T and the studies conducted in São Paulo. The chapter ends with recommendations for future research both in Brazil and worldwide, as a contribution to more accurate and useful comprehension of the subject.

2. Public perceptions of science: developing a new discipline

Science and technology are undeniably important in the modern world, and their influence on processes of political change in contemporary societies is equally beyond doubt. This is a structural condition – with a positive or negative charge according to the case and the analytical viewpoint – of societies that are moving or desire to move increasingly towards what is known as the knowledge-based economy. The importance of science in modern society has an implicit corollary: scientific issues become more than ever issues of science, technology and society (Vogt & Polino, 2003).

Science and technology affect society in various ways, through the economy, politics and the affairs of the community (or civil society, as it is known in many countries). S&T also affect specialised institutional spheres (health, education, law, social security and welfare etc.), as well as most areas of culture such as the media, beliefs, behaviour, values etc. (Holzner et al., 1987). But how does society perceive these multiple influences of S&T? How does it "connect" with S&T? What does the general public think about knowledge application and its results? What perceptions does it have of the risks associated with certain technologies? How are the controversies aroused by scientific research addressed? How is knowledge appropriated? How much does society trust scientists and experts in general? How does scientific information flow through society? What kind of scientific knowledge should be absorbed? What attitudes do ordinary people take towards the local scientific system? Many more questions like these could be cited, and the search for answers has been going on for many years.

Attempts to understand the dynamics of the relations among science, technology and society led to the realisation of the need for indicators that can measure changes in public perceptions, social participation and scientific culture in general.

Criticism of S&T from social movements that emerged in the post-war years, intensifying in the 1960s and 1970s, was a major driver of interest in public attitudes to scientific evolution and technological applications. At the same time, Robert K. Merton and other sociologists began focusing on knowledge and scientific processes (Merton, 1973), taking the sociology of science as a legitimate object of research. Many analysts have since highlighted the importance and multifariousness of the relations between science, technology and other social institutions (Latour, 1988/2000; Ziman, 1977/1981).

Thus, over the last 30 years problems relating to public perceptions of science and scientific culture have become an object of interest for institutions and all agents involved in a variety of ways with research and development (R&D). So much so that these questions have become key elements in the public policy agenda for the European Union, the United States, Japan, Canada and, albeit to a lesser extent, countries in Latin America.

In parallel with these developments, the first initiatives were taken to produce instruments with which to measure levels of public perception and scientific culture, with the support of institutions responsible for science policy formulation and management (Bauer et al., 2000).

The U.S. National Science Foundation (NSF) was one of the pioneers. As long ago as the 1970s it gave equal importance to S&T indicators and to measuring public perceptions of S&T. Fourteen of the 15 volumes of *Science & Engineering Indicators* published by the NSF since 1972 (NSF, 2002) devote a chapter to public attitudes and public understanding of developments in S&T.

In the 1980s, new interest in the area and the potential for fresh tension between scientific institutions and society led to several initiatives to examine the public's understanding of science.[1] The British Government was the first into the field, commissioning a famous study known as the Bodmer Report (Bodmer, 1985). This confirmed the academic status of research into the public understanding of science as a legitimate interdisciplinary enterprise comprising theoretical models and empirical surveys based on quantitative and qualitative research methodologies, such as questionnaires and interviews, focus groups, media studies and citizen discussion groups, among others.

2.1 International & national context

Studies designed to understand the findings of surveys on public perceptions regarding S&T are especially relevant in countries where democracy has not yet been consolidated and extraparliamentary political organisation is weak, as is the case in most of Latin America. In this group of countries, opinion surveys offer information that can be used by government, social movements and other groups (Howlett, 2000).

Some authors stress a lack of correspondence between public opinion and public policy due to the "vague, abstract and transitory" nature of the former, but even if there is no direct link between the two, their relationship is important as a "backdrop" (Howlett, 2000). Capturing and understanding it in all its complexity is important for democratic societies. Thus the issue is one of democracy and politics with clear consequences for the idea of citizenship and day-to-day social relations. Public opinion plays a key role at the extremes of public policy formulation and implementation, agenda building and decision making: participating indirectly as one of several actors that represent different interests, it provides a measure of the response to government actions and exerts pressure on governments (Howlett, 2000; Monroe, 1998).

Surveys are now regularly conducted into public perceptions and public understanding of science in the E.U., Australia, Canada, China, the U.S., U.K. and Japan, among the leaders. The most frequently used methodological instruments are quantitative surveys and focus groups. Questionnaires are usually based on the model developed by the NSF, thus facilitating international comparisons (NSF, 2002; OECD, 1997a, 1997b; OST, 2000; Eurobarometer, 2001a). Surveys of public attitudes to specific aspects of S&T, such as biotechnology or information technology, often use questionnaires in conjunction with qualitative data derived from in-depth interviews or focus groups (Gaskell & Bauer, 2001; Eurobarometer, 2000b).

1. The Committee on the Public Understanding of Science (COPUS) was founded in 1985 by the three pillars of the British science system: the Royal Society, the Royal Institution and the British Association for the Advancement of Science. The U.S. has an Office on Public Understanding of Science (OPUS), part of the National Academy of Sciences. Similar initiatives exist in other countries, including Germany, Portugal and Canada. Other examples of growing interest can be found in actions under the aegis of Spain's National Plan for Scientific Research, Development & Technological Innovation, the inclusion of science education and diffusion in China's National S&T Programme in the mid-1990s, and the recommendations of the UNESCO World Conference on Science (UNESCO, 1999a, 1999b).

In Latin America the construction of indicators is incipient but there have been measurement efforts by governments or academia in Mexico, Panama, Colombia, Cuba and elsewhere (Vogt & Polino, 2003).

Brazil has had only one such survey, commissioned from Instituto Gallup in 1987 by the National Council for Scientific & Technological Development (CNPq) and its Museum of Astronomy & Related Sciences (MAST). The purpose of this survey was exclusively to construct indicators and references in the area of S&T to reflect perceptions of science among the urban population (Instituto Gallup, 1987).

Brazil's redemocratisation from 1990 onwards led to expansion of the public space and made the public-sector bureaucracy more responsive to organised pressure from advocacy groups. As a result, surveys were gradually recognised as instruments for research in this area as well as support for decisions on specific policy measures. A good example of this is the nationwide survey conducted in 1992 by the Ministry of Science & Technology (MCT) and CNPq to find out "what Brazilians think of environmentalism".[2] Respondents were asked questions about their opinions and values relating to the environment, environmental conservation and environmental education.

Nothing is known of similar initiatives by any government agency to find out what the public thinks about science, technology and related issues, especially their overall values and opinions regarding the content of S&T.

However, surveys have been legitimated as means for researchers and professionals in the public sector to glean information on the opinions, attitudes and behaviour of the Brazilian people, not just in respect of S&T but in general. Surveys designed to measure trends in political and social behaviour have thus become a means of gathering information on attitudes to the environment, consumption of scientific information, knowledge about scientific and technological discoveries, and opinions on their impact on daily life. Surveys on genome research and genetically modified food are typical examples.[3] A survey on GM food covered a nationwide sample and was conducted by Greenpeace in partnership with the Brazilian Public Opinion & Statistics Institute (IBOPE) in 2003. It found a high level of public knowledge on the subject and clear opinions regarding controls,[4] showing that surveys can be a useful instrument to support public policy formulation. Survey findings also confirm the idea that media discussion of public-interest issues including those relating to S&T, enhances access to information about such issues and heightens awareness of their impact on people's everyday lives.

In mid-2001, the Organisation of Iberian-American States (OEI) and the Network on Science and Technology Indicators – Ibero-American and Inter-American (RICYT), part of the Ibero-American Program on Science and Technology for Development (CYTED), took the initiative of conducting research in the region with the aim of analysing the phenomena involved in the processes of public perception, scientific culture and citizen participation in modern societies, financed and of producing indicators that would be useful to support political decisions. Surveys were prepared and conducted in Buenos Aires proper and part of metropolitan Buenos Aires (Argentina), Campinas (Brazil), Salamanca and Valladolid (Spain), and Montevideo (Uruguay). Field work and data processing were coordinated by researchers in each country belonging to the Network on Public Perceptions of Science funded by RICYT and OEI under a partnership agreement (Vogt & Polino, 2003; Polino, 2003).[5]

2.2 In search of indicators: a conceptual & methodological challenge

Classic studies designed to produce indicators of public understanding of science are usually organised on the basis of three main axes corresponding to the types of relations society establishes with science and the science and technology system: interest, knowledge and attitudes (Chart 12.1).

Indicators of interest aim to measure the relative importance society attributes to scientific research and technological development. They seek to measure at least three aspects: (1) public interest in S&T issues on the social agenda, such as new medical and scientific discoveries, environmental pollution, military and defence policy etc.; (2) respondents' assessment of their own knowledge in S&T; and (3) attentiveness to

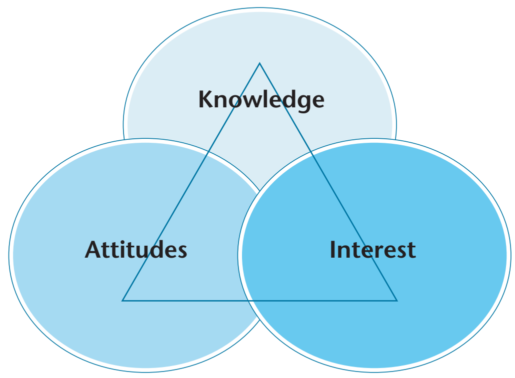
2. MCT; CNPq/IBOPE (1992).

3. Surveys conducted by IBOPE, Instituto Datafolha and Perseu Abramo Foundation between 1992 and 2001: Survey Database, Public Opinion Research Centre (CESOP), State University of Campinas (UNICAMP).

4. In this survey, 63% of respondents had heard of GM products, 74% would prefer non-GM products if forced to choose, 92% said GM food should be clearly labelled, and 73% said GM products should be banned (IBOPE, 2003).

5. The survey was coordinated in Brazil by Carlos Vogt (FAPESP and the Laboratory for Advanced Studies in Journalism, LABJOR/UNICAMP); in Spain by Miguel Angel Quintanilla (University of Salamanca); and in Uruguay by Rodrigo Arocena (University of the Republic). The RICYT indicators are available at: <http://www.ricyt.org>.

Chart 12.1
Three dimensions of public understanding of science



Elaborated by the authors.

ST&I Indicators in the State of São Paulo, Brazil – 2004, FAPESP

S&T policy, where the concept of "attentive" covers people who consider themselves "highly interested in" or "very well-informed about" a given area of science policy and simultaneously time are regular readers of a national newspaper or magazine.

Indicators of knowledge are used to measure the level of understanding of scientific concepts considered basic and of the nature of scientific research. An Index of Scientific Construct Understanding is produced in studies by NSF and Eurobarometer (NSF, 2002; Eurobarometer, 2001a, 2001b) on the basis of survey responses to a number of questions about the nature of science.

Indicators of attitudes cover various aspects, such as public attitudes to public funding for research, trust in the scientific community, and perceptions of the benefits and risks of science. They form the basis for the Index of Scientific Promise and the Index of Scientific Reservations (NSF, 2002), both on a scale from 0 to 100 and reflecting answers to questions designed to measure positive expectations or reservations about the promises of S&T. This group of indicators also compares the attitudes of scientists, lawmakers and the general public to the promises and limitations of S&T. Complementary questions are also asked to detect public attitudes towards official spending on S&T and the level of trust in certain scientific institutions. Public perceptions of various key issues on the policy agenda are measured through questions on nuclear energy, genetic engineering and space exploration, among others, and case studies of public attitudes to biotechnology and other areas are developed.

Other dimensions of public attitudes to science can be measured. Here the first group of indicators relates to the use of information and communication technologies (ICTs), taking into account the level of public access to computers and the types of technology within its reach. The construction of this type of indicator is based on the idea that the sources of scientific and technological information have increased in recent years owing to the development and diffusion of new information technologies. A clear example is the study of public perceptions of contemporary trends in the Internet.

The second group of indicators relates to the relationship between science and the media. The aim here is to measure the efficacy of scientific communication with the public and to detect the most frequently used sources of information about science, such as television, radio, newspapers, magazines, museums, science centres, public libraries, video libraries etc.

Other indicators that can be constructed relate, for example, to the opinions of scientists about journalists and vice-versa, and to belief in paranormal phenomena or pseudoscience. In the latter case the indicators can be used to measure the level of acceptance of certain fields, especially astrology, as scientific disciplines.

According to the latest NSF and Eurobarometer reports, most Americans and Europeans have highly positive attitudes to S&T but little understanding of the content of scientific knowledge and in particular of scientific methods. According to the NSF study, low levels of scientific literacy and little capacity for critical thought suggest that many Americans may not be prepared to make informed choices at the ballot box or in their private lives. Its findings show that interest in science and positive attitudes to scientific practices in general tend to increase in proportion to educational levels, which also correlate with income and other aspects of socioeconomic status. However, higher levels of scientific literacy and income may also correlate with more critical attitudes to technological applications and to the political control or social impact of scientific research. For example, the level of knowledge about the scientific aspects of biotechnology is higher generally speaking in the EU than in the United States, but social acceptance of commercial products derived from biotechnology is far lower among Europeans. In other words, ignorance is not always synonymous with fear and hostility, which may in fact be associated with greater knowledge of S&T.

The NSF and Eurobarometer findings are mirrored by most international studies.[6] The polarised nature of these findings arouses contradictory responses from the organisers of research into scientific culture. Low levels of public knowledge are a negative indicator and function as a wakeup call that translates into recommendations for the development of projects, programmes and strategies to disseminate knowledge about science more widely throughout society. The underlying argument is that deficient scientific literacy makes it difficult to take well-informed decisions in daily life and social contexts. High levels of interest and strongly positive attitudes lead to the conclusion that despite the fears aroused in society by certain fields of scientific research, a large majority tend to trust the soundness of the knowledge produced.

Analagous conclusions can be drawn from the only similar survey conducted in Brazil (Instituto Gallup, 1987), albeit with fewer questions than international surveys (only 27) and questions of a somewhat different nature. Only 20% of the respondents said they were interested in studying scientific topics. Nevertheless, when asked about their interest in receiving news of scientific discoveries, 71% said they would be very or fairly interested. About 72% considered scientific research useful and necessary to the nation, while 65% said financial support for research work and scientists was insufficient, especially in agriculture, medicine and medication, and the environment.

The studies mentioned above faced the challenge of trying to design ways of evaluating and interpreting public perceptions of science, public understanding of scientific processes and the so-called scientific culture in general. A significant volume of indicators has been proposed: indicators of scientific literacy and attitudes (as already mentioned), statistics on numbers of visitors to science museums, research into media coverage of science, readership of scientific publications etc.

Given the complexity and relative newness of the field, these quantitative indicators and standardised universal research protocols coexist with an ongoing debate about the epistemological models for an understanding of public attitudes to science and the concept of scientific culture.

The model that predominated until recently and was typical of Anglo-Saxon studies on communication of science in the 1980s is now known as the "linear diffusion model" or "deficit model" (Ziman, 1992; Gregory & Miller, 1998) (Chart 12.2). This is based on the hypothesis that scientific knowledge constitutes a recognisable body of codified, universal and objective information and that it is possible to measure how much of this information an individual has absorbed, thereby enabling a "deficit in understanding" to be defined.

The deficit model also assumes that the public is a passive entity with knowledge gaps that can and should be filled. It is a top-down model in which scientific information flows in one direction only, from scientists to the public. Thus it is a linear model, just like the one frequently used in the past (but now discredited) to analyse the development of science itself. More than ten years of research into science communication have shown that the deficit model can only partly explain the complexities of public understanding and perceptions of S&T (Gregory & Miller, 1998). There are a number of reasons for this failure in explanatory power.

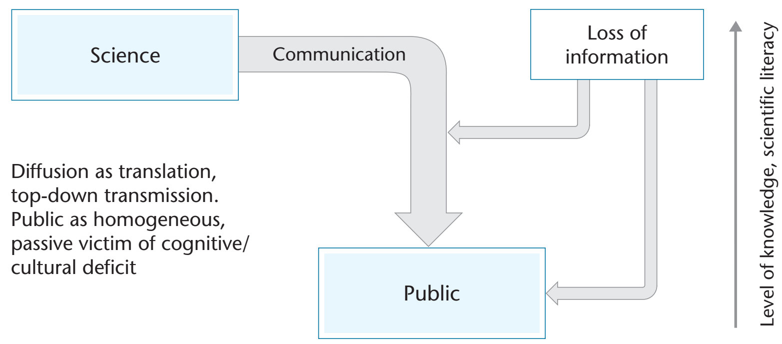
The first is that by treating the public as passive and analysing knowledge more in terms of gaps or deficits than content, this approach does not give due weight to the active construction of meaning, be it through the processing of messages or in terms of the motivations and emotional associations that inform social representations of S&T.

Secondly, the model does not treat scientific culture as a dynamic, collective, social process but as an individual attribute. Thus it overlooks the fact that understanding science depends crucially on the social context in which knowledge becomes operational (Irwin & Wynne, 1996).

A third point that deserves to be highlighted is that treating science communication as a matter of flows from an outside institution to society neglects the profound and dynamic exchange between contemporary science, which some sociologists call "post-academic", and other social institutions (Ziman, 2000; Greco, 2001; Castelfranchi, 2002).

6. For example: Miller et al. (1998); OST (2000); CONACYT (1999); New Zealand (1997); Malaysian Science & Technology Information Centre (2001).

Chart 12.2
"Deficit model" of public science communication



Source: Ziman (1992); Gregory & Miller (1998)

ST&I Indicators in the State of São Paulo, Brazil – 2004, FAPESP

The deficit model has been subjected to countless critiques in the last decade (Pitrelli, 2003). Various interpretations of S&T diffusion and social representations have been put forward, in the context of research projects with different epistemological affiliations. Reforms proposed in the area of public understanding of science include replacement of the notion of "public understanding of science", or PUS, with that of "public engagement in science and technology", or PEST (Science, 2002). The most frequently cited alternative models are as follows:[7]

- The "contextual" model, often used in studies of public risk perception and response (OST, 2000; NRC, 1989), acknowledges that individuals are not passive empty containers for information but process and reinterpret its meaning in the context of their cultural and personal circumstances;
- The "lay expertise" model, which privileges the role of local knowledge and everyday culture based in the lives and histories of real communities in interpreting and making social use of S&T (Burns et al., 2003);
- The "democratic" or "public participation" model (Miller, 2001; Hamlett, 2002; Wachelder, 2003), which rather than blaming the public for not understanding science seeks a deeper insight into the cultural and institutional reasons for this misunderstanding. Thus it sets out not just to inform society but to develop critical thinking that enables people to evaluate scientific developments as well as their social relevance and the associated risks;
- The "web" model (Lewenstein, 1995), which highlights the complex ways in which technical science communication (among scientists) and public science communication (diffusion) interact and refer to each other.

2.3 Use of research on public perception of science as policy-making input

This subsection discusses what has been done with the findings of surveys conducted in various countries and how governments have proposed to change public perceptions of science.

Official S&T programs and public policy for the area in several developed countries have increasingly prioritised scientific education and communication in response to these findings. The tendency is for forms of treatment to proliferate, with the development of many more academic specialisms, a vast reference literature, ample discussion of methodologies and the increasingly clear aspiration to put in place a "science of science communication". In principle, however, this should be avoided so as not to fall into the trap of trying to break with the hermiticism of scientific knowledge by creating a new conceptual and theoret-

7. A recent theoretical analysis of all these models can be found in Lewenstein (2003).

ical hermeticism that in turn requires explanations and helpful clarifications to keep society from evading its consistent impenetrability.

A number of subtle linguistic distinctions are already made, in English at least, to take account of this concern. The expressions "public understanding of science" and "public awareness of science" are variously deployed, for example, with the latter tending to imply elements of consciousness or attentiveness not necessarily present in "mere" understanding. The fact is that both the formal and informal apparatus of science education and communication, including the school syllabus, textbooks, museums, exhibitions, S&T events etc., have always matched the general attitudes and conceptions of the pedagogy in vogue.

The expression "scientific culture" seems better suited than the various other attempts to designate the increasingly widespread phenomenon of science communication and the place occupied in our everyday lives by the themes of S&T. It is far more capable than "scientific literacy", "science popularisation", "public understanding" or "public awareness" of encompassing all these dimensions while also containing in its field of significations the idea that scientific development is a cultural process whether it is considered from the standpoint of the production of science, its diffusion among peers, the social dynamics of science teaching and learning, or the diffusion of science throughout society as a whole, establishing the necessary critical relationships between citizens and the cultural values of their time and history.

When speaking of scientific culture, we should bear in mind that the linguistic structure of the expression itself offers at least three possible interpretations of its meaning:

a) "Culture of science". This gives two semantic possibilities:
   - the culture created by science
   - the culture of science itself

b) "Culture through science". Again, two possibilities:
   - culture by means of science
   - culture in favour of science

c) "Culture for science". Two possibilities here as well:
   - culture geared to science production
   - culture geared to science socialisation.

In this last case there are also two possibilities: *a)* scientific diffusion and the education of researchers and new scientists, and *b)* part of the education process not contained in *a)*, such as what happens in secondary schools, undergraduate courses and museums (education for science), and what happens in communication, responsible for the cultural dynamics of the appropriation of S&T by society.

These distinctions certainly do not cover the full gamut of possible interactions between individuals and the themes of S&T in contemporary societies, but they may contribute to a clearer understanding of the semantic complexity involved in the expression scientific culture and the phenomena it designates in our time (also alluded to by "knowledge society" and similar expressions that reflect the crucial role of knowledge in the political, economic and social life of those societies).

Within what is called scientific culture there is little significance in the distinction that opposes the context of science justification to the context of scientific discovery, establishing clear-cut epistemological differences between what is intrinsic to science and what surrounds it as historical contingency external to its norms, rules and constituent laws. The distinction loses force to the exact extent that as science has evolved it has increasingly taken account of the relationship between the observer and what is observed as an important part of its object.

Paradigm shifts such as those analysed by Popper and Kuhn[8] have also had important consequences for the cultures of those who do scientific research, those who teach science and those who seek to know how and why scientific activities are performed. Such shifts also affect the general values of most contemporary societies, inasmuch as they are part of the dynamics of the cultural process of S&T, known as scientific and technological culture.

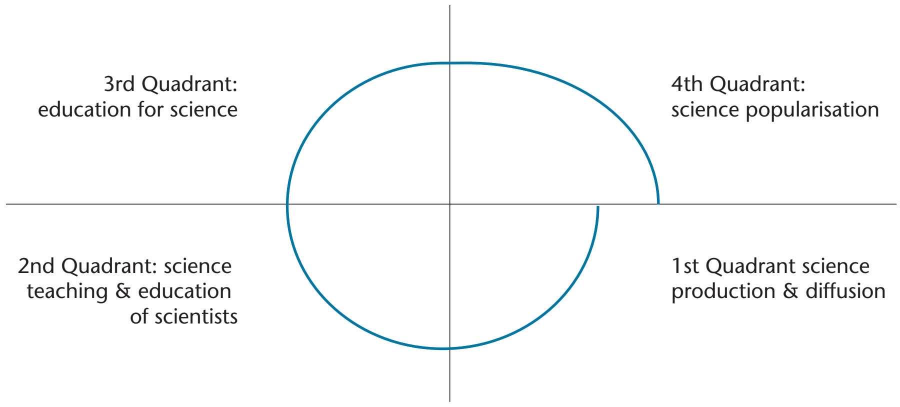
How to measure it? How to evaluate it? How to interpret it?

Since its conception there have been a great many studies on the subject of public perceptions of science, a large and growing sociological and economic literature linked to the performance of surveys, a significant volume of indicators and questionnaires, statistics on numbers of visitors to science museums, research on media communication of science and readership, and above all a substantial effort to define terms and methodologies that is typical of new knowledge areas.

The dynamics of so-called scientific culture can be more easily understood by visualising a spiral. Chart 12.3 illustrates the "spiral of scientific culture" as recently proposed by Vogt (2003). It is important to

8. See for example Popper (1980) and Kuhn (1975).

Chart 12.3
Spiral of scientific culture



Source: Vogt (2003)

ST&I Indicators in the State of São Paulo, Brazil – 2004, FAPESP

note the existence of two dimensions evolving along two axes, one horizontal (time) and the other vertical (space), and to include not only the constituent categories but also the principal actors in each of the quadrants delineated graphically and defined conceptually by the movement of the spiral.

Starting with the dynamics of the production and circulation of scientific knowledge among peers, i.e. science diffusion, the spiral then describes a second quadrant to depict the teaching of science and the education and training of scientists. It then moves into the third quadrant, which configures the universe of actions and predicates comprised in education for science, returning to the first axis and completing the cycle in the fourth quadrant with science communication or popularisation. Each quadrant can also be associated with a number of elements that, when distributed within them by the evolution of the spiral, also contribute to a better understanding of the scientific culture process.

Thus in the first quadrant the communicators and addressees of science are scientists themselves; in the second, scientists and professors are the communicators while students are the addressees; in the third quadrant, scientists, teachers, museum directors and cultural animators are the communicators while the addressees comprise students and, more widely, young members of the general public; and in the fourth quadrant, journalists and scientists are the communicators while the addressees are society in general and, more specifically, society organised into its various different institutions, above all civil society, which makes the citizen the principal addressee of this scientific culture dialogue. At the same time, other actors would be distributed among the quadrants.

It is important to note that in this form of representation the spiral of scientific culture completes the cycle of evolution by returning to its initial axis but does not return to its exact starting-point. Rather it evolves to reach a broader base of knowledge and public participation in the dynamic process of science and its relations with society, widening out as it comes full circle. Unless the process is interrupted, a new cycle begins of enrichment and active participation by the actors in each stage of its evolution. In short, what the spiral of scientific culture is intended to represent in its peculiar way is in general terms the constituent dynamics of the inherent and necessary relations between science and culture.

Finally, given that scientific culture is an attribute of societies, albeit created by individuals, it is not possible to say that each person "represents" a society and thus the whole of its culture. Instead, each person can be said to have a relation to society that cannot be reduced either to the society or to the individual. Thus scientific and technological culture is not just a stock of codified knowledge absorbed by the individual but also involves other no less relevant dimensions: institutionalised scientific and technological practices; practices of scientific and technological "rationality" applied to different institutional spheres or appropriation of S&T in such spheres (government, technical standards, education, communication, sport, manufacturing of goods and services etc.); distribution of information and knowledge in the general culture; quantitative aspects of the science system (human resources, investment, organisations, patents etc.); mechanisms designed to assure the sustainability of S&T institutions; and orientation of S&T activities. Thus a society will become more aware of the importance of science the more the question "Who and what are science and technology for?" becomes a topic in the general culture and a matter for social debate.

Public participation in S&T-related issues, as discussed in this chapter, is a fairly recent concern and connected with a view of S&T as means, mechanisms and institutions of power. The most general hypothesis indicates that however different the interpretations and cognitive traditions from which public perceptions of science, scientific culture and participation by citizens derive, they are nevertheless closely linked, and treating them as such leads to the analysis and evaluation of scientific culture in a particular society. Hence the relevance of pursuing indicators that highlight this association as a way of measuring how "science-oriented" a society is at a particular moment in its history.

The above considerations should be taken into account as the scope of research is broadened to construct universal and standardised numerical parameters for measuring scientific culture. This is a project currently under debate, and its form has been strongly influenced by the "deficit model".

A pilot case study covering three municipalities in São Paulo State, Brazil, is described below. It was designed to test a preliminary approach capable of identifying the key dimensions and main background themes involved in any analysis of public perceptions of science, thus paving the way for future qualitative and quantitative research of a more comprehensive and articulated nature.

3. Public perceptions of science in São Paulo: case study of three municipalities

3.1 Objectives & methodology

The case study conducted in São Paulo State 16 years after the nationwide survey by CNPq (see subsection 2.1) was part of a wider research project carried out by RICYT and OEI (idem). Questionnaires were applied between February and September 2003 in the municipalities of Campinas, Ribeirão Preto and São Paulo.

The main objective set by RICYT was to achieve progress with these studies until a methodology was established to contribute to an understanding of how people in this particular region perceived the role of science in society, as well as producing empirical and qualitative information for use in analysing the place of scientific culture in social dynamics (Polino, 2003). Thus the goal was to find out how people imagine scientific activities are conducted, who performs them, who funds research and what are the effects of S&T on society, among other questions.

The questionnaire was based on internationally consolidated methodologies such as those of the NSF (2002) and Eurobarometer (2001a & 2001b), among others. However, the expected results of this first survey were parameters that would help to find the right way to "evaluate" rather than "measure", as in all previous research of the kind, while also permitting some international comparisons.

The survey in Brazil began with Campinas and was then extended to Ribeirão Preto and São Paulo, eventually covering a sample of 1,063 respondents, a reasonable number in comparison with international studies. In the U.S., for example, NSF usually interviews between 1,500 and 2,000 people nationwide. Eurobarometer surveys cover about 1,000 people in the main EU countries, including a cross-section of ethnic or linguistic minorities.

Because the objective of this preliminary study was not to analyse a statistically representative sample of the Brazilian public but to make progress towards the production of suitable indicators for perceptions of S&T in the municipalities in question, the survey focused on upper- and upper-middle income groups with complete secondary schooling and above. This cutoff point was chosen in light of the need for comparability with previous research by RICYT. The coordinators are well aware that several aspects have to be perfected, but this does not affect the validity or legitimacy of the findings, especially given the importance of public perceptions for S&T indicators in general.

Of the 1,063 respondents, 557 were women and 506 were men. The age breakdown was as follows: 203 respondents were aged 18-24; 392 were aged 25-39; 316 were aged 40-59; and 152 were over 60.

The methodology was designed in accordance with survey criteria, which by definition entail rigid questions that cannot be explained or clarified by the interviewers, and succinct answers based on the respondent's skill with oral and written language. Researchers have used surveys in academic work since the 1970s, and research institutions regularly use surveys to poll public opinion or investigate changes in values relating to social and political issues, since the instrument is capable of capturing distinctions deriving from socioeconomic variations in the population samples studied.[9] Surveys are suitable for cross-border comparisons as far as the phrasing of questions is concerned, for example, guaranteeing maintenance of multiple-choice responses and measurement scales.

3.2 Discussion of results

This subsection discusses some relevant findings from an analysis of the data collected by the survey. It also illustrates a number of possible readings of this treasure trove of information and opinions. It goes without saying that the discussion set out below is not the only one possible and that the raw data can be analysed from other standpoints.

An interesting approach is to analyse responses by age group and/or level of educational attainment. For this purpose the data were broken down by age into four groups (18-24, 25-39, 40-59, and over 60) and by education into three groups (complete secondary, undergraduate and graduate: see Detailed Table 12.1).[10] A number of clear trends emerged when the answers to certain specific questions were cross-tabulated for these two parameters. The trends were tested for statistical significance (95% confidence interval) by the usual methods, such as the chi squared test and Kendall's t-tests for ranked categories (see methodological annex). Interesting examples are shown below in the course of the exposition.

Besides cross-tabulation of survey data, the findings were compared with those of the RICYT survey, based on identical questions for Argentina, Uruguay and Spain. Partial comparisons were also made with surveys conducted in other countries. Despite the necessary caution in making such comparisons given the different samples used, analogies in the results provide significant evidence of interesting parallelisms and common trends in the structure of scientific culture and public attitudes to S&T. These deserve further investigation in future research.

3.2.1 Social representations of S&T

Various items of the questionnaire referred to the respondents' attitudes to and representations of S&T. Social representations were defined for the purposes of this survey as the universe of images, expectations and values relating to S&T as an institution, as an instrument for action, as a source of knowledge and truth, and as a human or social group with a specific function.

This attitudinal dimension is crucial both for in-depth description of public perceptions of science and as a key element in the evaluation of public policy and decisions relating to S&T. This subsection analyses only some aspects of such attitudes, highlighting examples of cross-tabulations of variables that can serve as a basis for investigating the relations between this dimension and the profile of the interviewee sample. In addition, indices were created for sets of questions relating to attitudes, interest and knowledge, along similar lines to the procedures used in NSF and Eurobarometer surveys.

The set of indicators covered by this subsection is intended to reflect the following dimensions: images with which scientific ideas are associated; attitudes towards the usefulness of science; science as legitimate knowledge; representations of science in relation to society and daily life; science as a source of risk; images of scientists and scientific and technological activities; and certain representations of scientific development in Brazil.

3.2.1.1 Social representations of S&T

Detailed Table 12.4.1 shows the distribution of answers to the question "Which of the following phrases best expresses your idea of science?" Respondents were allowed to pick two of the nine phrases presented, reflecting positive, negative, ambiguous or neutral images of science. According to this classification, the following phrases can be considered clearly positive: "great discoveries", "technical progress", "improving people's lives" and "understanding the natural world". These four items accounted together for 74% of all the answers. Phrases representing negative or guarded views ("danger of losing control", "concentration of power" and "ideas few people understand") accounted for 13% of the total. Two phrases – "mastery of nature" and "rapid transformation" – have positive or negative connotations depending on other information supplied by the respondent. They accounted for 218 answers, or 10% of the total.

The next question was "What image comes to mind when you hear the word 'technology'?" The same model was followed as for the previous question, with the difference that this question focused on technology rather than science and the respondent was allowed to give only one answer, albeit an open-ended one, i.e. formulated by the respondent (Detailed Table 12.4.2). It is interesting to note that most answers referred to objects, suggesting that technology was represented as a material or concrete thing rather than as a form of knowledge.

9. Robinson et al. (1993); Inglehart (1997); van Deth; Scarbrough (1995).
10. The sample is broken down by employment situation and principal occupation in Detailed Tables 12.2 and 12.3 respectively.

These answers were similarly classified as positive, negative, ambiguous or neutral. Positive images ("progress", "discoveries", "development", "new technologies", "mastery of science", "innovation") accounted for 34% of the total, negative images ("fear", "nuclear reactor", "danger") for less than 1%, and ambiguous images for 61%.

3.2.1.2 Usefulness of science

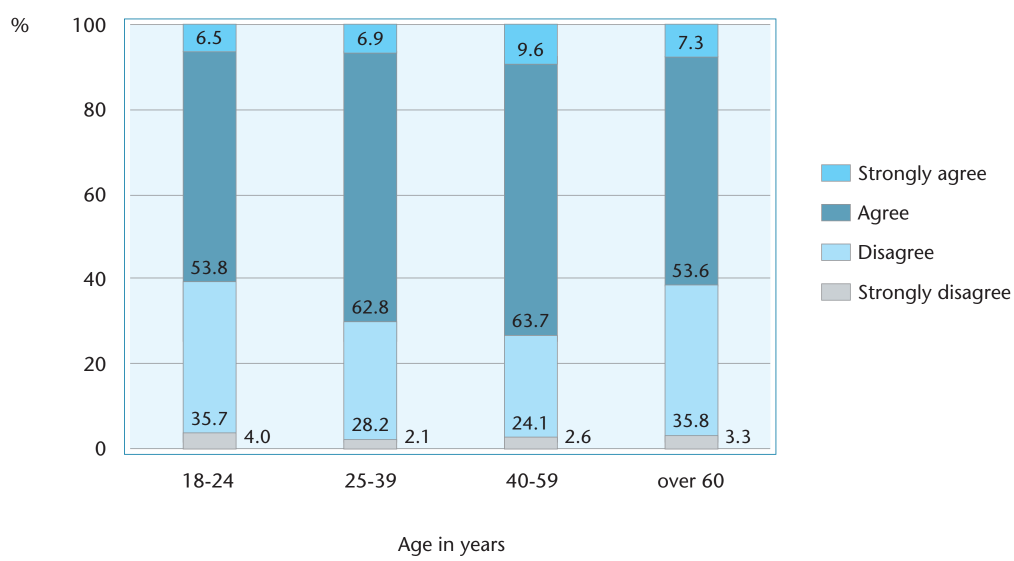
A number of variables are associated with the value placed on science for its usefulness in solving problems or improving the quality of life. These were explored by asking respondents to react to a set of statements using a four-point scale (strongly agree, agree, disagree, strongly disagree). The answers are shown in Detailed Table 12.4.3.

Thus 78% agreed with the statement that "the main cause of improvements in the quality of human life is progress in science and technology" (Detailed Table 12.4.3), similar to the percentage with positive images of science (Detailed Table 12.4.2). About 21% disagreed with the statement. However, positive attitudes to science did not entirely dominate social representations of its utility in terms of problem solving and improving people's lives. The vast majority clearly rejected absolute optimism, for example: only 19% agreed with the statement that "science and technology can solve any problem", implicitly acknowledging the existence of many problems for which S&T do not have answers (Detailed Table 12.4.3).

Another item alluded to the highly topical issue of unemployment and the idea that increasing use of technology by manufacturers eliminates jobs. Contradicting this image, however, 67% agreed with the statement that "applied science and technology will increase the supply of jobs", with fewer than 32% disagreeing. It is interesting to compare this with the survey conducted in Argentina (Vogt & Polino, 2003), where unemployment was a major concern at the time and just over half the sample (54%) said S&T were of no utility to improve the employment situation. Opinions were somewhat better balanced in other countries where the survey was conducted, especially Brazil, with more respondents taking a positive attitude on this topic. The percentage of answers in the "disagree" category was high in all countries, however, suggesting a general lack of absolute optimism or trust in science to solve all problems.

It is worth noting the absence of significant variation in responses among groups with different levels of educational attainment (null hypothesis satisfied). However, an interesting trend was observed in the breakdown by age group (Figure 12.1), where the proportion of respondents expressing trust in S&T as a

Figure 12.1
Responses to statement "Applied S&T will increase the supply of jobs", by age group



Elaborated by the authors.

Source: Survey of public perceptions of S&T conducted in Campinas, São Paulo & Ribeirão Preto (LABJOR/UNICAMP).

See Detailed Table 12.5

factor in job creation increased with age, except for the over-60s, where scepticism was markedly higher. A statistical analysis showed no significant difference between the distributions of these answers (Pearson's chi squared $\chi^2 = 15.7$ with 9 degrees of freedom, and value of $p = 0.074$).

In sum, although the survey found a tendency for people to see science as beneficial to humanity and as a positive factor in solving problems and improving the quality of life, most associated these qualities only with some aspects of S&T and were by no means unaware of negative consequences.

3.2.1.3 The idea of science in opposition to religion

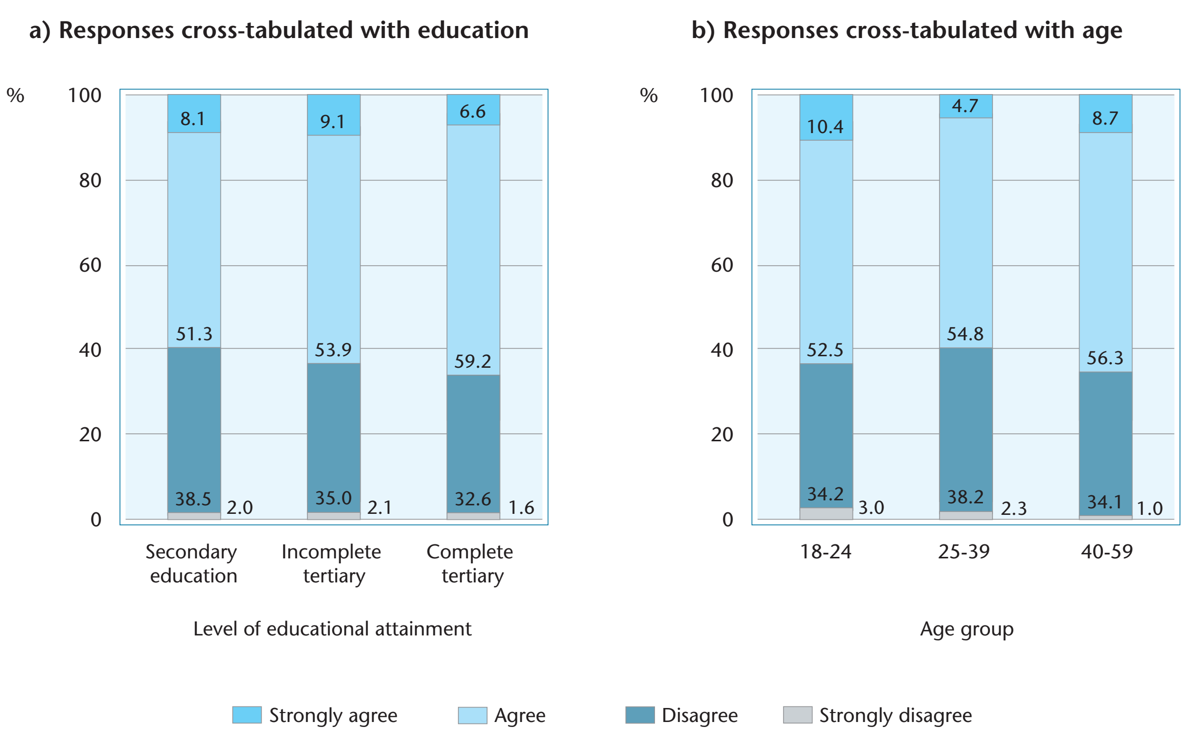
Another group of variables was related to representations of science as a source of knowledge or truth. These questions are set out in Detailed Table 12.4.4.

One of the questions was designed to gauge the relative value placed on science as opposed to religion. The results showed that they were not considered antagonistic or incompatible, although it was clear as a general trend that for these respondents modern society emphasises scientific rationality and places more trust in the truth of science than in religious faith.

There were no significant differences among the responses given by the various groups to the statement that "we attribute too much truth to science and not enough to religious faith". The distribution of these responses is shown in Figure 12.2. The proportions were roughly similar for all groups, and statistical tests (chi squared, tau tests) showed that the overall differences between the groups were in fact insignificant ($\chi^2 = = 14.2$ with 9 degrees of freedom, and $p = 0.117$; Kendall's tau-b = 0.314; Kendall's tau-c = 0.314).

Generally speaking, the dominant image of science as a source of legitimate knowledge had relative value for most respondents. They did indeed consider science the principal source of knowledge, albeit limited in scope, yet they apparently did not believe it was the only "truth". Thus they did not see religion and science as fundamentally opposed: science is a source of a cer-

Figure 12.2
Responses to statement "We attribute too much truth to science and not enough to religious faith". by education & age



Elaborated by the authors.

Source: Survey of public perceptions of S&T conducted in Campinas, São Paulo & Ribeirão Preto (LABJOR/UNICAMP).

See Detailed Table 12.6

tain kind of knowledge, which helps man control nature and solve problems; religion is a different category of truth expressed in faith, perhaps also a moral type of truth associated with man's responsibility.

What this kind of response seems to indicate is the absence of an unqualified, mutually exclusive opposition between science and religion in the minds of most people. Future research will no doubt develop this investigation further via other questions that would enrich the analysis.

3.2.1.4 Representations of science in its relations with society & daily life

Some dimensions explored by the questionnaire permit an approach to the problem of how science is perceived as a form of knowledge, an institution or a social phenomenon that is part of a society's culture and of the "world of daily life". As shown in Detailed Table 12.4.1, science associated with a closed universe of knowledge comprising "ideas few people understand" was an option chosen by a small minority of the respondents (4%). However, seen from the standpoint of science and its relations with daily life this topic warrants special attention. Responses to the statement that "the world of science cannot be understood by ordinary people" tended to be balanced (Detailed Table 12.4.4).

In sum, although it can be inferred that a significant proportion have an image of science as an inaccessible form of knowledge for ordinary people, this image does not prevent the integration of scientific activities into society as a component of culture, a source of useful knowledge or a means of solving people's everyday problems.

3.2.1.5 Images of science as a source of risk

Another aspect of public perceptions of S&T is the idea of risk entailed by the results of knowledge. Respondents were therefore asked to answer yes or no to the question "Many people think the development of science presents problems for humanity. Do you think that is the case?" (Detailed Table 12.4.5). Almost half (45%) responded in the affirmative, considering science a source of problems for humanity and thus taking a critical view of scientific activities. This should be interpreted as simply an indication of a belief that scientific progress also gives rise to problems, since responses to another question show that most did not see science as without benefits: 72% said science does more good than harm (Detailed Table 12.4.3). In fact, a larger proportion (51%) did not ratify the statement that science presents problems for humanity.

In this case, cross-tabulation with age groups did not show statistically significant variation but there was a clear increase in discordance as educational levels rose ($\chi^2 = 28.2$ with 4 degrees of freedom, and $p = 0.000011$) (Figure 12.3).

The next question followed on from the previous one by asking respondents to choose phrases from a list of problems facing humanity if they thought science was responsible (Detailed Table 12.4.6). Even those who had responded that science does not cause problems answered this question. The group of respondents with negative images of science can be better qualified using the second set of answers.

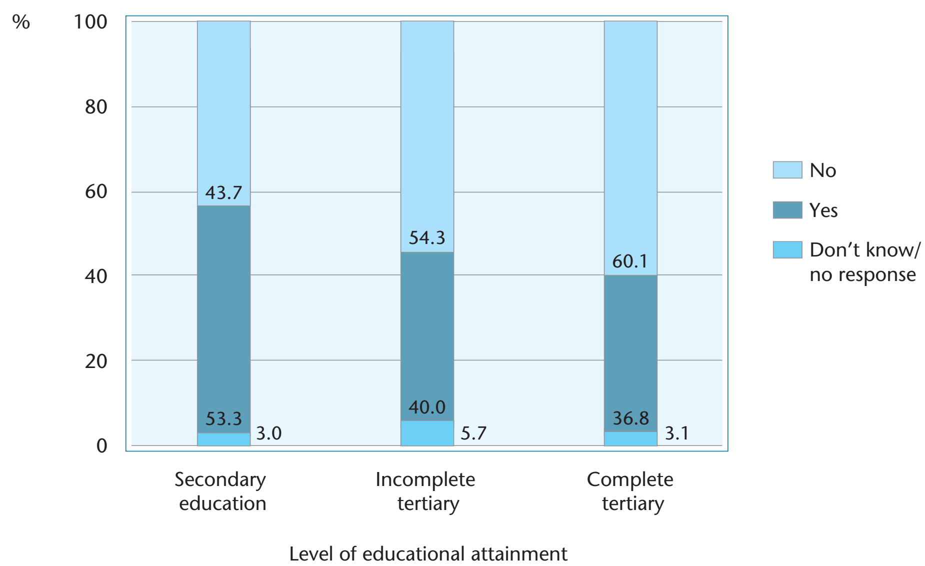
The phrase "use of knowledge for war" was the most frequently cited (290 times), followed by "dangerous applications of some knowledge" (211).[11] The next most frequently chosen phrase was "even greater concentration of power and wealth" (191), conspicuous for its political content. Also relatively frequent and conspicuous was "loss of moral values" (181), possibly indicating distrust of science for moral and religious reasons.

Thus the most frequently chosen phrases suggest an attitude that condemns certain uses of knowledge without casting doubt on the value of knowledge in itself or ruling out other applications that might be less dangerous or unfair. As for the relatively large proportion who associated science with a loss of moral values, although the survey did not ask about these values the response suggests that technological applications of science and the resulting mastery of nature are seen as necessarily weakening moral values: the arms trade, human cloning and environmental destruction probably figure among the consequences of scientific progress considered undesirable because they undermine such values. However, it should be noted that there was very little condemnation of knowledge as such, since only 59 respondents chose the phrase "excessive knowledge" (Detailed Table 12.4.6). Thus the overwhelming majority can be assumed to regard all knowledge as legitimate even when its application has results of which they disapprove or which submit society to unwanted risks.

Furthermore, despite the recognition that the benefits of science clearly outweigh its negative effects, it is equally clear that scientific controversies were seen by the vast majority (87.5 %) as fuelling uncertainty in society and hindering an appraisal of the consequences of development in certain knowl-

11. It is important to note that part of the survey (in the city of Campinas) was conducted during the Anglo-American invasion of Iraq. Intense news coverage of the coalition forces' high-tech weaponry may explain the significant proportion of respondents who chose the phrase alluding to war.

Figure 12.3
Responses to "Many people think the development of science presents problems for humanity. Do you think that is the case?", by education level



Elaborated by the authors.

Source: Survey of public perceptions of S&T conducted in Campinas, São Paulo & Ribeirão Preto (LABJOR/UNICAMP).

See Detailed Table 12.7

ST&I Indicators in the State of São Paulo, Brazil – 2004, FAPESP

edge areas ("there are issues on which scientists do not agree and it is hard to know whether they are harmful for humanity", Detailed Table 12.4.4). This again seems to portray a complex combination of attitudes that may well correspond to an ambiguous representation of the value of S&T and awareness of the precautionary principle.

3.2.1.6 Images of scientists and S&T activities

Public perceptions of S&T are not necessarily mirrored by widely held images of scientists and technologists. People can consider science a source of rationality while at the same time seeing scientists as motivated by personal gain or interests they regard as irrational from the standpoint of society. Similarly, images of S&T as a source of risk or subject to a concentration of power and wealth may coexist with a view of scientists and technologists as being predominantly inspired by positive values in society.

The next question in the survey asked respondents to identify the main motivations leading scientists to devote time and energy to research (Detailed Table 12.4.7). A third chose "vocation for knowledge", followed quite closely by "solving people's problems", with 23%. Power, money, prestige and winning important prizes were all chosen by a comparatively small percentage, suggesting they were considered secondary factors and probably seen as consequences rather than reasons for choosing a scientific career. Generally speaking, they seem to be regarded as aspirations extraneous to the sphere of science.

Part of the questionnaire was designed to find out whether respondents thought scientists should apply their specific skills to other activities apart from knowledge production: for example, they were asked whether the statement "scientists know better than anyone else what research should be done to foster national development" was true or false (Detailed Table 12.4.9). The results show that although most respondents had a positive image of scientists in the sphere of knowledge production, a significant proportion (43%) evidently did not trust them to decide how science should be used as an instrument of development. Thus if the findings are seen as a whole they suggest that the public believes scientists' motivations and the benefits of science are not a sufficient basis for policy decisions. This reflects a highly rational attitude to the dynamics of policy making in S&T, insofar as it can indeed be argued that scientific experts are not necessarily qualified to take sound decisions in matters of either politics or policy. The same polarity appeared in the responses to a question about the autonomy of scientists in practising their profession: just over half the interviewees evidently believed scientists should be free from government interference in order to be able to carry out sound research (agreeing with "the government should not interfere in the work done by scientists even when their salaries are paid by the government", Detailed Table 12.4.9).

3.2.2 Public understanding of the content of scientific knowledge

Continuing the analysis discussed in subsections 3.2.1.1-3.2.1.6, a relevant dimension of public representations of science relates to how much people understand the content of scientific and technological knowledge. In most surveys on public understanding of science, this is traditionally evaluated by asking respondents to say whether certain statements are true or false. Like it or not, such a methodology is grounded in the idea that scientific knowledge is a codified body of true facts. Knowledge can be reduced to "hard facts" on this or that subject without necessarily requiring a complete understanding of the related scientific theories and processes. Moreover, correct identification of the truth or falsehood of statements about scientific facts is no indication of practical knowledge on the subject, let alone that it is part of the respondent's life orientation. Generally speaking, therefore, it should be borne in mind that the items evaluated as scientific facts reflect the public's apprehension of an ill-defined "mass" of information about aspects of the world that are dealt with by science and have significance mainly as indicators of "consumption" of scientific information (via the media or school) rather than active knowledge or understanding.

Our survey presented 13 items, some of which were reproduced from Eurobarometer and NSF surveys, while others had been specially drafted for the RICYT project (see Section 2.1). Respondents were asked to say whether the statements were true or false, and could also choose the "don't know" option. Some statements coincided with knowledge certified as true while others were designed to be incorrect. Thus each respondent's choice of "true" or "false" should be interpreted in light of the correctness of the statement in question (Detailed Table 12.4.10).

Generally speaking, the number of correct answers was fairly high. This can undoubtedly be attributed to the profile of the survey sample, which included a large proportion of individuals with complete secondary education or tertiary education. Even so the proportion of correct answers reflected differences in educational level, in accordance with expectations. Items relating to geology and astronomy[12] were evidently more familiar to most respondents. At the opposite extreme, items relating to physics[13] had the lowest percentages of correct answers. Familiarity with biochemistry and genetic engineering[14] was relatively low, while the proportion of correct answers to items on biological evolution[15] was comparatively high.

It is interesting to note that the answers to items which regularly mobilise collective action and fuel social representations regarding the hazards of daily life, such as radioactivity, the function of antibiotics, genetically modified organisms, cloning or upper ozone depletion, were not significantly more correct than the answers to items less directly associated with the daily lives of individuals or society.

A number of analogies can be made with the U.S. and European surveys. The results were identical in all three surveys for at least five of these items. Chart 12.4 shows the proportions of correct answers to each of these statements in the three surveys concerned.

As can be seen from the chart, the results were similar in all three surveys. This is an indication that despite the small sample size relative to the population of São Paulo State and the survey's limitation to specific educational levels and age groups, its findings can be taken as a preliminary basis for further research into public perceptions of S&T in this region.

For the purposes of statistical analysis the sample was divided into groups based on general knowledge as reflected by the proportion of correct responses to the 13 statements. The groups were graded D, C, B and A for 0-4, 5-7, 8-10 and 11-13 correct answers respectively. Cross-tabulation with education showed grades improving with level of schooling, as expected. For example, 15% of the respondents with complete secondary education, 14% of those with incomplete tertiary and 10% of those with complete tertiary edu-

12. "The positions of the continents have changed over thousands of years" and "The ozone layer absorbs ultraviolet radiation".
13. "All radiation is produced by man" and "Electrons are smaller than atoms".
14. "Antibiotics kill both viruses and bacteria"; "Transgenic crops are the ones that have genes, the rest don't"; "A corn seed containing a gene derived from another organism is called transgenic"; "Two cloned animals are extremely identical but genetically there are differences"; and "Neurons are complex proteins used by the brain for all its functions".
15. "The first humans lived in the same epoch as the dinosaurs" and "Contemporary humans originated from a more primitive animal species".

Chart 12.4
Comparison of findings from São Paulo State survey with results of surveys conducted in U.S. (NSF) & Europe (Eurobarometer)

Statement	Survey		
	Survey in SP State (% responses)	NSF (% responses)	Eurobarometer (% responses)
A. Antibiotics kill both viruses and bacteria (false)	41.8	51.0	39.7
B. The positions of the continents have changed over thousands of years (true)	78.1	79.0	81.8
C. Contemporary humans originated from a more primitive animal species (true)	56.4	53.0	68.6
D. Electrons are smaller than atoms (true)	53.6	48.0	41.3
E. The first humans lived in the same epoch as the dinosaurs (false)	61.2	48.0	59.4

Elaborated by the authors.

Source: NSF (2002); Eurobarometer (2001); survey of public perceptions of S&T conducted in Campinas, São Paulo & Ribeirão Preto LABJOR/UNICAMP).

ST&I Indicators in the State of São Paulo, Brazil – 2004, FAPESP

cation were graded D. The corresponding proportions for grade A were 2%, 10% and 12% respectively.[16]

Cross-tabulation of these data with the answers to questions on attitudes to S&T produced arguably less predictable results. An example is illustrated in Figure 12.4, where answers to the statement that "the main cause of improvements to the quality of life for humanity is scientific and technological progress" are grouped according to general knowledge about science using the criteria described above. Contradicting what might be expected based on common sense, this cross-tabulation clearly shows that respondents with superior general knowledge about science tended to agree less with the statement. This tendency was confirmed by a statistical analysis showing that the differences were indeed significant ($\chi^2 = 34.15$ with 9 degrees of freedom, and $p = 0.000084$). This result appears to indicate that the more citizens know about S&T the greater their distrust of S&T. In other words, in this case the respondents took a more skeptical view of the relative importance of S&T to society. Once again, this result shows the complexity of research into public perceptions of science in our society and should encourage us to recognise the existence of dichotomies in these representations.

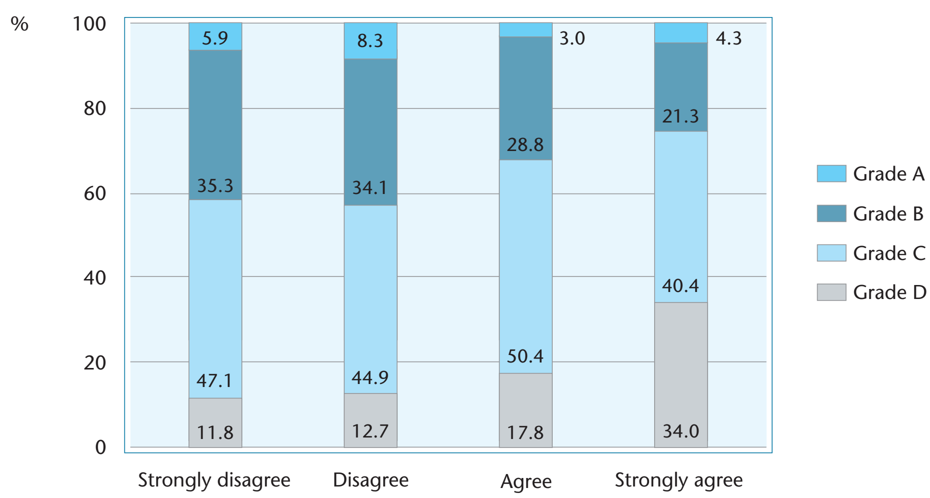
Similar statistically significant trends can be observed for other questions relating to attitudes to S&T (see Detailed Tables 12.5-12.8). To take just one more example, the responses to the statement that "applied science and technology will increase the supply of jobs" also reflected a clearly optimistic attitude among those with the lowest grades for general knowledge about science. Agreement was high or very high at 77% and 66% for respondents graded D and C respectively, compared with 67% and 56% for those graded B and A, respectivelly.

3.2.3 Social communication of science

The interaction between science and society through social communication of scientific activities is one of the key aspects of public perceptions of science. The circulation of scientific information in society should be understood in the context of practices configuring a circuit of public communication that comprises institutions and mechanisms of knowledge diffusion and sharing. The best-known modalities are scientific journalism and popularisation, but it is also important to bear in mind the knowledge transmitted by the various levels of the system of formal education, as well as the information embodied in products, processes and socio-political practices. The circulation of scientific information in society entails a series of processes, which sometimes come into conflict but through which scientific knowledge and the codes and values of S&T are transmitted to society, absorbed into the economic and cultural heritage, and converted into a particular daily use of science, constructing a wide variety of social representations not necessarily articulated to each other.

16. This distribution of respondents according to grades A-D was used to analyse the results presented in Detailed Tables 12.5, 12.6, 12.7 and 12.8.

Figure 12.4
Responses to "The main cause of improvements to the quality of life for humanity is scientific & technological progress" cross-tabulated with grades for general knowledge about science



Note: grades for knowledge based on numbers of correct responses to 13 selected specific questions (see Section 3.2.2). Groups graded D, C, B and A for 0-4, 5-7, 8-10 and 11-13 correct answers respectively.

Elaborated by the authors.

Source: Survey of public perceptions of S&T conducted in Campinas, São Paulo & Ribeirão Preto (LABJOR/UNICAMP).

See Detailed Table 12.8

ST&I Indicators in the State of São Paulo, Brazil – 2004, FAPESP

Social communication of science is crucial to the legitimating of scientific practice, especially in peripheral (as opposed to central) societies. At the same time, it constitutes a distinctive feature of modern culture, which is scientifically and technologically oriented and subject to interests of various kinds, from the debate on introduction of certain technologies to the democratisation of science.

The survey discussed in this chapter included an axis designed to investigate some of these processes of social communication, with the aim of understanding more about the consumption of science from various sources. Respondents were asked about their perceptions of the scientific information available from newspapers, magazines and television programmes, about how and why they consumed scientific content, about their consumption and evaluation of the Internet phenomenon, and about their perceptions of scientists and science journalists in terms of credibility and professional competence.

3.2.3.1 Consumption of scientific information & embodied scientific information

A large proportion of the information about S&T acquired by ordinary members of the public comes from print and broadcast journalism. The role of the media in providing access to scientific information is central to the construction of public perceptions of science.

An initial benchmark in measuring that role is the respondents' self-assessment regarding the scientific information they absorb (Detailed Table 12.4.11). This is a typical indicator used in international surveys (NSF, Eurobarometer etc).

Generally speaking, the results from the São Paulo State survey on this question did not differ substantially from those obtained by surveys in other countries. When asked if they considered themselves "well-informed about S&T", a large majority of respondents (84%) said they had "little" or "no information". A comparison with NSF and Eurobarometer survey findings specifically shows that in all three cases respondents tended not to consider themselves well-informed about S&T regardless of education. In the Eurobarometer survey, 33% said they were well-informed and 64% said they were not. In the São Paulo survey, 2% considered themselves well-informed, 14% said they had a "fair amount" of information, 72% chose the option "little information", and 12% chose "no information" (Detailed Table 12.4.11). In the NSF survey, fewer than 15% considered themselves well-informed about new scientific discoveries and the use of new inventions, while about 35% said they had little information. Thus European respondents appeared to be, or at least declared themselves, better informed than those of other countries about S&T-related matters.

Returning to São Paulo, most respondents consumed scientific information in newspapers (67%) and television (78%), largely on an occasional basis (Detailed Tables 12.4.15 and 12.4.17). Other questions were designed to identify perceptions relating to scientific content in the sources of information mentioned (Detailed Tables 12.4.14-12.4.17): about two-thirds said they actively sought scientific information in newspapers and on television, whether frequently or "now and then", while a third expressed little or no interest in S&T. Medicine and health were the most interesting scientific and technological subjects for this sample (as also in most surveys conducted in other countries). Not all topics considered relevant to society were also interesting to respondents personally: 63% said they had little or no interest in cloning, for example.

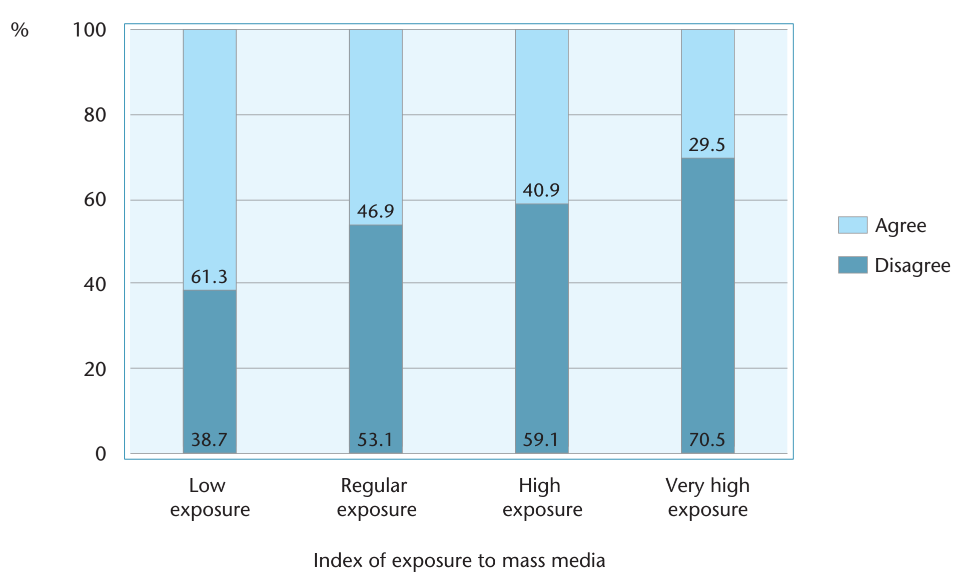
The ways in which consumption of information relates to basic knowledge of and attitudes to S&T were investigated by means of a specially constructed index of exposure to the mass media (i.e. other than special-interest media), taking account of variables that measured the time spent by respondents each day reading newspapers, watching television, using the Internet and listening to the radio. The index did not take account of educational attainment or knowledge about S&T.

These data were used to establish four bands of media exposure based on average daily time as defined above: "low exposure" corresponding to 0-4 hours per week, "regular exposure" for 5-9 hours, "high exposure" for 10-14 hours, and "very high exposure" for more than 14 hours.

Cross-tabulation of data for media exposure and attitudes to S&T highlighted a number of significant correlations: 61% of the respondents in the low exposure group and 30% of those in the very high exposure group agreed with the statement that "S&T are not concerned with people's problems" (Figure 12.5; Detailed Table 12.9.1).

The results showed that the proportions agreeing that "the benefits of S&T outweigh the negative effects" and "S&T will increase the supply of jobs" rose from 64% to 77% and from 61% to 73% respectively in the comparison between low and very high media exposure (Detailed Tables 12.9.2 and 12.9.3).

Figure 12.5
Responses to "S&T in general are not concerned with people's problems", by level of exposure to mass media



Elaborated by the authors.

Source: Survey of public perceptions of S&T conducted in Campinas, São Paulo & Ribeirão Preto (LABJOR/UNICAMP)

See Detailed Table 12.9

Media exposure also appeared to correlate with levels of knowledge about S&T in the survey sample. Among respondents in the very high exposure group, 8% had a high level of knowledge about S&T (grade A as defined in subsection 3.2.2) and 33% had medium knowledge (grade B), while none of the respondents in the low exposure group had a high level of knowledge and only 11% had a medium level (Figure 12.6; Detailed Table 12.10).

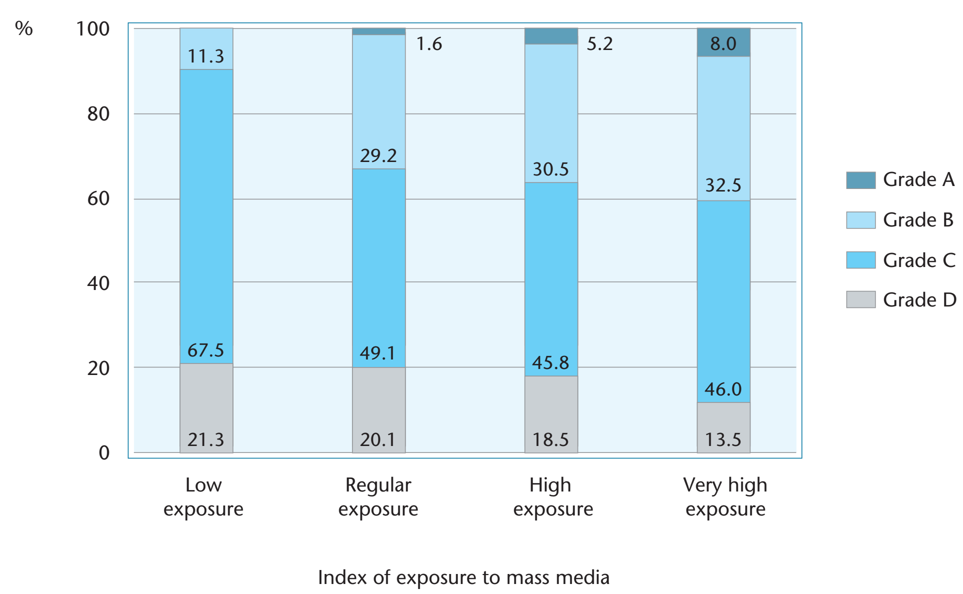
As emphasised earlier, interactions between attitudes to S&T and the overall profile of the public can be analysed in greater depth by future research based on larger, more representative samples and involving cross-tabulations, for example, between variables for principal occupation and questions on the usefulness and/or risks of S&T, or investigating correlations between media exposure and other indices for attitudes to and interest in S&T.

3.2.3.2 Opinions about scientists & journalists as communicators

Another part of the survey conducted in São Paulo State was designed to identify respondents' opinions about scientists and journalists as key protagonists of science communication in terms of professional integrity and communicative credibility. An initial pair of questions related to the use of clear and comprehensible language in science communication (Detailed Tables 12.4.24 and 12.4.25). According to the answers, this sample tended to believe that scientists were hard to understand in their communication with society only on some occasions. This suggests an assumption by respondents that any failure to communicate by scientists is not a structural condition of their professional skills but is fundamentally due to other factors.

Other items asked respondents to say who they would trust most to supply credible information about nuclear energy or biotechnology (Detailed Tables 12.4.21 and 12.4.22). Also here the answers were balanced overall. It is interesting to compare the data for São Paulo State on this point with the findings of the RICYT survey. In the other countries covered by that survey university scientists were seen as the most trustworthy sources of information on S&T (with 40%-50% of the answers), followed by environmental NGOs (Vogt & Polino, 2003). This was the case for information on both biotechnology and nuclear ener-

Figure 12.6
Public knowledge about S&T, by level of exposure to mass media



Note: grades for knowledge based on numbers of correct responses to 13 selected specific questions (see Section 3.2.2). Groups graded D, C, B and A for 0-4, 5-7, 8-10 and 11-13 correct answers respectively.

Elaborated by the authors.

Souce: Survey of public perceptions of S&T conducted in Campinas, São Paulo & Ribeirão Preto (LABJOR/UNICAMP).

gy. The survey conducted in the Brazilian cities of Campinas, Ribeirão Preto and São Paulo, in contrast, showed a high level of trust in academic scientists but an even higher level in NGOs, at least as in connection with biotechnology.

3.2.4 Public participation in S&T affairs

The concept of public participation refers basically to articulated dimensions such as knowledge democratisation processes (circulation of qualified information, social learning etc.), the existence and availability of channels for participation, formal or informal, and integration of social knowledge and needs into the development of S&T. The survey discussed in this chapter focused in this regard on controversial issues such as nuclear waste, GM organisms, industrial contamination etc., in an attempt to identify experiences of effective participation as well as attitudes and obstacles to participation.

The first set of questions sought to relate the respondent's attitude to public participation in controversial debates on S&T with actual experience of participation (Detailed Table 12.4.26). The vast majority said it was important to participate (Detailed Tables 12.4.30 and 12.4.31) but a significant proportion also noted many obstacles to participation by non-experts (Detailed Table 12.4.32).

Most respondents who had ever participated said they did so in the context of public demonstrations (Detailed Tables 12.4.27 and 12.4.28). Few had engaged in more passive activities such as complaining by phone or signing a petition on the Internet, and still fewer in formal institutional protest such as taking legal action. This moderate preference for active protest probably reflects the high visibility and media exposure of some NGOs regularly involved in the debate on controversial S&T-related issues.

4. Convergences between findings of surveys in São Paulo & other countries

The main indicators relating to public perceptions of science that are currently under debate (produced by the U.S. National Science Foundation, Eurobarometer, and the U.K. Office of Science & Technology) were formulated at a time when the "deficit model" still predominated. This model assumes that the public is a passive mass requiring educational programmes to improve its knowledge of S&T. It sees ignorance as the main reason for "anti-science" attitudes, i.e. critical opinions or preference for precaution about the benefits of science.

However, what recent international studies have shown about the three main dimensions of public perceptions of science (interest, knowledge and attitudes) – and the findings of the São Paulo survey described here show the same trends – is that, first of all, the scientific literacy dimension reveals the remarkable complexity of the notion of "scientific knowledge" and entails epistemological problems that invalidate the many definitions proposed in recent decades (Laugksch, 2000). The analysis also highlights the difficulty of making appropriate judgments regarding those who know the science system and its functioning through the use of simple, isolated questions about certain kinds of scientific content, as is the case in traditional surveys.

With respect to attitudes, the findings for Brazil and other countries on some fundamentals of public perceptions and social representations of S&T seem surprisingly similar despite major social and cultural differences between countries. For example:

a) high levels of interest in S&T;
b) low levels of information about S&T, accoring to the respondents themselves;
c) very high recognition of the value and importance of basic scientific research to all societies;
d) concern about the impact and social control of S&T, emphasising different aspects in different countries.

So-called "anti-science" attitudes were expressed by a minority in all countries with the partial exception of Japan, where respondents voiced certain concerns about technology (Miller et al., 1998). These attitudes did not take the form of fear or a priori objections to science and the work done by scientists. Instead, they were expressed as what might be called cautious criticism regarding some aspects of the social impact of S&T or social control of science. Moreover, the public cannot be simply divided into two groups, "anti-science" and "pro-science". It is far more accurate to consider interconnected categories that take into account complex combinations of attitudes, levels of interest, cultural exposure to S&T-related issues etc.

Another aspect of public attitudes to S&T and the social role of scientists is the existence of unexpected links that the deficit model cannot entirely explain. For example, the classic assumption of a linear mechanical relationship between lack of knowledge and anti-science attitudes does not seem to apply universally, and vice-versa in the sense that some groups with very low levels of knowledge or interest express complete trust in science while others with higher levels of knowledge or interest do not approve of certain aspects of S&T.

The analytical distinction between polarised "anti-science" and "pro-science" groups has historical and social roots. Such distinct and opposite groups can be said to have existed less in reality than in the imagination of researchers interested in boosting support for scientific activities as a whole or surmounting society's objections to experimentation in certain fields. It is arguable that the distinction began with C. P. Snow's classic book about "two cultures" (Snow, 1962), which posits a radical opposition between the worlds of literature and science. In this essay literary intellectuals, embodying the traditional culture, were not just said to be hostile and rejectionist towards scientists, but also and above all were branded with being scientifically illiterate. To some extent the widespread classification of ordinary people as either anti-science or pro-science reproduces Snow's vision, albeit much more broadly and in profoundly differing historical and cultural contexts.

Decades after Snow provoked a heated debate on the subject, however, many scholars regard public perceptions of science as part of a broader cultural system. It makes sense to speak of "scientific culture" as a separate category only as an instrument for analysing the complex interactions between S&T and the overall culture of a given society (Vogt & Polino, 2003; Wynne, 1991; Collins & Pinch, 1993; Ziman, 1984, 1991).

Thus to discuss the impact of S&T in the various fields of human endeavour and how S&T becomes a living part of the broader culture, it is necessary to formulate suitable analytical instruments. The findings outlined in this chapter can serve as a starting-point for the construction of new tools while at the same time implicitly containing the old methodologies. This has the advantage of permitting international comparisons and also of constituting a benchmark against which to undertake work of a new kind with the aim of understanding cultural phenomena, which are too complex to be methodologically limited by the use of closed-end questionnaires designed for very different locations (the central countries).[17]

Culture is not a measurable entity. It is dynamic, historical, flexible and often contradictory. The responses collected offer only clues, pointers to something that is not an attribute of individuals but a condition of society (Vogt & Polino, 2003). Cross-tabulation of responses against a range of questions, especially those relating to the three areas of perception – interest, knowledge and attitudes – may result in even stronger indications but cannot produce anything immediately conclusive.

Take, for example, the use of the word science in so many of the items in questionnaires. Many different meanings are attributed to the word even by scientists, let alone outside the field of science proper, depending on their personal history and the theories they espouse. For some researchers, science means only the so-called hard sciences. Others would extend its meaning to include some fields of the life sciences, such as biology. However, adherents of other theories would include human sciences, such as sociology, anthropology and psychology, for example.

Analysts are duty-bound to ask themselves whether what respondents understand by science covers the entire spectrum of scientific activities or is limited to the common-or-garden caricature. It is equally relevant to consider whether such homogeneous meanings are shared by all groups used for the purposes of cross-tabulation (income, education, age etc).

The quantitative data collected will be made stronger, more significant and suitable for the profiling of what is called scientific culture if they can be integrated with qualitative data. The latter can be collected using the wide range of instruments created and traditionally used by practitioners of human sciences, such as focus groups, ethnographic research methods etc. The next step after laying this foundation should be to reformulate the qualitative questionnaires available in order to surmount the challenge of making them suitable for local application without losing their international comparability.

5. Conclusions

The case study carried out in three municipalities of São Paulo State and discussed in Section 3 represents a preliminary investigation necessary for the exploration of some of the fundamental characteristics of public perceptions of science. In addition, it served to collect empirical data for use in adapting and reformulating methodologies and conceptual tools in order to build up a suitable apparatus for further development of this kind of research in Brazil.

The project was designed to be exploratory. Hence the limited sample, in terms of geography and

17. Nevertheless, data collected by large-scale surveys are a fundamental reference for single-issue polls. Public opinion on matters such as labelling of GM food, for example, can be adequately measured by specific questions.

demographics, and the use of survey methodology alone for quantitative analysis.

A possible plan for extending this research project to the whole of São Paulo State, and even for a nationwide survey, would therefore have to include at least two types of amplification:

a) Enlargement of the survey sample:
- to cover a representative cross-section of the population of São Paulo including all socioeconomic groups, thus permitting more complete comparison with the 1987 CNPq/Gallup survey and international surveys;
- to deepen the investigation of specific segments considered especially representative for certain aspects of public perceptions of science or in connection with policy making. For example, adolescents and young adults may be particularly interesting insofar as their environmental awareness can be taken as an indication of deeper dimensions of those perceptions. Also social groups attentive to the development of S&T, such as scientists themselves.

b) A richer selection of methodological tools that can be used to investigate more complex or profound aspects of public perceptions than can be measured by quantitative and partial surveys.

Thus the findings of the survey conducted in three municipalities of São Paulo State can serve as the basis for a new questionnaire covering all socioeconomic groupings. The structure and content of the questionnaire can be designed, as is customary in this field (Eurobarometer, 2000; Gaskell & Bauer, 2001), in accordance with the results of focus group discussions, which can be qualitatively analysed and used to

Project "Our Daily Science"

The main aims of "Our Daily Science" are to build links between science communication and the initial and continued education of secondary school teachers in the area of the sciences of nature and their technologies; to contribute to the practical realisation in the classroom of the National Secondary School Curriculum Guidelines; to establish new possibilities for relations between the production and circulation of scientific knowledge, education for science and science communication; and to foster the increasing adoption of a scientific culture that enables all members of our society to participate more fully in the discussion of science and technology.

"Our Daily Science" seeks to motivate students in state schools to take an interest in science, on the basis of material produced by *Pesquisa FAPESP*, a monthly publication with a print run of 44,000 copies containing a wide variety of articles on research projects and findings in all knowledge areas, not just in São Paulo State but also in other parts of Brazil and even in other countries. The publication contains sections on S&T Policy, Science, Technology, and the Humanities.

The project will be part of a programme implemented by the São Paulo State Department of Education (SEE-SP) and its "Knowledge Network" (Rede do Saber), an interactive high-speed intranet which interconnects all regions of the state. The network currently comprises more than 2,500 computers, 100 videoconference rooms in 89 locations around the state, nine TV studios, and an operations centre to monitor network use and provide logistical and technical support for system managers.

The idea is to select articles on scientific research from *Pesquisa FAPESP*, prioritising topics of relevance to the contextualised teaching of natural science and mathematics in accordance with the national curriculum guidelines, of a suitably multidisciplinary nature and adequate to classroom use.

This material will serve as a basis for the production of six annual guides to the use of the selected texts for teachers of biology, general science, physics, mathematics and geography at state secondary schools.

The project will initially cover about 1 million students at schools throughout the state. They will be assessed in terms of their perceptions and understanding of S&T at three different times: before, during and after implementation of "Our Daily Science" with the young people to participate in the project.

The project is expected to enable participants to see S&T as important and interesting and as a real presence in their lives. It also aims to give them an understanding of their role in S&T policy formulation.

complement the quantitative and more issue-specific analysis typical of the survey approach. The questionnaire should be drafted so as to take account of the characteristics of the sample to be covered and should include all dimensions of public perceptions and especially attitudes to science. It should also be designed to guarantee comparability and accompanied by testing methodologies and scales. Future research might also contemplate questions relating to the content of scientific communication in the mass media.

Besides being investigated in regular surveys, these aspects can used to construct a time series of indicators of public perceptions of science, thereby serving as public policy input. This proposal to create and consolidate indicators of public perceptions of S&T, understood as elements of science awareness or understanding and attitudes to science, should also include the construction of a stable system of measurement.

A "laboratory" particularly rich in information and stimuli, both in the direction of studying specific social groups and to try out in-depth quantitative and qualitative methodologies, can be analysed by means of a case study linked to the project "Our Daily Science" submitted by FAPESP to the Ministry of Science & Technology, in partnership with the São Paulo State Department of Education.

References

BAUER, M.; PETKOVA, K.; BOYADJIEVA, P. Public knowledge of and attitudes to science: alternative measures that may end the science war. *Science, Technology and Human Values*, v. 25, n.1, 2000.

BODMER, W. *The public understanding of science*. London: Royal Society, 1985.

BRASIL. Ministério de Ciência e Tecnologia. *O quê o brasileiro pensa da ecologia?* - Research report. Brasília: CNPq/IBOPE, 1992.

BURNS, T.W.; O'CONNOR, D.J.; STOCKLMAYER, S. Science communication: a contemporary definition. *Public Understanding of Science*, n. 12, 2003.

CASTELFRANCHI, Y. Scientists to the streets : science, politics and the public moving towards new osmoses. *Jekyll. Comm.*, n. 2, Jun. 2002. Available at: <http://jekyll.sissa.it/jekyll_comm/commenti/foc02_01_eng.htm>. Accessed Jun. 2002.

COLLINS, H; PINCH, T. *The golem. What everyone should know about science*. Cambridge: Cambridge University Press, 1993.

CONACYT. *Indicadores de actividades científicas y tecnológicas: 1998*. Mexico, 1999.

EUROBAROMETER. *The european report on science and technology indicators*. Bruxelles: Office for Official Publications of the European Communities, 2001a.

__________. *Europeans, science and technology*:12/2001, 2001b. Available at: <http://europa.eu.int/comm/public_opinion/archives/eb/ebs_154_en.pdf>. Accessed Dec. 2003.

__________. *Europeans and modern biotechnology*: 3/2000, 2000. Available at: <http://europa.eu.int/comm/public_opinion/archives/ebs/ebs_134_en.pdf>. Accessed Dec. 2003.

GASKELL, G; BAUER, M. *Biotechnology: 1996-2000. The years of controversy*. London: Science Museum, 2001.

GREGORY, J.; MILLER, S. *Science in public: communication, culture and credibility*. New York: Plenum Press, 1998.

GRECO, P. Communicating in the post-academic era of science. *Jekyll.comm.*, n.1, mar. 2001. Available at: <http://jekyll.sissa.it/jekyll_comm/editoriale_jek0_eng.pdf>. Accessed Oct. 2003.

HAMLETT, P.W. Technology theory and deliberative democracy. *Science, Technology & Human Values*, n. 28, 2002.

HOLZNER, B.; DUNN, W.; SHAHIDULLAH, M. An accounting scheme for designing science impact indicators. *Knowledge*, v. 9, n. 2, 1987.

HOWLETT, M. A dialética da opinião pública: efeitos recíprocos da política pública e da opinião pública em sociedades democráticas contemporâneas. *Opinião Pública*, Campinas, v. 6, n.2, 2000.

INSTITUTO BRASILEIRO DE OPINIÃO PÚBLICA E ESTATÍSTICA (IBOPE). *Pesquisa sobre transgênicos*. Rio de Janeiro, December 2003.

INGLEHART, R. *Modernization and postmodernization cultural, economic and political change in 43 societies*. Princeton: Princeton University Press, 1997.

INSTITUTO GALLUP. *O que o brasileiro pensa da ciência e da tecnologia? Relatório*. Rio de Janeiro, 1987. Mimeografado.

IRWIN, A.; WYNNE, B. *Misunderstanding science? The public reconstruction of science and technology*. Cambridge: Cambridge University Press, 1996.

KUHN, T. *A estrutura das revoluções científicas*. São Paulo: Perspectiva, 1975.

LATOUR, B. *Ciência em ação: como seguir cientistas e engenheiros sociedade afora*. São Paulo: Ed. UNESP, 2000.

LAUGKSCH, R. C. Scientific literacy: a conceptual overview. *Science Education*, n. 84, 2000.

LEWENSTEIN, B. From fax to facts: communication in the cold fusion saga. *Social Studies of Science*, n. 25, 1995.

__________. *Models of public communication of science & technology*. (In press, 2003). Available at: <http://communityrisks.cornell.edu/BackgroundMaterials/Lewenstein2003.pdf>. Accessed Nov.2003.

MALASYAN SCIENCE AND TECHNOLOGY INFORMATION CENTRE. *The public awareness of science and technology in Malaysia*. Malaysia, 2000.

MERTON, R. K. *The sociology of science*. Chicago: University of Chicago Press, 1973.

MILLER, J.D.; PARDO, R.; NIWA, F. *Public perceptions of science and technology:a comparative study of the European Union, the United States, Japan, and Canada*. Chicago: Academy of Sciences, 1998.

MILLER, S. Public understanding of science at the crossroads. *Public Understanding of Science*, n.10, 2001.

MONROE, A.D. Public opinion and public policy, 1980-1993. *Public Opinion Quarterly*, v. l.62, nº1, 1998.

NEW ZEALAND. Ministry of Research, Science and Technology. *Science and technology interest, understanding and attitudes in the New Zealand Community*:1997. Available at: <http://www.morst.gov.nz/publications/interest/index.htm>. Accessed Jul. 2002.

NATIONAL RESEARCH COUNCIL. Committee on Risk Perception and Communication. *Improving risk communication.* Washington, D.C.: National Academy Press , 1989. p.332.

NATIONAL SCIENCE FOUNDATION - NSF. *Science and engineering indicators*. Washington, DC: U.S. Government Printing Office, 2002. (Biennal Series). Available at: <http://www.nsf.gov>. Accessed Nov. 2003.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT - OECD. *Promoting public understanding of science and technology*. Paris, 1997a. (OECD/GD, 97 (52). Available at: <http://www.oecd.org/dsti/sti/s_t/scs/prod/e_97-52.htm>. Accessed Nov. 2003.

__________. *Science and technology in the public eye*. Paris, 1997b. Available at: <www.oecd.org/dsti/sti/s_t/scs/prod/s_tpub.pdf>. Accessed Oct. 2003.

OBSERVATOIRE DES SCIENCES ET DES TECHNIQUES – OST. In: WELLCOME TRUST. *Science and the public: a review of science communication and public attitudes to science in Britain.* London, 2000. Available at: <http://www.wellcome.ac.uk>. Accessed Oct. 2001.

PITRELLI, N. The crisis of the public understanding of science in Great Britain. *Jekyll.comm.*, n.4, Mar. 2003. Available at: <http://jekyll.sissa.it/jekyll_comm/commenti/foc04_01_eng.pdf>. Accessed Jul. 2003.

POLINO, C. Percepção pública da ciência e desenvolvimento científico local. *ComCiência*, jul. 2003. Available at: <http://www.comciencia.br/reportagens/cultura/cultura19.shtml>. Accessed Jul. 2003.

POPPER, K. *A lógica da investigação científica*. São Paulo: Abril Cultural, 1980. (Coleção - Os Pensadores).

ROBINSON, J.; SHAVER, P.; WRIGHTSMAN, L. (eds.). *Measures of political attitudes: measures of social psychological attitudes*. Oxford: Academic Press, 1993.

SCIENCE from PUS to PEST. *Science*, v. 298, Oct. 2002.

SNOW, C. P. *The two cultures and the scientific revolution*. Cambridge, UK: Cambridge University Press,1962.

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION -UNESCO. *Declaration on science and the use of scientific knowledge.* Presented at World Conference of Science, Budapest, 1999a.

__________. *Science agenda: framework for action.* Presented at World Conference of Science, Budapest, 1999b.

VAN DETH, J. ; SCARBROUGH, E. (eds.). *The impact of values.* Oxford: Oxford University Press, 1995.

VOGT, C. A espiral da cultura científica. *ComCiência*, Jul. 2003. Available at: <http://www.comciencia.br/reportagens/cultura/cultura01.shtml>. Accessed Jul. 2003.

VOGT, C.; POLINO, C. (org.) *Percepção pública da ciência: resultados da pesquisa na Argentina, Brasil, Espanha e Uruguai*. Campinas: UNICAMP/FAPESP, 2003.

WACHELDER, J. Democratizing science: Various routes and visions of dutch science shops. *Science, Technology & Human Values*, n. 28, 2003.

WELLCOME TRUST *Science and the public: a review of science communication and public attitudes to science in Britain.* London, 2000. Available at: <http://www.wellcome.ac.uk>. Accessed Out. 2001.

WYNNE, B. Knowledges in context. *Science, Technology & Human Values*, v.16, n.1, 1991.

ZIMAN, J. *A força do conhecimento*. Belo Horizonte: Ed. Itatiaia, São Paulo: Ed. USP, 1981.

__________. *An introduction to science studies: The philosophical and social aspects of science and technology*. Cambridge: Cambridge University Press, 1984.

__________. Public understanding of science. *Science, Technology & Human Values,* v. 16, n.1, 1991.

__________. Not knowing, needing to know, and wanting to know. In: LEWENSTEIN, B. (Ed) *When science meets the public.* Washington, D.C.: American Association for the Advancement of Science, 1992.

__________. *Real science: what it is, and what it means*. Cambridge: Cambridge University Press, 2000.