What do laypersons want to know from scientists? An analysis of a dialogue between scientists and laypersons on the web site Scienzaonline

Falchetti, Elisabetta; Caravita, Silvia; Sperduti, Alessandra

Public Understand. Sci. **16** (2007) 489–506

What do laypersons want to know from scientists? An analysis of a dialogue between scientists and laypersons on the web site *Scienzaonline*

Elisabetta Falchetti, Silvia Caravita and Alessandra Sperduti

Scienzaonline is an interactive web site developed by the Museum of Zoology of Rome that offers various services. After the site had been online for three years, we examined approximately 800 questions received by the service *Expert on line* to understand what laypeople's interests in science are and in which life contexts they emerge. The contents of the questions were categorized to reveal the function and the nature of the knowledge that people expect from "experts". Some kind of actual accomplishment motivates most of the questions, though a considerable number of them have knowledge and understanding as their objective. Information is the main form of expected knowledge and disciplinary knowledge is viewed as the privileged source of it. A relevant percentage of messages reveal the desire to obtain explanations and validations of reported facts, an aid to go beyond factual knowledge. Striving to find answers to "great unanswered questions" emerges as a passionate intellectual endeavor for some people.

1. Introduction

In Italy, in contrast with other nations, relations between science and society, between the scientific community and the general public have come to the fore relatively late owing to the delay with which science has been considered as an integral part of cultural heritage, as well as the key to economic development, and therefore as the object of a necessary and widespread acculturation of laypeople. Now, however, there is an inversion in the trend, both in relation to the offer as well as the request for scientific information, and also in the attitude of the academic community towards communicating scientific matters. A recent study analyzed one of the most valued Italian newspapers, *Il Corriere della Sera*. The study focused on scientific articles published between 1946 and 1997 and stated that the number of scientific articles nearly doubled from 1980 onwards (Bucchi and Mazzolini, 2003). Of these articles, 52.7 percent concerned biology and medicine. It is interesting to see how this corresponds to data produced by a sociological study that was carried out through a national survey (Borgna, 2001): Borgna found that Italians tend to identify science and technology with medicine and medical technology. Moreover, their interest in science is concentrated on all aspects concerned with the

 ISSN 0963-6625 DOI: 10.1177/0963662505063797

care of human life, i.e. biomedical sciences. With respect to gender differences, women appear to have less faith than men in the merits of science and technological development and they are more alert to risks. The distinction between science and technology is often blurred, but the confusion is generated by the emphasis that the media and policymakers place on the benefits that are produced by the application of scientific research in terms of services, resources, quality of life, etc. (see also Bucchi and Mazzolini, 2003).

Humanistic culture is traditionally predominant in Italian schools. The time allocated to teaching science in compulsory schooling is very limited (2–3 hours per week). Italian students obtained low marks in the scientific literacy evaluation proposed by the Project for International Student Assessment (PISA). The Project's objective was to underline the ability to think scientifically and not the mastery of simple information shown by youngsters when they leave compulsory school.

In this context, therefore, many cultural institutions feel that it is important to integrate and support science education in school. The number of science museums, science centers, and visitors' centers in parks and protected areas is increasing in our country and these institutions are upgrading the quality of their educational actions, which share the goals and principles that inspire the worldwide movement for the Public Understanding of Science (PUS) and that have also been stated in the OECD (1997) reports.

Consequently, in recent years, an increasing number of museums and science centers have started to use the World Wide Web not only for improving their public image, but also for reaching out and opening to virtual visitors. Some of them allocate and design specific resources and services (such as forums and databases about their exhibits) for different targets of their audience: the general public, teachers, specialists. Recent information on the use of the Internet (http://gandalf.it/dati/index.htm) by the Italian general public indicates a progressive increase in the number of users and a leveling out with respect to gender, age, and geographic differences.

By taking into account all the above-mentioned aspects, the Civic Museum of Zoology of Rome has made an interactive web site available for the general public. *Scienzaonline* offers a virtual space for dialogue between laypeople and scientists.

Scienzaonline was designed and developed as a service for the general public but also as an instrument for research on the subject of the public's Internet relationship with science. The messages received by *Scienzaonline* in three years were considered as a resource for an explorative study of its audience. The improvement of the site itself and of the quality of communication with the public was the immediate pragmatic reason for carrying out an analysis of the messages. In addition, we envisaged broader implications of this study as a contribution to the comprehension of the public's interests in and needs for scientific knowledge, when interests are spontaneously expressed. Most of the studies about people's interests rely on people's responses to questions posed by interviewers or questionnaires. Consequently, what emerges is guided by externally generated motivations and goals. Wynne (1995: 364, quoted by Cajas, 1999: 765) pointed out three generic methodological approaches that have been used by researchers to study levels of public understanding of science:

- large-scale quantitative surveys;
- cognitive psychology or the reconstruction of the "mental models" that people appear to have; and
- qualitative field research observing how people use science in their everyday lives.

We suggest the use of electronic communication might provide tools for a new approach:

- textual analysis of people's self-initiated messages that expect feedback from scientists.

Electronic communication implies the composition of short written texts and this produces important consequences on the quality of the message and on the producer of the message. Writing implies more elaboration of the content, leaves less space for implicitness and supports metacognitive effects. Therefore, the science web sites that facilitate forms of dialogue with their visitors (such as *Scienzaonline*) can be important observatories of the public's perceptions, beliefs, goals and expectations about science and scientists. In addition, anonymity probably makes users more enterprising and courageous in their dealings with scientists and stimulates them to pose questions according to their real interests. We have found in the literature very few qualitative analyses of this kind of interaction.

2. The study context

Public interest in science

The problem that has fostered research on school science education for decades is: how to implement a "science for all" project that contrasts with that traditionally followed for "science for the élite" (Cross and Fensham, 2000). Provoking interest on the part of youngsters for scientific studies has become a pressing goal that requires changes that in all countries meet with the resistance of academics, with the school culture, and with the slowness of innovative procedures in school programs and teaching methods.

The lack of relevance of the science and technology curricula for students is considered as one of the greatest barriers against good learning. But who decides what is relevant? Fensham (2000) proposed an insightful distinction of categories of the public in relation to their need to know science. He draws the implications for differentiating strategies of enculturation and for the design of curricula, which should include humanistic-cultural learning objectives. Values, the nature of science, the social aspects of science, the human character of science revealed through its sociology, history and philosophy, and its relationship with technology.

The Relevance of Science Education Project (ROSE, http://www.ils.uio.no/forskning/rose/) promoted by the University of Oslo, Norway gathers and analyzes information from the learners about several factors that have a bearing on their attitudes to and their motivation to learn science and technology. The items in the questionnaire deal with students' interests in learning (*what I want to learn about …*, *my future job …*, *myself as a scientist*) and different science-related topics in different contexts (e.g. *me and the environment*). The students from developed countries are more interested in philosophy, strange phenomena, biology and health, and technology (in decreasing order and with gender differences). The students from developing countries claim to be interested in everyday science, technology, and biology and health.

Ongoing research in Sweden (Jidesjö and Oscarsson, 2004) shows that many of the subjects taught in science classes are among the subjects students don't want to learn, and that topics traditionally considered interesting and fun are among the least popular. Instead, students want to learn about things we cannot yet explain and about which we do not have a clear opinion.

Laypeople in out-of-school contexts learn science (*citizen science*) as required. Interest in science may be generated by social and occupational contexts; moreover, in critical situations professional experience rather than formal education could be the main source to rely on for finding solutions. This was highlighted by a study based on interviews and observations of nurses working in a hospital (Aikenhead, 2004).

To date, few studies have analyzed how some opportunities that are available to the public satisfy their need for science, which kind of scientific knowledge will enable them to "function effectively" in specific settings of their life or to engage with science (Dimopoulos and Koulaidis, 2003; Zimmerman et al., 2001), or how people actually use scientific knowledge. Ryder (2001) analyzed 31 published studies that examined situations in which laypeople interacted with science in informal settings; he remarked that in most cases the knowledge that people value as relevant when they are engaged in problematic situations is a kind of knowledge not very well defined even by science itself. An unforeseen result of his study was that people seemed to be curious and wanted to know more about the development and the use of scientific knowledge, because they want to understand how statements are produced and justified by researchers, thus revealing a critical and not passive attitude towards the authority of science and its reliability when applied to real contexts.

In his essay, Jenkins (1999) pinpoints how the relationship of citizens with science is more complex than actually revealed by surveys on PUS: with respect to everyday reality, science does not emerge as a coherent, objective, non-problematic knowledge, but as an uncertain and often contentious knowledge, which cannot provide answers to many important questions with an acceptable degree of reliability. A layperson's thinking may even provide better ground for comprehension and prove to be more suitable for action. Jenkins claims that the majority of persons have an interest in science in connection with decision-making and with the undertaking of actions concerned with a variety of problems and contexts; therefore they choose the level of explanation that meets their needs. He also warns about the risk of considering persons as a homogeneous group and science as an undifferentiated field of activity.

It can be said that one of the primary objectives of the studies that concern the PUS is to identify ways for optimizing the awareness with which people look to how science acts, how its language and results are interpreted, starting with the way in which scientific acculturation is presented in schools (Duschl and Osborne, 2002; Kolstoe, 2001; Newton, 1999).

The web in science communication

Research on public understanding of science makes a distinction among these dimensions: interest in, comprehension of and attitudes to science and technology.

A survey on users and navigation patterns of a science web site for the public was carried out in Britain (Eveland and Dunwoody, 1998). Data were collected through the audit-trail and a short questionnaire produced information on a sample of 399 repeat users. Demographic characteristics revealed that the model user was a 37 year old male graduate and that 31 percent of users were women, who were more interested than men in medical discoveries and environmental issues. Repeated users claimed to be highly interested in science (8.25 on a scale from 1 to 10).

The Weigold and Treise (2004) study is concerned with an important problem: how can web sites play a significant role in developing an interest in and understanding of science among teenagers. The authors assume that, notwithstanding what educators may think and like, students from elementary schools to universities in developed and developing countries increasingly see the electronic media as their partners. They carried out focus groups with 23 high school students, all high academic achievers, from which they drew interesting information: entertainment emerged as the prevailing reason for accessing sites, although the Internet is also occasionally used as a tool for completing school assignments; science-related web sites are not searched for, but might be unintentionally accessed through a browser; teachers do not encourage students as to educational uses of the Internet. The teens interviewed expressed their desire for message boards where they can post thoughts, ask questions and offer opinions.

In conclusion and in agreement with Miller's (2001) line of reasoning, it is legitimate to question whether the scientific community fails to communicate with the public (youngsters and adults) because of insufficient interest on the part of laypeople or because the model of communication is inadequate. Moreover, the interests and goals of the public should be better known since they might not correspond to those that the science community and society attribute, expect and wish to enforce.

Informal science education is one of the alternative ways of reaching the younger generations, but this too often does not meet the expectations of the institutions that back it. Informal science education and school science education both rely on communication strategies that, unfortunately, for a long time were inadequately differentiated. Electronic communication is introducing new possibilities for interaction and the response of the public seems very promising.

3. *Scienzaonline*: framework and policy

Scienzaonline (http://www.comune.roma.it/scienzaonline) is a joint project of the authors of this article, the outcome of a long-term collaboration between the Civic Museum of Zoology of Rome and the Institute of Cognitive Sciences and Technologies of the National Research Council, Italy. The goal of *Scienzaonline* is to make scientific culture less distant and alien to everyday life through the development of "tailored dialogue" with the public. At the core of the philosophy that guided us in designing the site is the assumption that a unidirectional flow of information, from active knowledge producer to passive knowledge receiver, should be replaced by an interactive model of science communication, as claimed by many authors concerned with the diffusion of scientific literacy and informed citizenry or scientific citizenship.

The guidelines of *Scienzaonline* are:

- to propose contents and languages that are accessible to "non-experts";
- to answer laypeople's questions to stimulate additional questions and to induce reflection;
- to increase interest and to initiate dialogue rather than merely providing information, particularly when young students are the target;
- to answer all questions, irrespective of appropriateness or interest, with a view towards building a less formal image of science;
- to satisfy requests that originate from the public and not *only* from scientists.

Scienzaonline is divided into various services: *Activities*, *Thematic cards*, *Forum*, *Expert on line*, *Link*, *News*. In *Expert on line* a group of experts in different fields of science and technology answers questions posted by the web site's users, who can also browse the database (Archive), which contains all the questions received and the answers provided by the experts.

4. Our study: an analysis of the *Expert on line* database

The analysis presented in this paper deals with the questions posted on *Expert on line*. Entry cards ask the users to state their age, sex, occupation and place of residence. This information was used to trace a user profile, although not all users provided the information requested.

After three years online, approximately eight hundred questions provided the database for *Expert on line*, thereby offering a significant sample of messages featuring the audience and for conducting a study to understand from our sample users what are the public's interests in science and where these interests fit into daily life.

We would like to stress that the questions were formulated by people who spontaneously and actively search for information and who wish to interact with scientists, since the approach taken by *Expert on line* is to satisfy interests already present and to support internal motivations for comprehension rather than to build interests and motivation. This research context is new and advantageous for knowing/understanding people's spontaneous interests in science; in fact, the majority of the current surveys furnish data based on questions arisen, asked, selected and directed by the researchers and not by the public.

Of the study

In particular, our inquiry of the database was aimed at the following objectives and research questions:

Verify the relation that exists between the request for science and the personal life of our users:

- In relation to what goal or event in the layperson's life is he/she contacting the scientist?

Probe the interests of the public:

- What kind of knowledge is sought, which contexts trigger the quest and how does the context frame the sought-after knowledge?
- Which science subjects arouse more interest?

Learn the relationship between user characteristics and knowledge requested:

- What is the ethnographical profile of the users and how does it correlate with the issues that we raised?

Obviously, our study cannot be considered as representative of the Italian population owing to its limited size and because the users of *Scienzaonline* represent a subset of persons who are regular Internet users. However, considering that the studies reported in the literature are so few and that the data are so limited, this analysis can provide some interesting preliminary information.

Methods

We have made a qualitative and quantitative analysis of the questions. With respect to the quantitative analysis, we developed a series of categories. After reading the texts several times, we built our system of independent categories. The categories are as follows.

Function of the expected knowledge from Expert on line, in terms of goals stated by the sender of the message or inferable by the content of said message:

1. *Practical*: when knowledge was requested either to solve some kind of actual problem or to accomplish some activity.
2. *Theoretical*: when knowledge was sought for the pleasure of knowing more, better and in-depth.
3. *Non-inferable*: when the function of the knowledge requested was not explicit and the information available did not authorize reliable inferences.

Nature of the expected knowledge, in terms of the epistemological nature of the inquired information:

1. *Information*: questions dealing with the knowledge of facts, phenomena, data, with disciplinary content.
2. *Explanation*: questions revealing a concern for the understanding of facts, phenomena, data; questions that aim at the interpretation of processes, at clarifying relations.
3. *Validation*: questions that move from, and make explicit, an existing base of knowledge about something which needs to be confirmed, substantiated, validated, supported, on an authoritative basis.

Nature of the content of the questions. This was considered under two independent aspects: A) in terms of the scientific disciplines that constituted the reference domain for the question; B) in terms of the framework in which the question was conceived by the sender of the message, which could be related either with science practices or with everyday practices and decisions.

- A—Science subjects
- B—Scientific knowledge defined according to the contextual frame in which it is meant to be used:

  B1—Subject matter framed in disciplinary terms, to be used in schools or in professional settings
    - a—Content, definitions
    - b—Models, theories
    - c—Methods, procedures, demonstrations, experiments
    - d—Information about the disciplines themselves

  B2—Knowledge framed in real world contexts, called into bearing by personal observations, by information provided by everyday life sources such as friends and media

  B3—Knowledge related to applied science, dealing with objects and issues relevant in the different kinds of practices of everyday life

  B4—Knowledge elicited by speculations on very general themes concerning the universe and our existence

  B5—Non-stabilized, often interdisciplinary scientific knowledge, frontier research, newly developed technology, controversial issues

  B6—Information about programs for university courses and criteria for choice.

The three authors separately and independently classified 787 questions received between December 1999 and January 2003 in various categories and later compared their respective classifications. Comparison among the coders was first done after coding one hundred messages in order to make the classification criteria uniform; in cases of disagreement, the classification was discussed and negotiated. Divergences were recorded but their number was negligible (only 29 cases).

It was not possible to establish a classification that complied with all the aims of the objectives for all 787 questions, since several entry cards were incomplete. In this respect, each Figure (1–4) lists the number of questions used for the analysis/analyzer. Data resulting from the scoring were computerized.

For the qualitative analysis, which aimed at highlighting emblematic ways of approaching the search for knowledge and the dialogue with experts, or ways of viewing science, we extracted a sampling of messages on which each of us had added notes and comments. Our comments and interpretations were discussed and provided grounds for a deeper understanding of our audience.

5. Results

The Expert on line *audience*

The demographic information provided by the entry cards provided a description of the *Expert on line* users. The 787 questions corresponded to 381 users (219 male and 162 female) between the ages of 7 to 74 years. The most frequent users of the service are 21–25 year old male students (42.5 percent of the total). During the three years in question, the percentage of women users increased: from 35 percent in 2000 to 46 percent in 2001 and 2002.

People living in Rome remain the main component of the audience (35.1 percent), perhaps because the site had been advertised in Rome through leaflets distributed to museum visitors and through advertisements in some newspapers. The other users are from many other Italian cities and in a few instances from abroad. The users comprised 59.2 percent students of various ages and types of schools, 13.7 percent office workers, followed by teachers (7.2 percent) and by a series of other categories of profession, such as journalists, entrepreneurs, scholars, retirees, computer programmers, nurses/doctors, laborers, housewives, farm workers, etc.

A rather high number of people are frequent users: 23 percent have posted at least two questions and 30 percent of them have posted four or more questions on the same or a different topic. We consider fidelity a good parameter for evaluating the level of appreciation of the service and of trust. In many instances, the dialogue between the user and the scientist consisted of numerous exchanges. Faithful users often addressed their new questions to a known expert and to some extent their style was familiar and friendly.

Function assigned by users to scientific knowledge

This category was not conceived to classify questions according to the kind of goals that were in the background and that senders might have explicitly or implicitly declared. Rather, it was meant to reveal to what extent people are interested in receiving scientific knowledge only because they can apply it in solving real and practical problems (as often maintained by science communicators), or because they are curious and they are pleased to take advantage of a contact with science because they praise its value in their own lives.

We report two questions as typical examples of the categories that we have described.

> *Practical knowledge*: "What are the most frequently used indexes to calculate biodiversity?" (the user is a student)
> *Theoretical knowledge*: "Is the mosquito considered a carnivorous or a herbivorous animal? And if it does not belong to either one of these groups, then which one?"

As can be seen in Figure 1, the great majority of questions are aimed at obtaining knowledge that is needed for some kind of accomplishment, activity, scholastic assignment or some other problem relating to daily life. On the other hand, we stress the significant number of questions that appear to be driven only by an interest in knowing and understanding for their own sake.

Since the number of questions differs greatly in each user group, we could obtain only indicative information concerning the variation of this dimension with users' age. By and large, a theoretical function is pursued more frequently by people after the end of their formal education (Figure 1). We consider this finding to be interesting for the consequences that might be drawn in developing educational policies. In some cases, it was impossible to make reliable inferences and therefore these questions (a total of 38) were not taken into consideration.

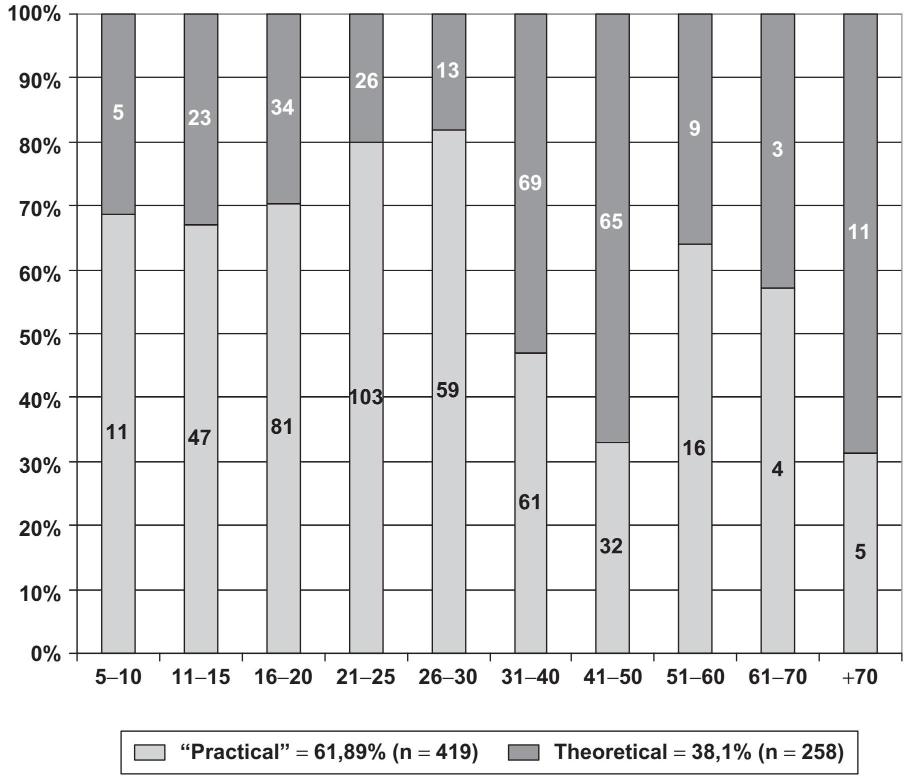

Figure 1 Aim of questions asked by age classes (years) (n = 677)

Nature of expected knowledge

We wanted to gain evidence of the epistemological nature of the knowledge that the users of our site were interested in. We had predicted that our public mainly wished to know more about some subjects, and to obtain explanations about partially understood information; we also expected that people would frequently seek the opinion of scientists either as a confirmation or as a guide for their ideas. As we will see, our hypotheses were only partially correct.

Examples follow of questions from the three categories—"Information," "Explanation" and "Validation"—that we identified.

Information: "Dear expert, I am writing to ask for information about Lampropeltis getulus californiae: its feeding habits, diurnal and nocturnal temperature, humidity and maximum size of the terrarium, behavior and relation with humans, books about the breeding of this snake, if any are available."

Explanation: "Why the sky is black at night?"

Validation: "I heard that a comet, of which I can't remember the name, has a tail longer than half a billion kilometers. Is this really a very unique event? What was the maximum size of the Halley comet? Wasn't Hale Bopp much bigger than the comet that is now in the media? …"

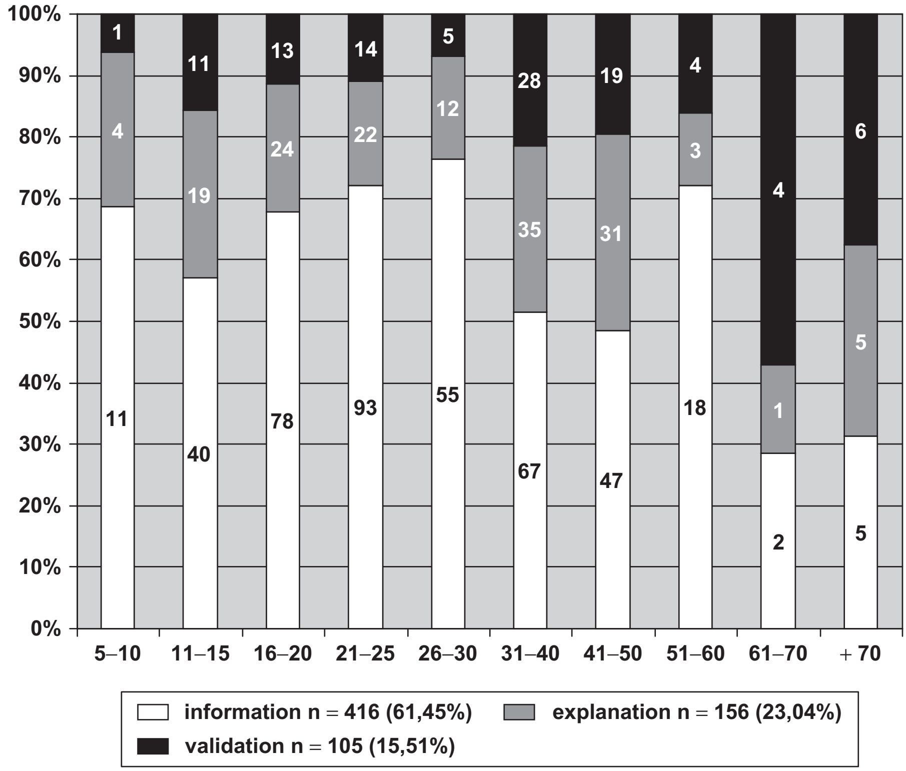

Figure 2. Nature of knowledge requested by age classes (years) (*n* = 677).

Figure 2 shows the distribution of questions among these categories: Information is by and large the main form of expected knowledge, with minor differences related to users' sex. But, again, the other two forms, which, in our opinion, reveal the desire of people to go beyond contents and facts, Explanation and Validation, make up a significant proportion of the questions (38.55 percent). As a tendency, questions from older people belong more frequently to these two categories. No differences were found between women and men in this respect.

By crossing these categories with those concerning the function of expected knowledge, an interesting confirmation was obtained: the Information category prevails in the subset of questions labeled as practical knowledge (79 percent on 419 questions), while about 50 percent of questions classified in the Explanation and Validation categories are included in the subset labeled as theoretical knowledge (258 questions).

Distribution of questions among scientific subjects

Questions cross a large variety of subjects, more than we expected according to the results of the Italian survey that dealt with the image of science (Borgna, 2001). Nevertheless, our results confirm that people are interested in life sciences, not particularly health care, with a peak in zoology (Figure 3). We do not believe that this depends on the fact that the Museum of Zoology is the manager of the site since this heading does not appear on the screen when the site is entered, or on the fact that there is a link to *Scienzaonline* from the museum's web site. At this time, we do not know how people access *Scienzaonline*, but we believe that the

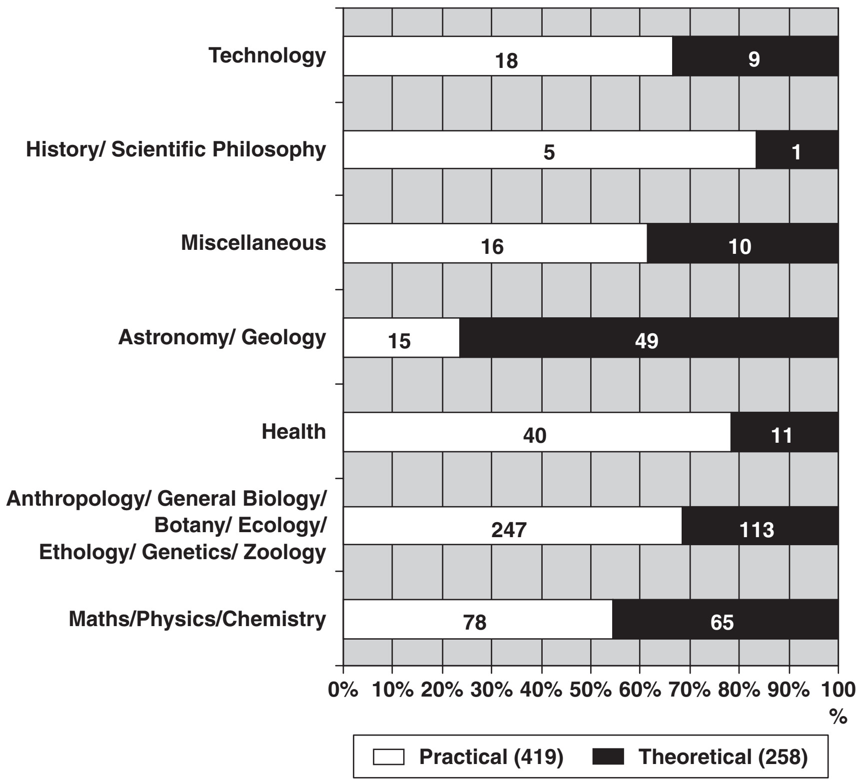

Figure 3. Subject of questions asked by aim of questions asked (n = 677).

majority of users access that site by navigating the Internet and/or by the principal research tools, by using "science" as key word.

Certain differences can be found between women and men: women pose fewer questions dealing with mathematics, physics and technology than men do, and more questions in the fields of ethology, botany, general biology and health care than men do.

History/scientific philosophy and biological sciences are the topics of questions that fall into the category of practical rather than theoretical knowledge, and that are unevenly distributed according to the nature of expected knowledge. Questions addressing astronomy have a predominantly theoretical function, while health care is the subject of concern mainly for practical reasons (Figure 3).

The Explanation category includes a higher percentage of questions (51 percent) dealing with "hard" sciences, while the Validation category includes a higher percentage of questions (53 percent) dealing with health care and astronomy.

Nature of the content of the questions

The experiential contexts that elicited the search for knowledge in the audience were relevant for us in order to understand how this external frame shaped the formulation of the question. When the use of canonical science was in the background, our categories (B1a–d) were aimed at pointing out which of the components featuring scientific knowledge and practice were addressed by users. But we also needed categories to classify many other messages in which the issues raised were not defined in terms of the topics considered by scientific disciplines and included in textbooks. The topics, though relating to science, were often defined in accordance with facts relevant in ordinary life practice, therefore they took a pre-disciplinary or a multi- or a cross-disciplinary form.

The questions included in the categories that aim at describing the content of the questions can be summarized as follows:

Disciplinary knowledge: "I would like to receive clarification about the demonstration of the generalized law of Hom [*sic*]. I need the information as soon as possible, in clear and elementary terms, since I have an exam."

Scientific knowledge framed in the real world: "I noticed that if I put food taken from the freezer on the marble table-top, the food defrosts very quickly. Is this possible? Why?"

Applied science: "I need to know the concept of 'magnetic coercivity' in rough terms. Particularly the concept related with the magnetic band of cards, like a credit card for instance."

Non-stabilized scientific knowledge: "What are the problems that hinder the use of hydrogen in producing energy?"

Speculation: "What kind of evidence confirms the Big Bang theory? In the absence of evidence, this theory and that of the Big Crunch seem to reach the purpose of validating religious positions that have nothing to do with science, rather than originating from observations of facts. Is my view plausible? Thank you."

Disciplinary knowledge constitutes the object of 53.2 percent of the questions. This finding is consistent with the identity of the users who form the main component of the audience, that is students. Second in rank is the number of questions concerned with knowledge in relation to real world contexts (15.4 percent). By crossing the two categories concerning function of expected knowledge and nature of content of the questions (Figure 4), it is clear that 74.5 percent of questions that are motivated by personal observations of reality pursue a theoretical

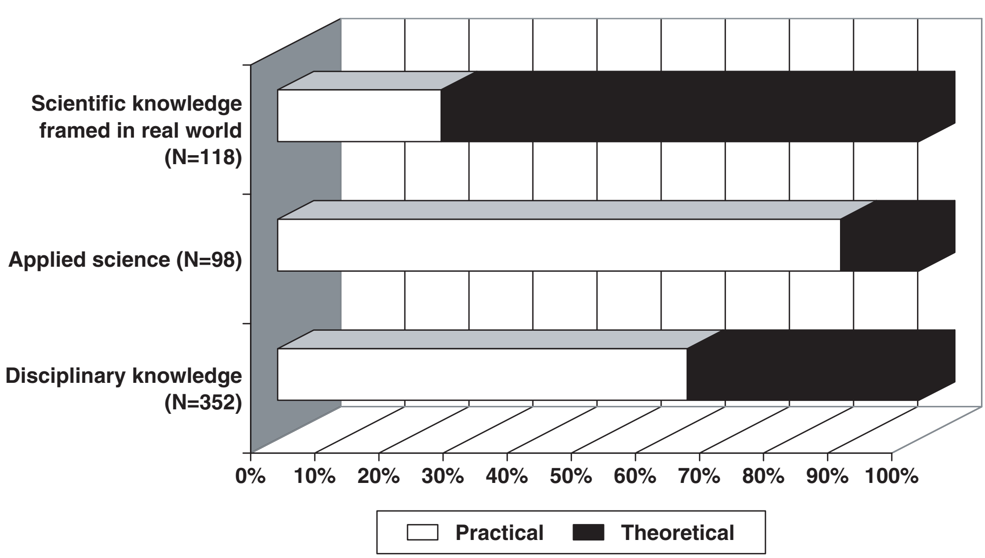

Figure 4. Nature of content of questions by fuction of expected knolwedge (n = 568).

purpose. In contrast, a high percentage (63.9 percent) of questions framed in disciplinary contexts have practical functions. When disciplinary knowledge is sought, this pertains to science contents (73 percent) rather than to theories (9 percent) or methods (13 percent). In a few cases it concerns information about the disciplinary field (3 percent). Finally, 14 percent of questions deal with applied science and the large majority of these are obviously practically oriented (87.8 percent) (Figure 4).

Non-stabilized science or topics currently under debate do not seem to be of particular concern for our audience: only 4.7 percent of questions address these issues, in spite of the fact that controversial issues related to the environment, genetics, genetically modified organisms and health were raised in the media during the three years in question.

Trends in people's questions that emerge from the qualitative analysis

Repeated reading of the messages made us aware of certain facts that, irrespective of the frequency of their occurrence, deserve comment. There are needs that neither scholastic education nor science popularization seem to satisfy and that a "scientific understanding of the public"—to use Paola Borgna's expression—should take into account.

Striving to find answers to "great unanswered questions" emerges as a passionate intellectual endeavor for people: the origin of the universe, the paradox of reality envisioned by the theory of relativity, the nature of matter and anti-matter, the causes leading to death, the alternative between actual existence and the perception of reality … these are some of the issues considered. These questions tend to be ignored by science teaching and by the media, as if assuming that people are interested just in information and ordinary topics that have a bearing on their lives. In addition, scientists prefer to avoid confrontation with philosophical themes and seem to forget that the split between science and philosophy was not that deep some centuries ago. Theoretical and philosophical reflection on sciences is mainly a search for knowledge, for an answer to theoretical and practical problems of humanity throughout history. The humanistic approach to science that is stressed by some authors is therefore supported by our findings.

Another interesting fact emerges from our data: the public is not as careless as some observers claim. Many people, including students, are not content with superficial knowledge of topics or phenomena. They are puzzled by the obvious reality, they are attentive to events that defy stabilized codification and they like to engage their thinking in finding out the deeper causes of facts that they notice: ice melts quicker on some kinds of surfaces than on others; the sky and sun change colors at different hours of the day or night; bubbles in fizzy drinks always start from the bottom of the glass; not all birds lay eggs as often as chickens do; rubber soles cause friction and this seems to be a general property of soft rather than hard materials.

Not only perceived reality, but texts, lectures and the communications of the media can sound deceivingly self-evident and exhaustive. Unfortunately, teachers may not be regarded as the right persons to help to consider facts or ideas at a less "safe" level of inquiry than is currently offered to students.

> Hi! I am 13 years old and I've had a great passion for astronomy ever since I was a child. Sometimes, at school, we do astronomy with the professor of mathematics, but the way she lectures is not very interesting: she talks about the sun, its size, earth movement, that kind of stuff, but I would like to study about better things, for instance about stars, about things that are still unknown but that need answers, about the formation of the universe … in short about things that are not simple but that my brain wishes to catch.

There are students who do not take what they are taught for granted, they have a desire to understand:

> How is it possible that parallel lines continue to infinity?
>
> The coat of animals must blend with the environment. But why then are tigers striped, leopards spotted and lions have a plain color?

But some teachers also make plain their need for a deeper understanding of what they teach, even though fewer teachers than we had predicted are part of our audience. Their questions appear to be motivated by: the need to improve their knowledge and confidence in the science matters that they teach, sometimes as a result of their students' questions or because they are troubled by unexpected results of laboratory experiments; the need for didactic support, either to present a topic or for laboratory activities; the wish to offer children opportunities for direct contact with scientists. Some teachers became faithful users of *Experts on line*.

Some expressions that people use in their messages seem to suggest that they know they need to master information about technological developments (e.g. cold fusion, hydrogen as automobile fuel, waste recycling, applications of biophysics, solar panels), but they are not so confident that the need they express will be acceptable to the experts and that they will be able to grasp the meaning of the answer. Some examples are:

> I hope that you will be able to give me an answer that I truly cannot find anywhere!
>
> Thank you very much for your helpfulness!
>
> Can you help me by trying to explain what …?
>
> Thank you for your precious work and the great patience you have with me …
>
> I know that my question might not be pertinent …
>
> My question might appear silly to you …
>
> Mine is probably a trivial question …
>
> I have an unusual question …

The high number of affectionate users of the service and the colloquial style of their messages suggest that the experts on our panel succeeded in maintaining an interactive dialogue, which is probably what laypeople look for. Some of our experts commented that certain questions are not properly formulated: too generic, too wide in scope, or simply not respectful of an academic way of raising questions on science topics. Questions may require interpretation and also a re-interpretation of the scientific knowledge from the expert's side. This might produce uneasiness and frustration but it teaches something important. If democracy demands that citizens have their say in the negotiation of solutions for matters that influence their lives, people need to learn how to ask good questions in order to receive understandable and effective feedback. Vice versa, it is important that "experts" learn how to tune in with laypeople's ways of viewing world problems. As Brady and Kumar (2000) suggest, taking scientific matters outside the academic context could help science communication skills to grow.

6. Conclusions and discussion

With respect to the objectives of this survey, we feel that certain conclusions are interesting, notwithstanding the fact that they were the results of an analysis of a sample with limited scope. Undoubtedly the purpose of *Scienzaonline* for users is to receive information in order to carry out some type of activity. Therefore the interest in the dialogue with the scientist and/or in the knowledge sought is often sparked by practical purposes. Nonetheless, we see differences between those who contact scientists in order to resolve a task (such as those students who must do research or who ask for advice for an assignment) and those who contact scientists in order to make a decision, to solve everyday problems, to make career choices, to heal animals or plants, etc. In this case, science is a reference in thought and action that in all probability also presumes trust in the utility of the scientific knowledge. This result seems to strengthen Jenkins' (1999) conclusions.

We remark that a significant number of persons in our public seem oriented towards finding intellectual satisfaction in scientific knowledge. Adults in particular seem confident that science is valuable and powerful in making reality more intelligible to them, especially the kind of reality that falls within their personal experience.

References to observed phenomena are widespread in the messages in our sample in terms of age, sex and profession. Inferable are not only a keen perception, but also emotions raised by the enjoyable tension towards comprehending the world around us, which is not just characteristic of young people. Older "affectionate" users of the site often emerge within this sub-sample of the audience, also because they elicit a responsive attitude from the experts who more willingly engage with them and feel committed in tailoring their answers.

With respect to subjects and topics that interest the public, our findings provide ideas for reflecting on the relationship between scientific knowledge "offered" institutionally and knowledge sought by the public itself and therefore on the expectations that institutions have with respect to the interests of the general public and their real interests. Our results do not completely confirm the data obtained from surveys conducted on the Italian public by interviewing people as to their interests in science. The subjects broached in the majority of the questions sent to *Expert on line* fall under the life sciences category in all respects, not just those pertaining to biomedical subjects. In addition, our "searchers of knowledge" reveal interest in a wide range of science subjects, more than was brought to light in other studies (such as Borgna, 2001). It is possible that spontaneous reasoning and freedom to pose questions encouraged our users to express their real interests.

With respect to our initial prediction, we were surprised to find that only rarely did users contact scientists for an expert opinion on particularly worrisome subjects, the so-called "hot topics" (typically environmental problems and genetic technologies). Interpretation is necessarily very cautious since our limited sample is an "Internet sample" that cannot be representative of all Italians. We have made a tentative interpretation. What scientists define as "hot topics" might not have a meaningful place in knowledge representations of the audience. The questions that are important to people (or the ones that they are able to articulate) are primarily concerned with everyday life and with education-acquired personal knowledge. It is well known that the ability and skill to formulate significant questions is dependent on one's own knowledge and experience. In addition to these reasons, the type of communication and the lack of confidence when addressing complex topics in a limited dialogue might also be factors.

Other results of our study differ from previous findings (e.g. Ryder, 2001). Our audience does not appear overly sensitive to the nature of the processes that form the basis of scientific knowledge (theories, methods) nor does it seem to be inclined to challenge the reliability of scientific information, either when framing their requests in a disciplinary context (as students are wont to do) or when framing in an everyday context. A somewhat uncritical attitude on the part of our public might be inferred that would be consistent with the non-inquisitive quality of our scholastic education and media communication.

With respect to the users' profile and their relationship with *Scienzaonline*, our study confirms that the public targeted by science communication cannot be considered as an undifferentiated entity (Jenkins, 1999; Borgna, 2001). As our findings suggest, user categories are not characterized by demographic variables only, but by attitudes towards reality and towards knowledge. There is a gap between the science primarily sought by students and the science expected by more adult users. But even when "school science" is the object of the questions, there are differences among user motivations: some of them are not satisfied with "school knowledge."

The profile of the average *Expert on line* user overlaps with the internationally reported features of the average Internet user. We are unaware whether the site is accessed by casual browsing, as reported by the students questioned by Weigold and Treise (2004). We do know that some of the students take advantage of the opportunity to communicate with scientists and that they like it, since they access the site again. This evidence confirms the validity of designing interactive science sites, more than science delivery sites.

There is no doubt that university students post the most questions. Even in Italy the Internet is increasingly becoming a support for their studies, and "expert sites" are seen as a resource for obtaining ready-made answers: an easier way versus other kinds of inquiry procedures or with respect to just thinking and reasoning—the practice that requires the most effort. But we prefer to concentrate attention on the kind of questions that reveal different attitudes and also on the limits of school teaching. A puzzling question emerged from our protocols: why do students address *Scienzaonline* rather than their teachers? A quick reply might be: because the Internet ensures anonymity and therefore it makes students more daring, it enables them to avoid any negative evaluations on the part of their teachers. Another reply might be that students trust scientists more than they do teachers. A certain number of questions, in fact, more or less explicitly convey the need to go beyond rote learning of superficial information and the awareness that school is not the right place for satisfying this need. When students are critical of what they have been taught, of what they can find in textbooks, or even when they state that their questions are the ones that "you would never address to a teacher," they implicitly confirm that they view school knowledge as a separate category from science.

It is very interesting to pinpoint the quite different attitudes inferable from the questions received from young elementary school students. They openly make "discoveries," they are curious and puzzled over field and class activities, and they expect the contribution of scientists as a natural extension of teaching, a more friendly way of receiving informed communication than reading books and encyclopedias.

Expert on line exemplifies the possibilities offered by electronic communication for tailoring science communication to the needs of people. The success of the site, the gratification and loyalty of the users are proof that the site has an excellent chance if used properly as a form of communication. Sites such as this could provide useful documents for re-examining the meaning of scientific expertise for non-scientists. Future research might be dedicated to investigating the correlation between the contexts in which interest in science spontaneously emerges and is located (personal matters, employment, leisure, political commitment) and the qualities of a person's concerns. We believe that the receivers should be the focus of the investigation and that more attention should be given to the experts engaged in the management of interactive sites. Analyses of their communicative practices should be carried out in collaboration with them as reflective agents to explore the qualities of dialogue that have proven to be successful, and the changes that the participation in the dialogue have produced in their scientific practice.

We can reasonably expect that the growth of forms of dialogue will develop laypeople's confidence in the accessibility of science and will enhance comprehension by their gaining pleasure from this. If information provided by the experts succeeds in taking into account the "frame" offered by the users in their questioning, scientists can help citizens to see, and to create, connections among science, school knowledge and everyday life: these are objectives that schools hardly reach. This kind of communication might be particularly relevant to those categories of the public who have a difficult relationship with science (such as people over the age of formal education or those who received a limited education in science subjects), though they have the desire to see its value in their daily lives.

Acknowledgements

We thank Laura Bennato, Silvia Colantonio, Alessandra Guidotti and Federica Pellegrini for their collaboration.

References

Aikenhead, G. (2004) "The Humanistic and Cultural Aspects of Science and Technology Education," Paper presented at the 11th International Organization for Science and Technology Education (IOSTE) Symposium, Lublin, Poland. URL: http://www.usask.ca/education/people/aikenhead/

Borgna, P. (2001) *Immagini pubbliche della scienza* [Public Images of Science]. Turin: Edizioni di Comunità.

Brady, I. and Kumar, A. (2000) "Some Thoughts on Sharing Science," *Science Education* 84(4): 507–23.

Bucchi, M. and Mazzolini, R.G. (2003) "Big Science, Little News: Science Coverage in the Italian Daily Press, 1946–1997," *Public Understanding of Science* 12: 7–24.

Cajas, F. (1999) "Public Understanding of Science: Using Technology to Enhance School Science in Everyday Life," *International Journal of Science Education* 21: 765–73.

Cross, R.T. and Fensham, P.J., eds (2000) *Science and Citizen for Educators and the Public*. Victoria, Australia: Arena Publications.

Dimopoulos, K. and Koulaidis, V. (2003) "Science and Technology Education for Citizenship: the Potential Role of the Press," *Science Education* 87: 241–56.

Duschl, R.A. and Osborne, J. (2002) "Supporting and Promoting Argumentation Discourse in Science Education," *Studies in Science Education* 38: 39–72.

Eveland Jr., W.P. and Dunwoody, S. (1998) "Users and Navigation Patterns of a Science World Wide Web Site for the Public," *Public Understanding of Science* 7: 285–311.

Fensham, P.J. (2000) "Issues for Schooling in Science," in R.T. Cross and P.J. Fensham (eds) *Science and Citizen for Educators and the Public*, pp. 73–7. Victoria, Australia: Arena Publications.

Jenkins, E. (1999) "School Science Citizenship and the Public Understanding of Science," *International Journal of Science Education* 21: 703–10.

Jidesjö, A. and Oscarsson, M. (2004) "Students' Attitudes to Science and Technology: First Results from the ROSE-Project in Sweden," Paper presented at the 11th International Organization for Science and Technology Education (IOSTE) Symposium, Lublin, Poland.

Kolstoe, S.D. (2001) "Scientific Literacy for Citizenship: Tools Dealing with the Science Dimension of Controversial Socio-scientific Issues," *Science Education* 85: 291–310.

Miller, S. (2001) "Public Understanding of Science at the Crossroads," *Public Understanding of Science* 10: 115–20.

Newton, P. (1999) "The Place of Argumentation in the Pedagogy of School Science," *International Journal of Science Education* 21: 553–76.

OECD (1997) *Promoting Public Understanding of Science and Technology*. Report OECD/GD(97)52. Paris: Organization for Economic Co-operation and Development.

Ryder, J. (2001) "Identifying Science Understanding for Functional Scientific Literacy," *Studies in Science Education* 36: 1–44.

Weigold, M.F. and Treise, D. (2004) "Attracting Teen Surfers to Science Web Sites," *Public Understanding of Science* 13: 229–48.

Zimmerman, C., Bisanz, G.L., Bisanz, J., Klein, J.S. and Klein, P. (2001) "Science and the Supermarket: a Comparison of What Appears in the Popular Press, Experts' Advice to Readers, and What Students Want to Know," *Public Understanding of Science* 10: 37–58.

Authors

Elisabetta Falchetti is coordinator of the Educational Department of the Museum of Zoology of Rome. She has an academic background in natural science and she currently teaches Didactic of Biology at the Romatre University. She is the author of numerous papers in science education. Correspondence: Museo Civico di Zoologia, Via Ulisse Aldrovandi 18, 00197 Roma, Italy, e-mail: e.falchetti@comune.roma.it

Silvia Caravita has an academic background in biology and is Senior Researcher of the National Research Council in Rome. She carries out research on teaching learning processes in science and in environmental education.

Alessandra Sperduti was formerly a researcher in anthropology, and is presently a science communicator and project manager for new media cultural and educational products. She is the author of fifty scientific papers and congress communications and of twenty scientific web sites and CD ROMs.