Tensions between science and education in museums and elsewhere

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A paradigm approach could be the answer to reconciling the aims of educators, science popularizers and museum professionals in the promotion of contemporary science and technology.

Science museums and science centres are meeting points for science, education and the theme parks of the 'educational' era. They are certainly a part of the informal education system. A recent report sponsored by the US National Academy of Sciences concluded that we have to revitalize schools using the tools provided by technology. In this paper I analyze the main components of the education problem to see what practical actions may be suggested to increase knowledge of science and technology, both among the general public and in the classroom for the benefit of young people. I consider three types of tension. The first is between producers of science and educators. Science is a mushrooming affair which causes scientists to work in very narrow disciplines. They can speak only from a specialist point of view. In contrast, educators want to provide their students with a broad knowledge of the fundamentals of science. The second tension is between the actual topics in the contemporary research fields and the curriculum generally. There is no overlap. The third is that there is a gap between the actual teaching of the abstract basis of science according to the curriculum, and the practical and experimental out-of-school use by students of machines with a high technology content.

Science for the scientist

One of the features that characterizes contemporary science is the large number of narrow fields into which this body of knowledge has split. For example, in my personal experience (40 years of research at Centre National de la Recherche Scientifique), I have seen what started out as a very small cut homogeneous field (physics and chemistry of lanthanides or rare earth) with a simple goal (to separate the rare earths in a pure state), broken into domains such as solid-state chemistry, metalurgy and spectroscopy. Each of these now has different chief, instruments, theories and practices. The circle of specialized people with whom it is possible to exchange information are now small research groups. Young people may not have the same sense of these irreversibilities and frequent splittings in science because they are naturally educated within a specialty, with no time to look elsewhere and very rarely the curiosity to do so. Only older scientists might be nostalgic for some former unity.

Topics across disciplines such as crystal field theory diverged so completely during my career that, as an inorganic materials spectroscopist, I cannot understand what scientists in that field are doing now for the metallic state, and the vice versa is also true. I also have the utmost difficulty following what the leading theoreticians (a handful of people) are doing today in advanced atomic spectroscopy (which in fact is now a branch of mathematics, dependent on continuous group theory). For those unfamiliar with the rare earths field, it may seem to be merely a sideshow on the science scene. But, across the periodic table of the elements there are 17 rare earths, which is a large proportion of the total, and the application of these elements to technology has transformed our culture and daily life. Colour television screens contain rare-earth phosphors, sound equipment is minimized using magnetic rare-earth alloys, medical X-rays are safer, and powerful lasers are feasible thanks to rare earths. People use rare
Science for the populariser

I have now been a practitioner of science popularisation for more than 15 years. The recipe I have used for the popular press, radio, television or for public lectures, has always been the same. I select a contemporary science paper from a primary journal (such as Nature or Science) and attempt to build a short story from it. I select papers that provide elements from which to build an attractive story: it mediates places, characters and situations which provide the emotional or aesthetic background needed to spur the curiosity of the reader, listener or viewer. The great metaphysical topics, the basic mythologies, are strong motivating forces. For instance, because they provide stories about creation, anthropologists or paleontologists are well represented in the media in contrast to rare earths; however, these fields have not provided anything to change people’s lives—they offer only entertainment. A list can be made of editorial devices that are likely to attract and hold the attention of audiences. For instance, the description of an amazing catastrophe, such as the Cretaceous—Tertiary event, is a good example of an advanced science topic surging on classical mythologies. In the press and on television, there are many stories in which the scientist-in-the-press travels across a metaphorical desert (which could be the sea, the Antarctic, the primeval forest, etc.). Sometimes the scientist meets fantastic animals (such as whales, bears and dinosaurs). I believe that science popularisation in the press or on television is not a pedagogical enterprise, but a literary one which handles only those science topics which have some “romantic” value. This literature is in fact very close to the traditional storytelling of tales, legends and myths. It contributes to culture by bringing new clothes to old themes.

Generally, I would suggest that the main elements in the central body of science are rarely popularised. For instance, chemistry is an area often neglected by the press. This is a difficult discipline to tackle, and a recent investigation shows that only 10 per cent of the US population understands the meaning of the word “molecule.” Without knowing what ‘molecule’ means, it is very difficult to talk
about chemistry, which leads me back to the educational end of the problem. There are, however, viewers, listeners or readers who have a scientific background and who need information on the cutting edge of research. It may be a small public, a combination of professionals and amateurs, but it does exist. Science popularization is then a specialized information service targeting a specific audience. However, it cannot be considered to be an educational activity within the framework of a formal curriculum. We were once told by a group of teachers that a collection of short video clips on everyday technologies produced by the Centre National de Documentation Pédagogique was 'very nice', but could only be used in classes within short intervals because they were not contributing towards the exercises needed to succeed at the exams. This remark clearly suggests education is in opposition to culture in matters of science.

Science for the museum

I have been working at La Cité des Sciences et de l’Industrie since 1989. In the permanent exhibition, Explora, and many temporary exhibitions, science and industry are combined to show what has been and future trends in research, and how they affect the citizen and society. It is hoped that the visitor will grasp what is state-of-the-art in sectors such as visual and audio technology, mathematics and computing. Visitors are also able to get a balanced briefing on contemporary problems such as those to do with issues surrounding the side-effects of industrial progress, like the environment or energy. Is there any contemporary science in these exhibits? The answer is ‘yes’. The postmodern ideology behind the Cité displays is important. The layout is inspired by the style born of the 1985 Paris exhibition at the Bourse du Commerce called Les Imbéciles, and conceived by the postmodern philosopher Jean-François Lyotard. There is no linearity—visitors are free to organize their visit in whatever way they please, and the experience will be different for every visitor (figure 1). The exhibitions are organized as a collection of fragments. The choice of the fragments has been made through collaboration between curators and members of the scientific or industrial community. Every fragment represents the partial contribution of someone deeply engaged in research or industry, operating under the constraints and taste of an exhibit designer. The topics are not covered as comprehensively as in a textbook. A collection of points of view, of techniques or of problems is presented, with some structure of course, but with the specific suggestion of to

Figure 1. The exhibitions at La Cité des Sciences et de l’Industrie are organized in a non-linear fashion, allowing visitors the freedom to choose their own route.
which order to follow from one fragment or group of fragments to another. Such a scheme demands effort on behalf of the visitor. They have to attend to the fragments and become involved if they want to glean more than a mere impression. Effort spent investigating the fragments will be rewarded by the discovery of connections with contemporary research and technology (including rare earths), but these will certainly not be directly linked to any formal curriculum. This is because 1 it is highly improbable that a curriculum makes references to advanced practices in science and technology (to give an example: the computer simulation of the growth of a tree); and 2 a postmodern layout, by definition, does not follow the traditional, linear, progressive profile of pedagogy. It offers everything on the same level; it does not establish hierarchies. Postmodernism is currently at the centre of a raging theoretical debate on the role of science in society. Some scientists believe that it undermines the scientific way of thinking.

The pedagogical strategy of the Cité

The exhibitions at the Cité are extensively used by school groups, especially the Cité’s Youth events, a week of activities using Cité resources and centered on a technical or scientific theme. School visits are different from those of the opportuneneb visitor. Teachers and children do not usually come by chance. Their visit has been prepared beforehand with meetings between Cité staff and teachers, which encourages familiarity with the contents of the exhibits and enables the material on display to be used in an efficient way. This material, being a direct projection from science and industry, demonstrates particular issues within the larger content of the curriculum. Consequently, it provides a chance for discoveries and surprises within a broad scholarly topic, and it sustains the interest of the children.

The pedagogical strategy of the Cité is to use the displayed objects as tools within an interactive framework. They are expected to generate sets of questions. A prominent, visible and recognizable object (an object-figure), can be the point of departure. After observation, answers to questions are to be found in several smaller displays. A real presentation (such as the anti-farm in the ‘Cité des Enfants’), is much more efficient at encouraging active participation than, say, a video. The object-figures behave in the museum as icons, emblematic pieces connected to science and technology that anyone can recognize as such (e.g. a space rocket, aeroplane, car, skeleton or map).

We do not expect children to master a large number of precise pieces of knowledge during their visit. The important point is to show them a method of collecting information and deriving questions which are difficult to answer. The Cité staff are not substances for teachers, who still have to organise their classes to gather information. For teachers, the main task is to be sure that the method has been understood.

The connections with the curriculum are broad and are left to the discretion of the teachers. The Cité can be used most easily in the framework of multidisciplinary topics linked to societal problems (health versus biology, for instance). Many fragments in the exhibitions can be easily connected to everyday life, social debates and economic, technical and industrial issues.

Other services at the Cité

Weekly conferences are presented on selected topics by French scientists. There are also seminars or colloquia. These provide a direct link between the interested public and the scientific community. The Cité organizes debates on issues of contemporary science and technology, many of them in association with other media such as the French daily newspapers. The best-attended debates have been on health issues (such as Alzheimer’s disease), or sociological issues (such as the parasitic craze). We have a large multimedia library, open free of charge to the
public, called the Médiathèque, with 300,000 volumes and 4500 scientific documentaries available on ten 'Sciences Actualités', and the Médiathèque, maintained by a team of journalists, presents science and technology news on a day-to-day basis. They also make education documentaries and manage weekly radio broadcasts. The Cité, in addition to housing exhibitions, presents opportunities to meet scientists and to debate science news.

The Cité runs a service called Science Contact which aims to bring together journalists and scientists (modelled on the British Media Resources Service). At the Médiathèque, the public has access to files containing information on the 'hot topics' in science. Enquiries, especially from teachers, are dealt with by the staff.

Contemporary science and education: a postmodern solution?

Contemporary science is not presented very well in France. The tension between science and the education system reveals a similar, and rather serious, lack of understanding between scientists and the general public. The image of science is tarnished by its association with the genesis of societal problems, and especially health problems. There is clearly an intellectual anti-sciences movement going on in the western world. The media give extensive coverage to science, but generally within the 'romantic' framework (with the exception of publications like La Recherche). Enhancements in museums are constrained by the time it takes to interpret a discovery, and by the capacity of their staff to assimilate quickly what is going on in the scientific community. As for education, contemporary research has not penetrated the contents of the formal curricula which strive to provide a comprehensive coverage of the fast progress of knowledge. For many children, science at school is just a boring chore, loaded with formulae and complicated words. If, indeed, we live in a postmodern era, we must understand that encyclopaedias is a dead utopia. It is impossible to learn everything about all things. Moreover, the ideal of being able to master a few essentials in many domains is no longer feasible: make a living, very specialized knowledge must now be mastered. And people may have to grasp several unrelated bodies of knowledge in their lifetime.

We may have to learn how to handle knowledge in fragments, but detailed, attractive fragments rather than superficial overview. A sound way of making progress in that direction might be to start from the contemporary content of primary scientific papers. The subjects dealt with can, in many cases, be explained to the public (as in the tradition of the British weekly magazine New Scientist). If the curriculum were to make provision for the inclusion of contemporary science, it may become more meaningful than the current situations in which the curriculum is remote from day-to-day reality.

Interest in an area of science can be aroused in a group of children by formulating an attractive scientific story selected from any medium. Then, using a hypertextual model like that underlying the World Wide Web, one can proceed in two directions: towards more sophisticated information—the primary sources, or towards more basic explanations, presented in a way that is adapted to the understanding of contemporary science and technology.

Of course, in the process most of the abstract components of the basic topics are lost, especially the formal mathematical apparatus; but presentations should be orientated towards a cultural understanding of the subject. The important pedagogical point is to provide a strategy for establishing meaningful links between fragments. A future curriculum would have the essential task of suggesting starting points for a collective work of research in the classroom. Teachers would have to be trained to use the many components of the informal science teaching systems, including museums. But for France, this would mean the abolition of checklists, standardization, and the liberation of local initiatives.
A practical exercise can be conducted on almost any short scientific story in the press or on television. Science-based news stories could be starting points for an exploration of other parts of the formal curriculum. For example, a documentary on the potential for using modern Doppler techniques to observe the movements of the foetus could be a springing point. This allows one to introduce the definition of ultrasonography, which may lead on to the basic subject of vibrations (which is in the curriculum). As the Doppler technique is used by boats to echolocate their prey, there is an easy entry to the natural sciences. The Doppler effect itself is experienced by anyone listening to traffic. So different fragments can easily be connected together across a raft of sciences and technologies.

Use of such a method, which is quite easy to apply within the framework of computer-network-assisted education, depends on a change in educational procedures and habits. In a world where adaptation is going to be a basic skill, the students will have to learn how to collect and learn from useful information, even if the subject is as first unfamiliar.

What part can science museums play in an education oriented towards the collecting of fragments of knowledge? They clearly could be resource centers for exhibiting the disciplines underpinning contemporary science and industry. The iconography example above may provide a scenario for an exhibition, centered on the concept of vibrations in continuous media that would use a number of fragments based on results from contemporary research (non-invasive techniques to see inside the body, the physiology of bats, a network of earthquake detectors, etc.) and interpreted using multimedia.

The nature of the actual topics dealt with by scientists is at the heart of the tensions between education, the scientific community and the public at large. There is a lack of awareness, on the part of the school system and the public, of what science and industry are actually doing today. In my opinion, a practical way to bridge this gap is the technique of linking fragments, as I have described above. Certainly, museums and the other components of the informal education system can work in that direction, but it will require a change in the mind-set of staff who seem to stay away from the effort and imagination necessary to penetrate contemporary science and industry. The scientific community would be in a better position to explain its work if it collaborated with museum staff and educators on exhibitions. Clearly a three-sided task forces is needed.

A science museum is part of the urban scenery. It is a public building which is usually rather sober and impressive in appearance. It has the old function of a temple: it is a repository of knowledge. I believe this function has to be enhanced. The science museum may not be a place to contemplate the greatness of the past, but rather a place in which the contemporary scientific and industrial achievements—and problems—are displayed on public ground. A great didactic effort needs to be undertaken, to keep up with the advances of science and industry, but somehow this challenge has to be met if our society is to preserve some unity.

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Notes and references

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10 See for instance http://hebra. weizman.edu/ index.html, much information about education sites on the Internet may be found at http://www.kp.pcnh.edu/ wired/ blueweb2/index_bd.html.