THE CENTER FOR INFORMAL LEARNING AND SCHOOLS

Communicating Science: A BAI Roundtable Summary

Jonathan Osborne, PhD

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This roundtable explored the challenges confronting science educators in presenting and communicating science in contemporary society. Informal science institutions (ISIs) and teachers are 'knowledge intermediaries' (Irwin, 1995) between science and its wider public. However, one of the problems, for both the public and for science's intermediaries, is that science is a cumulative discourse of ever-increasing complexity. Not only can the knowledge be difficult to comprehend, but the process by which such knowledge is derived and validated itself is also poorly understood. For instance, a recent UK survey showed the public to be predominantly ignorant of how science is regulated. In addition, new topics, such as nanotechnology and string theory, stretch the public imagination. In this context, the traditional paradigm within which ISIs situate themselves is to focus on making science fun and exciting through phenomena, predominantly physics-based, which can be experienced first hand. In so doing, they have neglected not only the processes of science (Arnold, 1996; Bradburne, 1998), but also much of the world of science that is only accessible by instrumentation. Conversely, schools, in attempting to meet the demands to incorporate some contemporary science, have constructed curricula that are more abstract and less comprehensible whilst still failing to significantly address the processes and nature of science.

This roundtable began by focussing on two questions: What do we know so far, and what would we like to know? In terms of what is known so far, several themes emerged in the discussions. There was, for instance, a sense that ISIs had been effective at placing science on the public agenda as being something of cultural significance. Indeed, in contemporary society, the cultural credibility of any major city in the developed world that lacks either a science centres, museum, or botanic garden is open to question.

The offerings of ISIs are diverse. On one hand, natural history museums present collections of mammals, insects, or other living objects that often tell a fascinating story about the complexity and diversity of life. Science centres, in contrast, offer a phenomena-based experience, often compelling and aesthetically pleasing, that provides the opportunity to engage in empirical inquiry of specific phenomena. Such experiences open up what Wong (2005) has described as the 'imaginative sensing of possibility;' that is, the idea that there is more to the world than meets the eye. In addition, several museums have begun to attempt innovative means of communicating science. Thus, in the UK, there has been the development of the new Wellcome wing with its exhibit Antennae, which has a specific focus on contemporary science; the new Darwin centre, which has tours conducted by scientists of the laboratories in which they work, and a program of public dialogue events. Likewise, the Dana centre, opened by the Science Museum, which has a program of public dialogue events that regularly attract audiences of 60 to 70 young people several nights a week to discuss contemporary issues in science. Other examples are the recent Einstein exhibition on tour in the U.S. The exhibition attempted to tell a story about one man and his achievements set in the social context of the time or museums with a specific focus on the life and work of one individual. Thus, it is clear that the world of ISIs is attempting to branch out and explore new modes of communicating and engaging the public with science.

In the formal context though, education about science is still deeply rooted in nineteenth-century ideas that the basic function of science education is the preparation of the next generation of scientists. The dominant form of pedagogy associated with such a view is transmissive and authoritarian, presenting science as a body of received knowledge to be acquired. The clear failure of such a system to address the needs of the majority have led to an increasing number of voices articulating the view that an education in science is an essential part of a contemporary education – 'science for all.' Traditional science courses are seen as ill-suited to this goal for as well as developing an understanding of the major explanatory themes of science, students need an education, which provides them with a knowledge of the processes and practices of science. One of the basic aims is to develop the individual's capability to engage critically with science and make more autonomous decisions about its worth and implications.

Whilst there have been several attempts to transform science education to meet the needs of all students and to place more emphasis on science as a 'way of knowing' beginning with the PSSC and Nuffield reforms of the '60s, none of these have managed to take root in any enduring form. Either components of these innovations have been assimilated into an existing standard frame that sees science education as a form of

training for the next generation of scientists, or the nebulous nature of the reform – such as teaching science through inquiry – leads to confusion and uncertainty. Yet there is a clear moral argument for reform as science education 'for all' can only be justified if it offers something of value to all. The innovations in the English curriculum which attempt to split science education for future scientists from that of science education for citizenship offer one potential way of liberating science education from the Gordian knot that binds it to the training, rather than education, of scientists. Nevertheless, despite these developments, current intimations are that the demands of 'high-stakes' testing regimes such as those found in the UK, and those about to be introduced in the U.S. with the demands of the No Child Left Behind Act, will only exacerbate the situation. For too often such tests are predominated by items that simply demand factual recall. Hence the focus is on content knowledge, which is comparatively easy to assess by such means. As behaviourism is still alive and well in the formal classroom, the demands of such tests mean that teachers will commonly resort to rote learning and repetition as a means of ensuring that such knowledge is acquired – exactly the aspects which research shows makes formal science education so unappealing. Moreover, there is little evidence that knowledge acquired in this manner has any coherence or that it is retained.

The structures of formal education were also well adapted to nineteenth-century society where information for the majority was not readily accessible from sources other than teachers. With the growth of other modes of communication, and the expansion of their availability, particularly in the past decade through the Internet, access to alternative sources of information have expanded considerably. Moreover, the quality of much of the manner in which much of this information is communicated has improved significantly. Consequently, the educational experience available from informal sources and contexts offers an alternative to school, one which is continuing to grow, and, in addition, challenges the authority of the teacher. Indeed, the introduction of interactive whiteboards in schools offers a means for the teacher to utilize many of these resources within the formal context. The outcome is that the boundary between formal and informal contexts is dissolving to some extent and the Internet offers a means of strengthening the interdependence of the two. Schools will draw on resources provided by ISIs who, in turn, will be able to influence the nature of formal education.

Embedded within both formal and informal contexts, nevertheless, are still notions of education rooted in what Reddy (1979) has described as the 'conduit metaphor.' This is the argument that the common metaphor that permeates much of educational thinking is the view that education is a process of information transmission – a process where success is the norm and failure is the exception, and where the learner is a passive receptor of information. This is so despite an extensive body of research within the formal sector that demonstrates that failure is the norm and success the exception[1], and that the learner must be active. The latter notion is a basic tenet of the constructivist view of learning, which sees it as essential that the learner is active in the process of communication. Indeed, this theoretical perspective is one of the few that have widely adopted in the ISI field (Hein, 1998). However, evidence would suggest that is has yet to take root or that there are many instances where its implications have been applied successfully.

What do we need to know?

The second part of the discussion turned to what were the pressing research questions for the field. A number of themes emerged in the discussion here. Foremost was a sense of uncertainty about what was it that ISIs were trying to communicate. On one hand, there was a sense that science was undersold in society. The achievements of the scientific endeavour represent both a major intellectual and cultural feat, which is often unrecognised or forgotten. Not only have they transformed the world we inhabit both in terms of our technological capability and our health and safety (penicillin alone must have saved over a 100 million lives since it went into commercial production), but they are a major contribution to the identity of the modern individual. We are all, in one sense, children of the Enlightenment where the workings of the world and our bodies are seen as explicable or comprehensible; where rational thought is valued over other forms or argument; where the basis of belief resides in a commitment to evidence; and where the scientific endeavour has freed us from the shackles of received wisdom. Access to such a body of cultural capital should, therefore, be more than a commonplace, and one function of the ISI is provide a physical context to celebrate this achievement in much the same manner as the art gallery invites us to contemplate and reflect on the achievements of Van Gogh, Rembrandt, and others and the enduring meaning of what they offered. In many senses, the standard portrayal of science offered by many a science center is of science as a body of

[1] Good summaries of this work can be found in some of the work of Rosalind Driver and colleagues (Driver *et al*., 1985; Driver *et al*., 1994)

wondrous, intriguing but arcane phenomena, which are decontextualised from individuals' lives whose meaning is often not self-evident.

The dilemma for science, nevertheless, as Beck (1992) has identified, is that as well as being a source of solutions science has also become a source of risk. As a consequence, a healthy society – that is, one that recognises its responsibility to sustain its future existence as well as its current survival – requires a populace that can critically engage with the political and moral dilemmas posed by advances in contemporary science. The problem confronting education in both formal and informal contexts is how to develop the systems and structures that will generate the critically engaged public that society requires. Within the formal sector, science education courses have begun to focus more on developing a better understanding on the processes and practices of science. In the U.S., that has been undertaken by placing a greater emphasis on teaching science through, or as, a process of inquiry (National Academy of Science, 1995). In Europe, the emphasis has been on developing courses (De Vos & Reiding, 1999; Hunt & Millar, 2000; Millar & Osborne, 1998) that teach a set of 'ideas-about-science' for which there is a growing body of empirical evidence that these are consensually agreed aspects of the nature of science that are essential components of any science education (Osborne *et al*., 2003). There is some limited evidence that such courses are achieving their aims in part, but much more extensive evaluation is required.

Likewise, within the informal sector, representing or mediating the contemporary view of science has been a challenge for many science centers. As Tili et al. argue (2005, submitted):

> On the one hand, there is the conception of science as impersonal, objective knowledge, with incomparably powerful truth-claims and cultural authority, the preserve of those who have successfully navigated through the various meritocratic gates of formal education and the scientific establishment, and subscribed to the scientific game, with its highly structured pedagogy and highly demanding initiation rites. On the other hand, science centres have to respond to public skepticism about and suspicion of science - what the Parliamentary Select Committee on Science and Technology (2000) described as 'an apparent crisis of trust' on the part of the public. In this conception, science is seen as an exclusionary institution, incomprehensible, having dubious relations with corporate business and politics, and an instrument and effect of an underlying Eurocentrism. The challenge for science centres is to steer clear of both conceptions, and carve out some space where some form of science gets communicated and experienced against the grain of scientism and negative public perceptions of science.

Negotiating this space has led to several initiatives of differing kinds: Many science centers have established themselves as arenas where controversial issues in contemporary science are discussed. Public events with invited speakers are offered and much of the sessions are devoted to open debate and questioning by the audience. For instance, The Dana Centre in London, an adjunct to the Science Museum, runs several such events every week in a purpose-built environment with its own dedicated bar. Such events represent a departure from the standard model, which saw the public as merely deficient in knowledge – a model that dominated much of the early work on the public understanding of science and still lingers. Nevertheless, experience of working with such fora is still in its infancy. How, for instance, are such events best facilitated? What are the long-term outcomes of such events? What is the nature of the discourse that is most valued by the participants? Such questions are the focus of some of the doctoral and post-doctoral students working for CILS.

More innovative still is the attempt by the Natural History Museum in London to open up the space where scientific research is done to the public on guided tours, which are led by the scientist themselves. This innovation has been built to address specifically the criticism that exhibitions of scientific objects tend not to be related to the environments in which they are studied and to give visitors a much more immanent experience of how scientific knowledge is produced. Others, such as the Glasgow Science Centre and the Cité de la Science in Paris, have attempted to design multimedia exhibits that explore the effects and possible causes of global warming in innovative and creative manners. Much of this work has been ground-breaking in that it has demanded that ISIs and their staff reconceptualise both what it is that they are presenting and explore new means of mediating the message or issue that they wish to present. Few evaluations have been conducted and those that have, such as that conducted by Dillon et al (2005) for the CILS work at King's, have identified, perhaps not surprisingly, a number of issues that remain to be addressed. One, for instance, is that it is very difficult for museum educators to transcend the dominant paradigm where the mediation between the sciences and its public is seen as a process of information transmission. How can research contribute and inform museum professionals working with such forms of

public engagement? Specifically, how can it help them to clarify the goals, improve the forms of interaction, and evaluate the goals?

Another issue explored was the issue of which audiences were being addressed. It is well known that the audience visiting informal science institutions fails to engage with adolescents and, further, that the demographic profile is dominated by educated, white, middle-class, ethnic minorities; blue collar/working class groups are notable for their absence. What aspects of science, and what forms of communication, would make informal science institutions both more credible and more valued by these groups within the contemporary society? For instance, is one of the problems that what is valorised by ISIs is a very Westernised conception of what counts as science, giving little recognition of alternative forms of science and technology and their historical contribution? Likewise, feminists would argue that the vision both of what counts as significant knowledge in science and its underlying epistemology are a reflection of a male worldview. Addressing such perspectives is not simple and raises questions about the epistemology and ethical questions associated with judgements of what knowledge is to be valued and why. The controversy about the presentation of the history of Australia as presented in the recently opened National Museum of Australia is a good example.

Another issue is how to 'translate' the ideas of science into forms that are readily assimilable by lay people. One possible mode for communicating science is narrative. However, little is known about how to embed science, with its emphasis on hands-on engagement, within a coherent narrative—or, for that matter, whether it is possible to embed many of the explanatory stories that science has to offer within a more familiar and everyday genre of discourse. Expository text – the standard genre of science – is univocal, non-dialectic and its major focus is either descriptive or explanatory. Narrative texts commonly deploy a narrator, a temporal sequence, and agents and entities that interact – most or all of, which are commonly missing in the textual presentation offered within informal science institutions. With the advent of the Internet, ISIs are increasingly exploring visual and multimedia approaches to science communication, but little is known about their outcomes.

And yet, as Montgomery (1996) has argued, 'science must come down and become a part of what is common, what is accountable.' But how is that to be done? Science centers attract a body of creative and innovative people who are continually attempting to test the boundaries of the possible. However, the field will only grow if it learns from such experiences. Hence, developments in this field require both a better understanding of the potential functional effectiveness of such approaches coupled with some empirical testing. In summary, the feeling was that the field was confronted by many challenges whose resolution could be assisted by programs of focused research.

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