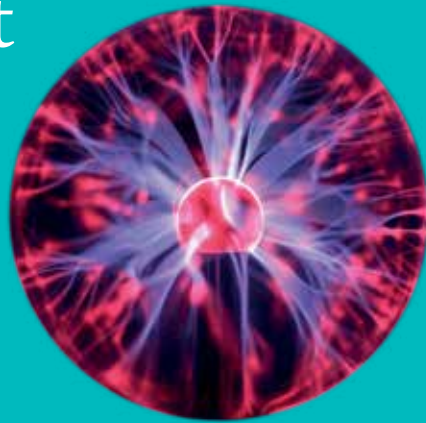


Informal Science Learning Review: Reflections from the Wellcome Trust

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By Clare Matterson and John Holman

Introduction

The vision of the Wellcome Trust is to bring about extraordinary improvements in health. We have long believed that this requires a public that is both inspired by and engaged with science, its development and its application. This belief is reflected in the many activities that we fund to support science learning across museums, science centres, broadcasting, performance, gaming and more, as well as the development of our own venue, Wellcome Collection. Over the past 15 years, we have invested nearly £150 million in this field.

In short, we want to know what we get for this investment. Therefore, in summer 2011 we commissioned two reports on the learning of science in informal settings outside school. The questions that we sought to answer were:

- What is the scope and range of this type of activity in the UK?
- What is the impact of this activity on young people's interest in and attitude towards science?
- How is this activity evaluated and what have we learned?
- How does this activity relate to other parts of the education system?

The reports, from (UK-based) GHK Consulting (GHK) and from (USA-based) Stanford and Oregon State Universities (S-O), were published in December 2012 and are available on the Trust's website. This briefing picks out the key themes arising from these commissioned works and provides a perspective from the Wellcome Trust on the findings.

1 Informal science learning in the UK

1.1 What is informal science learning?

A wide range of groups 'do' informal science learning – broadcasters, museums, artists, communicators, sole traders and universities, to name a few. All these groups and more have been supported by the Wellcome Trust over the years, with funded examples shown in Appendix 1.

There is no accepted definition of informal science learning; the GHK report described the term as commonly referring to activities taking place outside the formal education system which seek to raise awareness of, and interest and engagement with, science and other STEM subjects. The link and proximity to classroom-based/formal varies widely.

1.2 Why does informal learning matter?

Even when in full-time education, young people spend only 18 per cent of their waking hours in school. There is a lot of time available for influencing their learning outside the formal system, and we are persuaded that informal science can engage and interest people in ways that formal settings cannot. While school matters in helping students cover the required breadth of content and develop formalised and general principles, experiences outside the classroom are essential to give meaning, relevance and context to the ideas that schools offer. As important, they often provide emotional contact, where it is possible to have a hands-on experience, be challenged or provoked, or simply enjoy the moment.

This view points to the importance of the totality of the 'system' that supports science education – regardless of the place and context in which it happens. As the S-O report emphasises, learning should be seen as a cumulative set of experiences that are part of the system, yet such experiences are typically viewed – whether through funding, policy, assessment or evaluation – in isolation from one another. We return to this concept frequently because it is a crucial to understand and maximise the impact of informal science learning.

While many may recognise the narrative about why informal learning matters, few are familiar with the supporting evidence. The S-O report shows that evidence does exist about the value of informal science learning experiences, but is often not UK-derived and, in any case, not well known or used by practitioners. In turn, policy makers, funders and school managers are unlikely to be aware of the evidence and may need persuading that informal science learning matters.

Notable evidence to support the idea that extensive learning takes place outside of formal education is clear and persuasive. Researchers have conclusively shown the positive impact on student attainment of learning experiences during the summer gap and the PISA 2006 study shows that school extracurricular activities relate to better performance, enjoyment and more positive attitudes to science (S-O). We are also struck by Falk and Needham's research showing that whereas schooling and childhood experiences contribute 17 per cent of the variance in adults' science knowledge, adult informal learning experiences contribute 39 per cent. Such objective evidence can convince, yet we need more well-researched 'killer facts' to help persuade funders, educators and policy makers that informal learning is a critical component of an effective science education.

1.3 Informal science: the current landscape in the UK

Science education – both formal and informal – is a complex system with many interactions. The analogy drawn by S-O is that of a managed forest ecosystem and, strikingly, schools – the 'keystone organisms' in the system – are seen to collaborate much less frequently with informal learning organisations than these organisations do with each other. What is clear is that schools, as the gatekeepers to young people, have many suitors from informal science, but tend to be selective about whom they engage with. The informal science community, in turn, is anxious to define itself as distinct from schools, yet is dependent on them.

The reports describe the considerable diversity of informal science activity across the UK, with many complex interactions and considerable innovation. Such a finding is not a surprise; we see this as a great strength of the UK science scene and, as far as we can tell, such diversity and innovation are not matched elsewhere.

The reports also convey a strong sense of mission among practitioners of informal science, though perhaps less clarity about what they are trying to achieve. These are people and organisations that believe passionately in the importance of science as part of our culture,

and want to convey this to others. Their aims are “making science enjoyable and interesting, inspiring interest in and/or engagement with science, and changing attitudes to and/or raising awareness of the importance of science” (GHK) and “making science ‘fun’ with the intent of teaching ‘science by stealth’” (S-O). Sometimes this strong mission is due to the belief that that science in schools is seen as difficult or boring. More positively, many teachers and practitioners of informal science know that it can provide students with enriching experiences that would not be possible in the classroom or are not part of the curriculum.

Like schools, informal science practitioners have a strong sense of equity and of the need to benefit all parts of society in all its diversity. While this is hard enough to do in the formal education system, which has a captive audience and a legal obligation to reach all, it is even harder for a sector that has to win its audience. No wonder, therefore, that informal science providers see schools as an important conduit to the more inaccessible audiences – and are sometimes frustrated to find that schools can themselves be hard to reach. Inevitably, some practitioners of informal science are better than others, and the sector has no quality control mechanism to compare with Ofsted. Indeed, S-O noted that “self-criticism from within the informal community was rare”. The reluctance of some schools to engage with informal science may simply be because they have had a bad or indifferent experience in the past.

Despite the commitment to reach all parts of society, access to informal learning experiences is not even. Across the landscape, the best-served audiences are children between five and 16. Under-fives and adults are relatively under-served, suggesting that messages about the cultural value of science to the adult society are neglected. Within STEM (science, technology, engineering and mathematics), science is by far the best covered. Lower socioeconomic groups and rural communities are typically under-served. If informal science learning is a key component of an effective science education, these under-served groups are placed at an educational and long-term economic disadvantage.

1.4 The problem of measurement

Within formal education, objectives are clearly laid down by regulations such as the National Curriculum. By contrast, apart from the broad goal of making science interesting and engaging, informal science tends to lack clearly stated goals. While this may give welcome scope for creativity and unexpected outcomes, it makes it harder for practitioners and their funders to measure success. Not surprisingly, funders are keen to know whether the money they give to informal science has an impact on learners – does it make a long-term difference to their attitudes to science? Practitioners are also keen to evaluate, but for more formative purposes – they want to know how their activities can be improved.

A picture is painted of a community that does a lot of evaluation, mostly formative and in line with the scale of funding available to them. 87 per cent of providers report some kind of evaluation activity, with 91 per cent of them describing it as formative. The commonest method is surveys of users (98 per cent); also common are observation of visitors, exit surveys, group discussions and analysis of visitor data. Most providers carry out these measurements themselves rather than engaging an external evaluator. Across this diverse field, there are differences in what is considered important to measure: broadcasters, for example, are mainly interested in viewer figures, while museums seek more detailed feedback. Overall, this is a community eager to find out what its users think of its activities, but less inclined or able to measure long-term impact.

Indeed, is it reasonable to expect each provider to attempt to measure long-term impact, when it is near-impossible to distinguish the effect of a single activity from the welter of other experiences that fill young people’s lives? Perhaps it would be more appropriate to ask providers to concentrate explicitly on what is ‘good enough’: effective proximal

measurements of short-term impacts. By this we mean measurements close to the activity, to assess enjoyment, choice and knowledge, leaving it to national or research organisations to attempt to find ways to measure longer-term impacts or cumulative effects, such as changes in attainment, attitudes and general aptitude for learning. This would relieve each provider of the need to be accountable for the long-term outcomes of each of their interventions, yet would place their activities within an overall ecology of learning.

While we acknowledge the difficulties of measurement and attribution for these types of activities, we do believe there is a need to be more adventurous about evaluation. One approach could be to determine whether there is a robust set of proximal measures that are known to correlate, across different providers, with more distal outcomes. The proximal measures can be the responsibility of the provider; the general correlation with the distal would be to be uncovered by research initiated by funders.

Alternatively, there could be greater learning from other sectors, such as public health, which experiment with methodologies on 'theory of change' when assessing health interventions, a process by which all elements required to bring about a given long-term goal are defined, rather than just setting out the nature of the intervention followed by the intended outcomes. These ideas are offered to encourage a more sophisticated approach to evaluation across the sector, in terms of both methods and the sharing of findings. We return to this in section 2.1.

1.5 Research, practice and profession

Not only is the link between evaluation and research currently underdeveloped: a striking finding is the lack of reference to the research literature by the informal science community when developing its activities and events. In truth, this is little different from the school teaching community, but it does raise the question of the theoretical basis on which the informal science learning community believes that it is operating or the knowledge base that it is drawing on to devise its activities. For example, given how much emphasis is placed on engagement and interest, it is surprising how little the community uses existing academic theories of how to gain and sustain interest.

This lack of theory and knowledge base underpinning informal science learning has not curtailed its ability to diversify, to be creative and to innovate. An appropriate explanation might be that informal science learning practitioners can be characterised more as craftspeople operating through a model of apprenticeship, observation and audience approval. This contrasts with the 'professional' tradition whereby formalised mechanisms are developed to ensure knowledge is recorded and training is made available to both new and existing entrants to the field.

This discussion also raises the question of whether concentrating too closely on defining outcomes *a priori* risks stifling the creative process. There is no doubt that expecting a creative person to define precise learning outcomes risks driving out creativity and originality to the detriment of the experience and the development of the field. A balance needs to be struck.

2 Where do we go from here?

2.1 A better-managed ecosystem?

Science education is described by S-O as a managed ecosystem that needs better management to improve interactions and fill gaps in coverage. But this is not as simple as it seems and could have unintended consequences. There is the question of whether it is

even feasible to manage such a diverse field, many of whose operators are small private organisations working on tight margins, whose main priority is survival in the marketplace. And who should be the managers? Past experiences of central government intervention are not encouraging, and even the Wellcome Trust, committed though it is to this field, does not have the resources or capacity to take on such a commitment. Most importantly, there is the risk of cramping the style of the organisations whose unregulated creativity is the source of so much innovation.

However, the idea of a loose collaboration between organisations involved in funding and supporting informal science learning, through some kind of funders' forum, with a shared agenda, is an idea that we believe is worth exploring.

The initial agenda for such a forum arising from this work might be as follows.

- **Better evidence to support advocacy.** Policy makers and school leaders need persuading that informal science is worthwhile. This review has shown that convincing, objective evidence of impact exists but is poorly used. It would be helpful to have a collection of 'killer facts' – succinct evidence, preferably based on UK experience but also drawing on other countries, that informal science has a real and lasting impact on people's engagement with science. We do not see this as a new research programme but rather as a trawling exercise to identify what is already known and sharpen it for use.
- **Setting an agenda for research.** The reports have highlighted several areas where more research is needed, for example agreeing measures of long-term impact, conducting well-designed retrospective studies on the factors that influence people to move into scientific careers, or digging deeper into how to reach socioeconomically deprived audiences. By setting research questions and priorities, researchers and funders would be stimulated to develop funding packages or submit research proposals to existing funders.
- **Developing a more systematic approach to evaluation.** In section 1.4 we identified a number of issues around the evaluation of impact, including the question of how realistic it is to expect providers of informal science to measure its long-term impact. We suggest that there might be a more sophisticated approach to evaluation such as greater sharing of results, identification of a common set of related proximal and distal indicators of impact, and working with other sectors to test alternative methods.
- **Prioritising and identifying gaps.** Both reports identify areas where audience groups are under-served nationally – for example, provision targeted on under-fives, mathematics and on the particular interests of females. We believe that this is a vital issue to address and is a matter of social justice. The funders' forum should review and highlight areas of under-provision to enable providers and funders to respond and to set priorities.

2.2 A strong link with research and theory?

The reports offer a picture of a community that is highly expert in what it does, but whose skills are rooted more in practice than in theory – a description that also fits formal education in schools. But would the field benefit from a better application of theoretical insights to practice?

Take, for example, 'interest' – a word that occurs 95 times in GHK and 51 times in S-O. Clearly, sparking interest is the highest priority for informal science practitioners, who know from experience what works and what does not. But there is an extensive research literature on how interest is won and (crucially) sustained (S-O). Promising work is being done in the USA, supported by the Gordon and Betty Moore Foundation, on 'activation theory', which may lead to further insights.

Could the informal science community form closer links with those who carry out research into learning in the UK and elsewhere, to reflect on their practice and so advance it – and disseminate their findings across their communities? The convergence of theory and practice can be a powerful tool for professional development, as examples from formal education show. No doubt greater use of research literature by practitioners would also throw a light on the many gaps in theory and stimulate further, practice-oriented research.

Both reports identify the need for more research into informal learning based on practice in the field. S-O recommends establishing "one or more Centres for research evaluation and training, with a focus on non-classroom based STEM learning", and this is an idea that is worth exploring. There are many questions to be asked, not least how such centres would be funded, whether they would be physical or virtual, and what relation they would have to one another and to existing organisations. We believe that this is something that different organisations could consider at a number of different levels. For example, what are the opportunities for universities to form partnerships with providers to develop long-term research relationships? Should research funders support or form centres of excellence or seed centres of informal STEM learning?

2.3 Is this a self-learning community?

Should informal science start to operate more like a profession than a craft? It may be that the 'craft' model is the more appropriate for such a diverse and innovative field. Even so, the community would benefit from a more systematic sharing of experience and of professional insights from research and the grey literature, to build and share its own base of knowledge and experience. Linked to this, professional development in the community would benefit from a more systematic approach, and possibly a common approach to accreditation.

We believe that it is essential for the community itself to develop its own sense of 'profession' that is valuable and appropriate to practitioners. There are already a number of organisations bringing together parts of the informal science community: for example, the Association of Science and Discovery Centres and the Council for Learning Outside the Classroom. We suggest that bodies such as these would be appropriate to lead the development of professionalisation, perhaps working with a university partner with expertise in learning.

2.4 Better integration of formal and informal?

What would motivate schools to become less inward-looking and better integrated with informal science, so that young people get a better all-round experience of science, with interest sparked outside school and sustained within it? It is school leaders in the end who are the gatekeepers and decide whether out-of-school experiences are valued or merely tolerated. What would convince government departments responsible for education and culture to work together in the recognition that "good learning is good learning, regardless of where it happens" (S-P)?

More compelling evidence of the power of informal learning to motivate and engage would help to win the hearts and minds of hard-pressed headteachers and hard-nosed policy makers.

2.5 How can providers be more effective with hard-to-reach groups?

The reports identify several under-served communities, but the most challenging to reach are the lower socioeconomic groups, who may see informal science as ‘not for the likes of us’. Yet people from these groups have much to gain from engaging with science, because of the career pathways it opens up. GHK identifies useful examples of how they can be reached, which should be shared among the informal science community.

Spreading best practice is important, and so is encouraging providers to take more risks. But it is hard enough for schools to reach and engage with these groups, and even harder for the informal science community, who do not have the power of compulsion and for many of whom the highest priority is simply survival in the marketplace. As indicated above, this could be a matter for further consideration by a funders’ forum.

The GHK Family Studies identify an entire age group that is hard to reach in its own way, whatever its members’ socioeconomic status: the 11-to-16-year-olds, or ‘tweens’. If the goal is to influence future subject choices and careers, this is the critical group to reach, yet these studies show that most families leave it to the tweens to make their own choices of leisure activities. GHK identifies the types of activity that tweens find appealing, which are identified with the nebulous concept of ‘fun’. The message is that, to reach tweens, informal science needs to target them directly rather than via their families. This may be another area where more sharing of successful ideas between practitioners is needed.

3 Conclusion

This review of informal science learning – via the two reports – is helping us reflect on our own activity, and we hope that there are also valuable messages for the informal science learning community, other funders and government. The purpose of this work was to take stock of a dynamic and diverse field and help identify possible future directions for the Wellcome Trust and, we hope, for other funders of such work.

We have no wish to intervene with a heavy hand in a field that is so diverse and dynamic and has such a strong sense of mission. But this review has shown the limitations of the community in its use of theory and research, its need to garner evidence more effectively and its need to become more professional in its sharing of knowledge and expertise. We do believe that some orchestration of activity, perhaps through a funders’ forum, is worth considering. There is much to think about, and over the following months we intend to disseminate these reports and hold workshops to facilitate discussion and future actions by the many practitioners and supporters of this field, of which the UK can be justly proud.

We are most grateful to the teams from GHK and Stanford University–Oregon State University for their meticulous work and the insights they have given us, and to the Advisory Committee which has guided us through this review. They are:

GHK, Red Kite and Brand Driver team

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- Michael Reiss, Institute of Education
- Matt Locke, Channel 4
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Appendix 1 Wellcome Trust investment in informal science learning

At the turn of the millennium, the Wellcome Trust made an investment of £48 million for science centres and museums in the UK. Since then the Trust's investment in informal science learning has broadened and now spans a variety of disciplines including broadcast, performance and debate. The Trust has invested a further £50 million on informal learning activities in the last decade, through a combination of grant-giving and Trust-led activities.

Table 1: Categories of informal learning activity supported by the Wellcome Trust from October 2003 to September 2012 (does not include Wellcome Collection)

Category*	Total spend	% of spend	No. of projects
Performance	£5,174,204	10.5	160
Online, including gaming	£1,785,681	3.6	31
Multimedia	£2,498,945	5.0	101
Music	£657,277	1.3	17
Museums and science centres (capital)	£17,525,232	35.4	31
Museums and science centres (activities)	£2,595,698	5.3	27
Fairs, festivals and public spaces**	£3,463,648	7.0	87
Magazines, books and comics	£289,042	0.5	9
Experiments, workshops and demonstrations	£1,753,066	3.5	49
Exhibitions	£3,264,687	6.6	61
Debate and discussion	£2,690,999	5.4	51
Broadcast	£5,145,905	10.4	201
Art and photography	£2,543,626	5.1	83

* Projects involving multiple components have been categorised as the most substantial component (for instance an exhibition with an accompanying website has been classed as an exhibition)

** Fairs, festivals and public spaces includes conventional science fairs and competitions as well as activities in more unusual settings such as music festivals and shopping centres

Examples of Wellcome Trust informal learning projects

I'm a Scientist, Get Me Out of Here!

A science dialogue event where school students talk to real scientists online for two weeks. They read about research, ask questions and hold live text chats. It is like science lessons meet *The X Factor*, as students choose which scientist will win £500 to communicate their work.

imascientist.org.uk

Inside Nature's Giants

The award-winning documentary series that gets under the skin of the largest animals on the planet. Most wildlife documentaries show how animals behave, but by exploring their anatomy, *Inside Nature's Giants* reveals how these creatures really work.

www.channel4.com/programmes/inside-natures-giants

Theatre of Debate

Y Touring Theatre Company uses a rich mix of live performance and digital technology to engage audiences in an informed debate around the outcomes of the latest scientific research. Their work explores themes and questions that will shape our futures and that we all need to have a say in.

www.theatreofdebate.com

Inside DNA: A genomic revolution

An exhibition dedicated to genomics that has toured science centres and museums, with associated website, educational materials and a public programme of events, workshops and

debates. The exhibition has e-information kiosks, games and objects that explore current genomics, identity, health and evolution.
www.insidedna.org.uk

Sneeze

In this game you are a virus infecting humans. Survive by making your human host sneeze and infect other humans. The likelihood of infection and speed of virus transmission varies depending on the ages of your targets – and affects your score!
www.routesgame.com/games/?challengeId=2

Design and Gerontology

Working with fashion designers and scientists, students studied the science of ageing to design a clothing collection inspired by changes to the mind and body. The designs demonstrated physical and functional ageing changes and also formed an innovative fashion collection.
www.actiondog.net/d&g/

Wellcome Trust

The future of science depends on the quality of science education today.

We are a global charitable foundation dedicated to achieving extraordinary improvements in human and animal health. We support the brightest minds in biomedical research and the medical humanities. Our breadth of support includes public engagement, education and the application of research to improve health. We are independent of both political and commercial interests.

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