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MAKING IT LIVE

An evaluation of Pulse (phase 1)

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An evaluation of Pulse (phase 1), a Wellcome Trust initiative to support young people's performing arts projects inspired by biomedical science.

Prepared by the Centre for Applied Theatre Research,
University of Manchester

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“We’re part of the story now, we know what’s happening” – year 10 pupil, University of Oxford Botanic Garden and Oxford Community School.

“It makes it more human and more thinkable somehow to us…it just makes it feel more real to us” – participant, All Change.

“You get to feel it and go through it and know what it’s about as well as learning it” – participant, All Change.

Acknowledgements

Thanks to all the young people, teachers, scientists and artists who contributed their thoughts, feelings and stories about Pulse projects during interviews, and who were willing to have the evaluation team observe and participate in creative processes.

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Executive summary

The Pulse funding initiative, managed by the Wellcome Trust, supports performing arts projects with young people that explore the impact of biomedical science in the 21st century. In 2003–04, 23 funded projects were carried out in both formal and informal educational settings, including schools, colleges, youth theatres, community centres, museums, science centres and gardens. Projects exhibited a variety of aims and objectives (from research and development to clearly specified educational outcomes), performing art forms (theatre, dance, music, digital media), models of practice (large-scale performance, peer-led theatre-in-education, performance art installations, site-specific work and stand-alone workshops) and scientific subject matter (genetics, medicinal properties of plants, nanotechnology, treatment of disease, GM foods). See section 1.1 of the full report for a descriptive summary of the initiative. Young people were engaged in Pulse in a variety of roles, including as performers, researchers, consultants, writers and audience members. The evaluation of Pulse sought to identify the funding initiative's effectiveness in supporting high-quality performing arts and science provision with young people (see section 2 for the evaluation methodology).

Evaluation findings

Over 8600 young people and 125 professionals were directly involved in the creative processes of Pulse projects in 2003–04. They included professional artists, youth theatre leaders, arts education workers, science and drama teachers, scientists, science communicators, and hospital and medical staff (see section 4 for a detailed quantitative summary of the initiative). The evaluation found that Pulse made a unique contribution to both the arts and science education/communication sectors by delivering a diverse range of live and dynamic projects, a proportion of which exhibited innovation in terms of aesthetic form and manner of engaging young people.

The use of theatre to debate topical issues in science is not new; the performing arts have long been used to explain science to the public. The format, style and aesthetic of such ventures have changed along with the general shift in focus of science communication initiatives from providing 'unknowing publics' with information about science to engaging people in debates about the social and ethical questions, possibilities and problems of scientific advances. Aesthetically, this shift has led to a development away from modernist theatre practices of fixed and one-way relationships between audience, actors, scientists and educators, and towards more participatory and empowering models of engagement.

Impact on young people

Where successful, Pulse projects have enhanced young people's science knowledge and understanding, and engaged young people in experiences of science education and communication that they describe as inspiring, personally relevant, enjoyable and dynamic. Successful projects have also provided important opportunities to gain types of knowledge and experience styles of learning that cross the constructed boundaries between disciplines and conventional learning formats in formal education. Pulse projects challenged conventional understandings of science learning. The feedback of young people suggests that the experience of shock and surprise, or feeling moved or touched, can be as important a science outcome as information gain (see 5.1, 5.5–5.9 and 5.11 for young people's conceptualisations of their learning experience in Pulse projects). The science subject matter was also shown to encourage the development of innovative and unique arts experiences for young people involved in some projects (5.5). The need to find a form or style to represent complex ethical issues and/or technical information, and to explore multidimensional subject matter, challenged young people's and artists' conceptions of arts process and form, and of science as a discipline, as well as their existing skills and abilities in both subject areas and understanding of the relevance of science to art and vice versa (5.5).

Artists' willingness to share responsibility for creative processes with young people and to ensure young people's responses were at the centre of processes has enhanced the quality of young people's experiences. Projects have provided an opportunity for young people to play a responsible social role – with the science subject matter providing a sense that what

they were doing was important (5.11). Performance methodologies and science concepts have come together to create contexts for exploring issues from a variety of perspectives, illuminating the social, emotional and ethical dimensions of a range of scientific subject matter. Young people's accounts of participating in Pulse projects clearly support a link between participating in performing arts projects, fostering creativity and increasing engagement in science (see section 5 for the overall impact of Pulse on young people).

Impact on teachers, arts professionals and science professionals

Pulse projects increased the capacity of many arts professionals to take part in performing arts and science projects in the future. Many arts professionals expressed a sense of having discovered a new perspective on practice, including the possibility of taking professional trajectories in new and exciting directions (6.2). Projects in schools have provided unique points of contact with the curriculum over a range of subjects, including science, drama, visual arts, citizenship, religious studies and personal, social and health education. Teachers report that participation in Pulse projects provided opportunities for professional development – especially regarding increased knowledge of and confidence in creative approaches to science and performing arts teaching (7.1) and highlighting possibilities for cross-curriculum links (7.2). Most science professionals were very enthusiastic about their involvement in performing arts projects. Projects exhibited diverse ways of employing a science professional, from one-off encounters at the start of projects to ongoing interdisciplinary engagement between science and arts professionals. Science professionals enabled artists to identify areas of debate, explore social and ethical dimensions of the science focus, and identify points of engagement for young people (see 8.1 for the role and activities of science professionals across Pulse). Some scientists stated that involvement in Pulse led them to reappraise their way of engaging in science communication activities (see 8.2 for science professionals' recommendations for science mediators involved in future Pulse projects).

Models of learning and engagement

The participatory arts were effectively employed to enhance young people's awareness and ability to engage with science issues in everyday life, as well as to introduce young people and artists into a multidirectional, ongoing debate about science with a range of communities. As such, the participatory arts were shown both to **facilitate** the communication of science and to **reconstruct** science as a set of open, adventurous, inclusive, alive, enjoyable and dynamic processes, with relevant (inspiring, shocking, emotive) concepts about the world. Pulse, with its focus on participation, exploration, innovation and engagement, sits perfectly within the current context of science communication and education, with its corresponding emphasis on engagement, debate, interaction and contextualising science (see 3.1–3.3 for more on models of science communication). Pulse represents an open invitation to artists, scientists and young people to experiment with the forms, contents, relationships and boundaries between disciplines implicit in conventional science learning and communication formats (see 5.5, 5.8 and 6.3 for how participatory performing arts processes have worked to problematise science and facilitate engagement in social and ethical debate).

As the relationship between science and society has become more complex, non-naturalistic forms implicit in a live arts approach have provided cutting-edge learning experiences that powerfully engage and involve audiences in the ethical questions raised by science. Non-naturalistic forms, for example, may be more likely to avoid giving a 'message' and to encourage exploration of complexity. However, the capacity of arts, education and science professionals to experiment with form and content is affected by their own confidence in engaging with complex social and ethical debates raised by scientific development as well as by their ability to inspire and enthuse young people. The research suggests that young people want to discuss controversial and ethical issues but that there are few opportunities to do so within the science curriculum. Education professionals trained within specific disciplines are therefore unlikely to have the broad-based skills and knowledge (in the sciences, humanities, and participatory and ethical enquiry) to facilitate such opportunities. Pulse projects operated within a gap between conventional disciplines. Successful projects were staffed by partnerships between individuals who exhibited high-quality skills in four key fields: creative/artistic (ability to explore subjects from novel perspectives and aptitude for taking

risks); scientific (interest or fascination with science or with the human and social dimensions of science); educational (ability to create enjoyable opportunities for young people to reflect on new concepts and information within creative processes); and social (ability to engage with other partners and inspire young people). See 3.3 and 8.3.

Good practice

The following 'indicators of potential success' have been identified via an analysis of successful projects, and may serve as guidelines for future projects, particularly at the application/selection stage:

- A skills base (contained within partnerships and/or networks of professionals engaged in projects) that includes: demonstrable creative/artistic expertise; scientific knowledge and/or evident fascination with science and the human/social dimensions of science; educational awareness; and social skills including an ability to engage with partners' agendas and inspire young people. Such partnerships should exist, at least in their infancy, prior to the start date of projects. All partners need to demonstrate an ability to step outside of normal institutional/disciplinary frameworks and try out new perspectives and ways of working (3.3, 8.3, 9.4, 9.5).
- Effective budgeting that allows time for relationships to develop between partners that include complex organisations with very different needs and agendas (9.6).
- Links with a range of scientists and others with a stake in the issues explored (rather than one 'science representative') and the ability to pull such people into a participatory and dynamic process.
- Where appropriate, careful planning to support and safeguard the scientific as well as artistic outcomes of projects, by devising the appropriate strategies to guide young audiences' interpretations of complex scientific information (5.13, 6.4–6.7).
- Careful consideration of whether a public performance by young people is appropriate for the processes envisaged, and if it is, commitment to providing adequate preparation time and to extending opportunities for young people to take creative responsibilities within those processes (9.3).

Key recommendations

The evaluation team makes the following key recommendations for improved planning and implementation of the initiative (for a full list of recommendations, see section 11):

- The timetable and budget of projects must allow time for an adequate learning curve for artists.
- Activities designed to support young people's interpretation of performances should be carefully planned and delivered by artists working with non-arts specialists.
- The Wellcome Trust should continue to ensure that projects are made accessible to diverse groups of young people.
- All participating organisations should consider what follow-on projects might need to be signposted/supported to sustain young people's ongoing engagement in science.
- Projects seeking to work in schools should attempt to identify a member of senior management in schools to act as liaison and champion for the project, and proposal development should include at least one teacher from a target school as a consultant.
- 'Reflective practice' models of evaluation may be more appropriate for artist-led evaluation, as they are more akin to processes that high-quality artists already employ when assessing their work, and facilitate a sense of ownership over practice associated with innovation. Initial and ongoing reflective practice days for artists to share practice may inspire connections between science and the creative process and clarify the aims of Pulse to arts organisations.
- The Wellcome Trust's management of Pulse has exhibited enthusiasm and care for the process and outcome of projects without being prescriptive or seeking editorial control, and should be continued. This management style has promoted artistic freedom, experimentation and innovation. The above suggestions for improved planning and implementation of the initiative assume the continuation of this degree of style and support.

1. Introduction

The Pulse funding initiative, managed by the Wellcome Trust, supports performing arts projects with young people that explore the impact of biomedical science in the 21st century. From June 2003 to December 2004, Pulse supported 23 performing arts and science projects with young people across England. This report presents the results of an evaluation of those projects, carried out by the Centre for Applied Theatre Research (CATR).

The Pulse initiative and its evaluation take place in a context where the pace of scientific development is ahead of public awareness of and engagement in debates about the social and ethical implications of science in society. Young people in particular will be directly affected by difficult issues arising from the impact of scientific development on healthcare, family and overall quality of life. Pulse is one strand of the Wellcome Trust's work to encourage public engagement in social and ethical debates arising from advances in biomedical science, and to better prepare young people for the future.

Evaluations of previous projects funded by the Wellcome Trust have suggested that the performing arts can be a useful and powerful tool for engaging young people in exploring the social and ethical issues arising from advances in biomedical science, and can enhance scientific literacy. The performing arts can engage young people and encourage them to tackle complex, emotive issues in creative and innovative ways. However, it is also clear that provision in this area varies in quality, methodology and impact. In addition, the evaluation that does exist mostly relates to evaluation of specific projects, showing how closely projects met their aims and objectives, rather than developing a broad contextual awareness of performing arts and science, or extrapolating larger conclusions about practice (Jackson and Johnson 2002). The evaluation of Pulse aims to address gaps in knowledge about the impact of performing arts and science projects with young people, and to generate guidelines for effective practice.

The evaluation findings indicate general themes and larger conclusions relevant to the field of work. This report therefore provides the beginnings of a theory and evidence base to explain the impact and mechanisms of successful performing arts and science projects with young people. The evaluation findings have relevance both within and outside the performing arts sector, providing useful guidelines for future performing arts practitioners and contributing to current debates in educational and social policy, specifically in the areas of science education, citizenship and fostering creativity. The evaluation has been a stimulating process that raises questions about method, partnership working, definitions of 'quality' of participatory and educational performing arts practice with young people, and ongoing questions about appropriate models of evaluation for arts projects.

The evaluation has been managed and carried out by Jenny Hughes (Research Associate, Centre for Applied Theatre Research), with supervision provided by Tony Jackson (Director, Centre for Applied Theatre Research and Senior Lecturer, Drama Department, University of Manchester). Two science education specialists, Brenda Keogh and Stuart Naylor have provided science support/consultancy. This report was written by Jenny Hughes.

The Wellcome Trust is an independent research-funding charity established under the will of Sir Henry Wellcome in 1936. The Trust's mission is to foster and promote research with the aim of improving human and animal health. The Trust is committed to engaging society by stimulating an informed debate to raise awareness and understanding of biomedical science, its achievements, applications and implications.

The Centre for Applied Theatre Research (CATR) is based within the University of Manchester and exists to promote research into a variety of performance activities, including activities in non-theatre settings (schools, prisons and museums) and particularly those activities that engage directly with social, educational and cultural policy.[1]

[1] Appendix A gives contact information for CATR, the evaluation team and the Wellcome Trust.

1.1 Descriptive summary of Pulse (phase 1)

The Wellcome Trust has a history of funding performing arts and science projects with young people, through its support for several ground-breaking projects carried out by Y Touring Theatre Company (since 1995). These projects adopted a model of touring performances (of plays written in consultation with scientists, doctors and patients) to schools and public venues, followed by workshops and post-show discussions with actors in role and supporting educational materials. Pulse represents the second phase of the Wellcome Trust's support for the performing arts and aims to develop range and capacity for carrying out high-quality performing arts and science projects within the arts sector, by supporting artists who are new to working with science subjects and new methodologies or models of practice.

Projects were funded in bands, with small grants (up to £3000) and larger projects (up to £10 000 and up to £40 000). The small grants were envisaged as support for research and development, and youth theatres or teachers who wanted to facilitate projects in schools. The middle band was envisaged as supporting larger research and development pieces, and projects that assembled a creative team leading to targeted workshops and work-in-progress performances. The higher level of funding aimed to support full productions and costs of touring productions funded from elsewhere. An invitation to apply for funding led to 200 initial applications and subsequent selection of 23 projects for funding. Criteria for selection included: innovation in terms of interacting with young people; range of practice (youth theatre, schools, professional productions, small and large projects, polished projects, and work in progress or research and development pieces); significance of the science explored and evidence of collaborations in place to support the science information; and artistic merit and originality. Approximately £300 000 was allocated across the initiative.

The 23 Pulse projects funded in 2003 exhibited diversity in terms of methodology, art form, setting and science subject explored. The overall initiative involved over 8600 young people, engaged across a range of dimensions including as performers, researchers, consultants, writers and audience members. Pulse projects also engaged a total of 125 professionals directly in creative processes of projects, including professional artists, youth theatre leaders or arts education workers, teachers, scientists or science communicators, and hospital or medical staff.

1.2 Case study projects

The evaluation included general monitoring and evaluation of each funded project and case studies of three key projects. In order to provide a more concrete view of the Pulse initiative, detailed descriptions of the case study projects are given here.[2] It is important to note, however, that the initiative exhibited diversity in terms of method, organisation, art form and subject matter, and that these projects should not be viewed as models for future practice.

The three case study projects included:

- All Change – 'Skin Deep' (up to £40 000)
- University of Oxford Botanic Garden with Oxford Community School – 'The Rainforest Pharmacy' (up to £10 000)
- Tricycle Theatre with Copland Community School and Technology Centre – The History of Disease Project, 'Don't Bug Me!' (up to £3000).

'Skin Deep' was a digital dance performance devised and created by young people working with artists and scientists over a period of five months. The project was conceived and directed by All Change (an arts organisation based in north London specialising in using the arts to promote social inclusion) in partnership with Sadler's Wells. The final production premiered at Sadler's Wells' Lilian Baylis Theatre in spring 2004. The project aimed to develop understanding of and promote dialogue and debate about the science of genetics and its impact on society. It was launched in November 2003, with local youth groups and schools invited to a science presentation by Dr Anand Saggar, a clinical geneticist at St

[2] See Appendix B for summaries of all 23 funded projects.

George's NHS Trust, followed by a short participatory dance workshop. The launch was attended by more than 50 young people from the local area. A devising and rehearsal schedule ran from January to March 2004, with weekly creative workshops culminating in a week-long intensive rehearsal period and three performances for school audiences and friends/family. Participating organisations included Fresh Start (an alternative education project), Highbury Fields School, Richard Cloudesley School and Central Foundation School, all based in north London. Artists involved included a digital and video artist, a creative writer, two dance artists, a dance and video artist, and a musician. Approximately 50 young people were engaged in the creative process during the course of the project. A second science consultant was Alf Linney, a medical imaging physicist from University College London, who provided access to medical imaging technology for artists and young people through the course of the project.

'The Rainforest Pharmacy' was a collaboration between the University of Oxford Botanic Garden and Oxford Community School, also working with a professional theatre consultancy. The creative process and final play centred on the story of the harvesting of African cherry from rainforests for the production of Prostatin. To launch the project, a year 10 drama class from the school attended a promenade performance at the garden of 'Green Fingers and Healing Hands' (a pre-existing production devised by the theatre consultancy working in partnership with the garden), followed by a presentation about the project from the theatre consultancy and garden staff. A core group of nine year 10 drama students then volunteered to work with a professional theatre consultant, the drama teacher and the garden arts education worker to develop their own promenade performance over the course of a ten-week devising period (with one workshop a week, carried out in the school drama studio after school). An intensive rehearsal period in the final week of the project at the garden led to a series of performances for audiences from local schools and friends/family in June 2004. The performances were followed by tours of the garden for audiences, led by garden staff.

The History of Disease Project, 'Don't Bug Me!', was a collaboration between Tricycle Theatre and science and drama teachers from Copland Community School and Technology Centre in London. A group of eight year 10 students (self-selecting, and working in school time with additional rehearsals in their own time) worked with a drama worker from Tricycle Theatre for approximately six two-hour sessions, as well as with a drama teacher and a science teacher. They devised a play exploring the history of disease, focusing on modern and historical epidemics and their treatment, and how infection is passed on. The devising process was supported by additional sessions led by the drama teacher after school. The group performed their play to year 5 pupils in four primary schools in the local area. The project has led to another drama project following the same model, exploring environmental issues.

1.3 Structure and format of this report

The report is structured into 11 main sections (plus an executive summary, bibliography and appendices), with themes covered as follows:

- the first sections describe the background to Pulse and the evaluation method and process (sections 1–2)
- the context section provides a background to the Pulse initiative, and a brief review of research on science education/communication research and current thinking about the role of drama and science in ethical education (3)
- the quantitative summary of Pulse includes information relating to numbers of young people, artists and scientists involved across the initiative (4)
- the bulk of the report describes the findings of the qualitative aspects of the evaluation, including a presentation of findings relating to the 'outcomes' or 'impact' of Pulse on young people, artists, teachers and scientists, and an exploration of the processes involved in facilitating successful projects (5–9)
- finally, there is a discussion of the findings and recommendations for the Wellcome Trust, artists or other professionals involved in future Pulse projects (10–11).

In order to best represent the exciting and diverse range of practice within the initiative, and, in particular, to inspire artists involved in the development of this field, the report incorporates

descriptions of specific activities, methods and models that artists involved in projects found to be particularly effective or that were in some way interesting or innovative. These descriptive examples are concrete illustrations of the more theoretical schemas presented in the findings (to support ease of reading, these are presented in text boxes).

Excerpts from interviews with young people, artists, teachers, youth theatre leaders and scientists are included throughout the report. Names of organisations that received the funding to run projects are given where excerpts have been used, unless this needlessly and unfairly exposes particular organisations (in the judgement of the evaluation team). This is done in the interests of providing an evaluation report that identifies learning points for future projects, rather than exposing particular organisations to censure.

2. Evaluation aims and objectives

The evaluation sought to identify the funding initiative's effectiveness in supporting high-quality performing arts provision and produce evidence relating to:

- the outcomes for young people and others involved in projects
- the quality of creative processes
- the success of projects in reaching and engaging target audiences
- the creative processes and outcomes of a sample of key projects.[3]

The evaluation sought to achieve the following objectives (as identified in the original research specification from the Wellcome Trust). These have been used to guide the evaluation in all its stages:

- to determine the effectiveness of the programme in terms of meeting its organisational objectives, the delivery of the funding initiative and the impact of its outcomes
- to describe the development of the projects in terms of establishing the theme, target audience and the success or otherwise of collaborative relationships
- to determine the nature and quality of the creative process as well as the final product
- to provide evidence of the scientific content and artistic delivery of each project and the balance of these
- to determine the success and effectiveness of the individual funded projects in terms of participation and the audience reached
- to determine the educational and attitudinal impacts of projects
- to make recommendations for future performing arts initiatives.

2.1 Evaluation activity

The evaluation consisted of the following interrelated elements:

- a survey of all projects funded by the initiative
- capacity building and support for performing arts organisations evaluating their projects, including an 'evaluation capacity-building' day in June 2002 and ongoing monitoring of artist-led evaluation
- monitoring and evaluating each funded performing arts project, including artist-led evaluation and case studies of three key projects.

The researcher visited each project prior to its start to agree an evaluation plan with artists. The evaluation plan for each project included:

- monitoring rates of participation in each project (including a demographic breakdown of participants regarding gender, age and ethnicity)
- pre- and post-project evaluation with participants (via either questionnaires or creative and participatory evaluation techniques)
- pre- and post-project evaluation activity with teachers and/or other partner organisations
- feedback from audiences where appropriate.

A researcher from CATR attended the majority of live performances generated across the initiative and a number of workshops and rehearsals. Data collection also included gathering video recordings of live performances, copies of session plans and marketing material/programmes. The lead researcher was available to projects for ongoing support and consultation regarding any aspect of the research and evaluation, including telephone and email contact, extra visits to projects where necessary, and dissemination of evaluation materials and resources. The evaluation team adopted a flexible approach to the evaluation and made specific inputs to the evaluation of each project as appropriate, depending on capacity within each organisation and 'fit' to individual projects. Many projects were visited

[3] See Appendix C for a summary of the evaluation proposal.

more than twice (two visits were identified as sufficient in the original proposal), as the original plan did not allow provision for viewing all live performances and it was generally not possible to coincide viewing performance with final interviews.

CATR sought to carry out semi-structured interviews with the arts and science team from each project, and, where feasible within the time and budget limitations, interviews with young people participating in projects in addition to the case study projects.[4] During interviews participants were asked to review the process of projects, describe their views of successful and less successful moments, make recommendations for future projects and explore links to other learning experiences, including science learning. Artists were asked similar questions, with an additional focus on how a science stimulus was managed within a creative process, advice for future professionals and feedback about working with the evaluation team and with the Wellcome Trust. Scientists and teachers were asked to review their experiences and make recommendations for the development of projects and for scientists or science communicators involved in future projects. During interviewing, the researchers used pre-prepared interview questions and also drew on concepts, phrases and wording offered by interviewees to follow up responses and elicit further information.

2.2 Case studies

The case studies provide an opportunity to assess examples of practice in more detail, generating a more intricate evidence base for analysis and relevant practical information for future practitioners. Three case studies were selected according to criteria carefully constructed by CATR in consultation with the science consultants and the Wellcome Trust (including the significance and value of the science, art form and methodology of projects, type of participant, and base). The case studies allowed for greater direct contact between the evaluation team and participants of projects, including observation of processes and qualitative interviews with participants and other stakeholders. The three case study projects were:

- All Change – 'Skin Deep'
- University of Oxford Botanic Garden with Oxford Community School – 'The Rainforest Pharmacy'
- Tricycle Theatre with Copland Community School and Technology Centre – The History of Disease Project, 'Don't Bug Me!'

2.3 Analysis of qualitative data

The evaluation generated a large quantity of qualitative data, mostly in the form of interview transcripts. A qualitative focus (as opposed to an experimental approach) is appropriate to this evaluation for a number of reasons. Qualitative research can be useful in areas where there is a lack of theory and concepts to describe and explain processes. Integrated performing arts and science projects are an underdeveloped area of practice, and use of a qualitative approach supports researcher sensitivity to unexpected processes and outcomes in participant experiences. In addition and in relation to this, it is very difficult to identify measurable outcomes or indicators for participatory arts processes as they do not occur under controlled conditions. The arts research sector is in its infancy and there is a need for high-quality qualitative research to generate appropriate theoretical frameworks that might, in the future, assist in the development of rigorous scales and assessment tools for measuring impacts.

The evaluation team used grounded theory to analyse qualitative data (Glaser and Strauss 1967; Glaser 1992; Strauss and Corbin 1998). Grounded theory generates theories about how processes work from a close and engaged examination of phenomena. The findings that emerge from grounded theory analysis aim to develop understanding and provide a framework for future action. An outcome of the analysis will be a theoretical framework exploring how the performing arts might 'work' with science to enhance young people's

[4] See Appendix D for an example interview schedule.

engagement in science. The theory, according to standards of validity employed in grounded theory, should have strong 'fit' to artists' and young people's experiences.

In grounded theory, data analysis proceeds by means of coding (the construction of categories that describe things in the data). For our analysis, a pre-devised coding scheme was used to explore data (constructed by means of discussions within the research team) and new codes were identified in the data by means of the lead researcher's reading and interpretation of interview transcripts.[5] This combined deductive and inductive approach to coding resulted from the need to ensure that the analysis generated findings of direct relevance to the research questions within the time frame available as well as remained sensitive to unexpected themes in descriptions.

A comment on the sample and sampling method. Qualitative interviews with 75 young people (from eight projects, including case study projects) were carried out by the lead researcher over the course of the initiative. The interview data were supplemented by questionnaire returns and interviews with young people supplied by artist-led evaluation (17 of the 23 projects completed questionnaires with participants and young people as audience members) as well as observations of all projects by the evaluation team. The sampling method was of necessity convenience sampling. Other than the case study projects (which were studied in depth, including interviews with all participants) the research team sought to carry out interviews on as many additional projects as possible within time, resource and other practical constraints. As a result, the research findings should not be viewed as representative of the whole initiative, in the conventional sense of that term. They should rather be viewed as 'indicative' of the range and types of responses/outcomes and experiences across the initiative.

2.4 Limitations of the evaluation

There are important limitations to this evaluation that should be highlighted. Most of the findings have been established from analysis of young people's and other stakeholders' representations of their experiences in interviews (though these were 'checked' against observations of many projects). It is difficult to assess correspondence of what young people say about the impact of projects and their subsequent behaviour and experiences, especially in the long term. In addition, interviews and observations were carried out very close in time to projects; it is difficult to know whether impacts and outcomes last beyond the space and time of the project. As noted below, quality and quantity of evaluation data received varied greatly across projects, leading to over-representation of some projects in this report.

2.5 Narrative of the evaluation of Pulse

A principle governing the management of the evaluation was to fulfil the aims and objectives at the same time as remaining flexible and responsive to the specific nature of each project and evaluation capacity within each organisation. This section of the report provides a brief narrative of the evaluation as it unfolded over the course of the projects. It includes:

- evaluation of the 'evaluation capacity-building day'
- artist-led evaluation – obstacles and difficulties
- what worked?
- use of creative and participatory evaluation approaches
- dissemination of evaluation findings.

2.5.1 Evaluation of the 'evaluation capacity-building day'

The evaluation capacity-building day on June 19 2003 was attended by representatives from 20 funded projects. The event provided a welcome opportunity for the research team to build relationships with project representatives and communicate plans regarding the wider evaluation. It included:

[5] See Appendix E for the a priori coding schema.

- an introduction to creative and participatory evaluation techniques (active, informal group exercises that involve participants in exploring their experiences, concerns and views about projects)
- a presentation of the evaluation proposal
- a discussion of aims, objectives and indicators of success of projects in partnership with representatives to generate material to inform standard evaluation tools and questionnaires
- communication about general support needs and an opportunity to discuss fears and concerns regarding the evaluation.

An evaluation pack, including descriptions of exercises and the content of discussions, was written by CATR following the day and disseminated across projects.

Feedback from participants showed that many felt the day met expectations and was quite useful, especially the introduction to theatre-based evaluation techniques and discussion about formal evaluation. There were a number of negative comments however. For example, some participants suggested clear indications and guidelines as to how to evaluate projects would have been useful rather than a participatory approach. In addition, more opportunities to discuss actual practice and network with other artists would have been welcome. A minority of participants expressed varying levels of resistance to the evaluation during discussions. There were concerns that the complex personal and social processes involved in arts projects cannot be captured by measurement-based evaluation and that the evaluation would overwhelm practice.

Participants in the evaluation day tended not to include artists involved in project delivery. The evaluation day was timetabled for early in the process and organisations tended to send a management representative rather than a practising artist. While the day was successful in that it clarified messages about the importance of evaluation, it was not always the case that those messages, and indeed the suggested approaches, filtered through to artists with direct responsibility for projects. This may have been one factor leading to difficulties when implementing the artist-led evaluation.

2.5.2 Artist-led evaluation – obstacles and difficulties

CATR envisaged that each funded organisation would facilitate some aspects of the evaluation independently. Specifically, projects were expected to manage pre and post-evaluation activity with young people and partner organisations. How did this work?

Early in the evaluation process, it became clear that the quality of data generated by arts organisations varied widely, as artists' interpretation of and ability to execute (in terms of willingness, time/resources and expertise) the evaluation was variable. Some projects did not systematically collect information from participants at the start and end of projects. Among projects that did supply information, often the quality of data was not useful in terms of fulfilling the objectives of the overall evaluation, especially in its lack of depth and detail. This means that data supplied by some organisations has been of limited use for the evaluation. As a result, CATR sought where possible to carry out in-depth interviews with young people and partners of projects (in addition to the case study projects, and within time and budget constraints).

Artists were asked to explore their experiences of the evaluation in final interviews with the evaluation team. A number of themes emerged from these discussions. It is clear that some concerns expressed at the evaluation day were maintained throughout the project, specifically that the evaluation was not relevant to ongoing practice and that the needs of the project took precedence over the need to complete evaluation. Variability in the quality of the data supplied by arts organisations resulted from a variety of factors:

- low levels of evaluation capacity or expertise within organisations
- lack of commitment to evaluation
- evolution of projects leading to change in evaluation plans and staff
- lack of clarity from the evaluation team regarding specific form and amount of evaluation data expected.

Importantly, some artists reported that they carried out evaluation as part of their daily practice, though not evaluation that was amenable to being written down and recorded via questionnaires or within creative evaluation exercises, for example:

> "You're always evaluating…what's the impact of that? Are they doing that? Are they able to engage with that? This needs to happen in order for this person to engage with it, let's do something different…you have a visual feedback straight away, you know that someone's understood because of what they're doing there in front of you, so sometimes it's a non-verbal process, you don't need to ask the question or get them to fill in a form" – lead artist, Hampshire Dance.

2.5.3 What worked?

The overwhelming majority of projects were happy to facilitate the lead evaluator's visits to projects and contact with young people and other professionals involved in projects, and to participate freely and openly in interviews themselves. The evaluation process included many very interesting and stimulating discussions with artists and others involved in projects, generating in-depth and rich data that have been used to generate the evaluation findings in this report.

Positive feedback from practitioners about the evaluation included:

- appreciation of the flexible style of the management of the evaluation by CATR
- evaluation activities were helpful in keeping the process relevant to young people and establishing a sense of their ownership over processes
- arts organisations benefited from receiving in-depth insights into how projects were perceived by participants
- finally, many artists stated that they enjoyed reflecting on their experiences in interviews and found this a useful way to evaluate their own process: "It's good to have these kind of conversations, much more valuable than writing a report" (project artist).

In addition, there were examples of detailed arts organisation-led evaluations carried out by a handful of projects. It is notable that, in all but one of these cases, the evaluation was managed not by the artists involved, but by a project coordinator or researcher attached to projects. The one successful evaluation led by an artist was interesting, as the evaluation data generated by interviews with participants were used both to support the evaluation and as creative material in the final work-in-progress performance.

2.5.4 Use of creative and participatory evaluation approaches

Some companies (eight) incorporated participatory or creative evaluation approaches into their evaluation, though it should be noted that this approach was not adopted wholesale. There were a number of reasons for this. For some, a significant amount of time had passed (from the capacity-building day) by the time projects had started and initial enthusiasm for these approaches had worn off. In many cases, the person attending the day was not the person involved in the project, so the knowledge base was not there. For other projects, the pressure on time and resources involved in doing the project simply meant that they did not attend to the evaluation.

Where creative and participatory exercises were used by CATR in our own evaluation activities within Pulse, we found the resulting data of limited use. The data generated by creative and participatory evaluation exercises do not clearly translate into written reports, and their lack of depth and detail do not lend so readily to any analysis that aims to generate

theoretical explanations of phenomena. However, the exercises were useful in stimulating conversations and breaking down barriers between researcher and young people prior to interviews.

Overall, the evaluation raised a number of issues relating to ongoing debates about the form, style and content of evaluation appropriate to arts practice. These issues are taken up in section 11 of the report (on recommendations).

2.5.5 Dissemination of evaluation findings

Interim findings, based on the themes and recommendations emerging throughout the process of the evaluation, were presented at three conferences:

- Pulse conference, University of Manchester – June 2004
- IDEA 2004 Fifth World Congress, International Drama/Theatre and Education Association in Ottawa, Canada – July 2004
- Theatres of Science: Crossovers and confluences, University of Glamorgan – September 2004.

These presentations provided an opportunity to disseminate lessons from practice and evidence of the impact of Pulse, and to participate in discussions that informed ongoing analysis.

3. Context – the performing arts and public engagement in science

Pulse represents a unique and innovative response to the Wellcome Trust's brief to encourage young people's engagement in social and ethical debates arising from advances in biomedical science. Performing arts projects within Pulse include a range of art forms, models of practice and ways of engaging young people. Such diversity poses a challenge for any evaluation of artistic quality or impact on young people's engagement with science. A brief exploration of the development of some of the strands in current thinking about the public communication of science and science education provides a useful framework for the evaluation findings.

3.1 Science education and communication

> "What is important is not that citizens should be able to…understand how science works…citizens should be able to use their understanding of science, so that science can help rather than scare them" – House of Commons Science and Technology Committee 2001–02, 18.
>
> "The ever growing importance of scientific issues in our daily lives demands a populace who have sufficient knowledge and understanding to follow science and scientific debates with interest, and to engage with society as a whole" – Millar and Osborne 1998, 1.

There is general agreement in the science education and communication sectors that the science curriculum needs to become more relevant to contemporary scientific issues (House of Commons Science and Technology Committee 2001–02). Research has shown that school students lose enthusiasm for science at key stages 3 and 4 (Delpech 2003, cited in Sanders 2004) and that science education does not sustain young people's wonder and curiosity about the world (Millar and Osborne 1998). The failures of science education are of concern at a time when science is transforming our relationship to the physical and social world so dramatically; policy makers and educationalists have identified a need to increase the general public's understanding of changes and support their engagement in debates about how to apply scientific developments in society.

'Beyond 2000: Science Education for the Future' (Millar and Osborne 1998), an influential report that explored the successes and failures of science education to date, concludes that science education is out of date in its emphasis on communicating a 'value-free' body of knowledge and science as a succession of facts to be learned. The report advocates the development of a science education that supports young people to develop a broad understanding of the major scientific ideas and critically engage with the problematic issues relating to scientific knowledge, including recognition of the ethical and moral implications of scientific developments. The report also identified the need for greater variety in teaching and learning experiences and advocated the use of explanatory stories and narrative to explore "the major ideas that science has to tell" (2013).

Burns *et al*. (2003) propose that the purposes of science communication are to generate: awareness of science (familiarity with new aspects of science); enjoyment or other affective responses to science (evoking positive feelings and attitudes that may lead to deeper encounters with science); interest in science (a cognitive rather than affective response, characterised by voluntary involvement); opinion formulation (opportunities to form and reform opinions and develop views that are complex and multifaceted and influenced by knowledge, beliefs and emotional reactions); and understanding of the content, processes and social factors involved in science.

In all, literature relating to young people's engagement in science education and public engagement in science documents a shift away from passive consumption of science, and science as a value-free body of knowledge, and a move towards participation, experimentation and exploration of science, including the incorporation of different methods, focus on broader social relevance of science and problematising the application of scientific ideas in society (Millar and Osborne 1998, Burns *et al*. 2003 and others). The difference

between passive consumption and active engagement in science is the main distinction between models of science communication that are referred to across the science communication literature. Weigold (2001) identifies three models:

- the deficiency model – a science-centred, top-down approach that assumes the public need more information about science and that 'science' has a coherent identity
- the rational choice model – a focus on providing information and opportunities for debate about the science that the public needs to know in order to be active and informed citizens
- the context model – a focus on how science is put to use, stressing a two-way communication between public and science community where the public is an active, joint producer of scientific literacy and where public communication is driven by the audience's needs and interests (also see Burns *et al*. 2003, Borchelt 2001).

Logan (2001) identifies two overlapping models of science communication: the 'scientific literacy' and 'interactive' models:

- the scientific literacy model emphasises the transmission of knowledge for improvement of health and quality of life, and increased ability to engage with social and ethical debates arising from scientific development
- the interactive model emphasises multidirectional and shared knowledge, 'engagement' rather than communication and an 'informal conversation' with the public – "an ongoing, live interaction between scientific experts, policymakers, scientists, lobbyists and representative citizens regarding the moral, ethical, and affective dimensions of science and medical issues" (53).

There is a clear emphasis on participatory approaches and active exploration, setting ethical debates in context, and problematising science in the recent literature on science communication. While such models can be a useful way of researching the field, we should be wary of categorising performing arts projects (or any initiative) as one or another model. Logan suggests that in practice, models may overlap with each other and include moments of information-giving and extended interaction.

Wiegold reports an assumption in the science communication literature that higher levels of knowledge or understanding correspond to favourable attitudes towards science, an assumption for which there is little research evidence to support. It may be that higher levels of knowledge lead to increased anxiety or anti-science feeling, or, that engagement in science produces more understanding of complexity rather than certainty about scientific development being either positive or negative. Leshner (2003) identifies a similar assumption when stating that increased knowledge might lead to more awareness of uncertainties in science. This latter outcome, that is, increased awareness of the complexity, uncertainty and value-laden nature of science, is one that is welcomed by most sectors of the scientific and science communication sector.

The need for evaluation of existing science communication and education initiatives is stressed by Edwards (2004) and others. However, Burns *et al*. (2003) point to the difficulty of measuring impacts of science communication initiatives, as they do not occur under controlled conditions. They suggest that not enough is known about the nuances of science communication in order to develop refined measuring tools for impacts. Burns *et al*. also suggest that qualitative research may be more useful in picking up such nuances and that there is a need to take a long-term view (for example, young people's development can be characterised as a multifaceted, cumulative process over time rather than as a result of a one-off intervention. Borchelt asserts the need to know more about the "ecosystem of communication" between scientists, mediators and other public information specialists in order to enhance public communication initiatives (2001, 199). These discussions provide useful departure points for future research.

Van Dijck (2003) posits that in the 21st century there is a 'multicultural paradigm' of science communication, based on a cross-disciplinary understanding of science that acknowledges how specific disciplines construct and communicate science. The evaluation of Pulse

provides an opportunity to explore whether there is such a clash of cultures noticeable in the performing arts' treatment of science and, indeed, whether there is evidence of such projects contributing to a cultural shift in ways of thinking about science in society. The positions in the science communication debate overall suggest interesting questions for Pulse and might provide a framework within which to interpret the 'narratives' of young people, artists and others involved in Pulse projects. Key questions include:

- The performing arts provide opportunities for 'live' interaction and dialogue about science – what are the impacts and limitations of these on young people's ongoing engagement in science?
- What impact do performing arts projects have on models of/approaches to science teaching and communication?
- How do the arts interact with and alter constructions of 'science' for young people and others involved in projects (and conversely, how does science reconstruct the artistic process)?

3.2 Learning theory and arts education

Conceptual frameworks drawn from learning theory, including multiple intelligence theory and learning style, may also provide a framework for the findings of the evaluation relating to learning impacts. Current thinking on learning styles is based on Gardner's theory that there are a range of at least seven or eight forms of intelligence and that each of us tends to develop and prefer some of these intelligences (these preferences account for personal learning style). Effective learning takes place if the learning experience is geared towards our learning style. While categorisations of learning style and types of intelligence are useful, in that they challenge narrow conceptualisations and processes dominating formal education, we should be wary of assessing individuals and activities as one or another category. Most people show preferences for combinations of styles at different points in time. In addition, a positive learning environment, learner involvement and collaboration have all been shown to facilitate learning and development. The arts can play a role in including a range of learning/ delivery styles by incorporating a diverse range of activities that draw on emotion and intuition, reflection and conceptualisation, visualisation and movement, and draw on the experiences of young people as well as introduce experiences of others.

The arts can also transform the learning environment by changing the physical space and stimulating high levels of enjoyment and social energy. It is argued that the arts share a creative mechanism that encourages critical thinking and the channelling of personal expression, and that they have more sustained effects because the context in which they occur and the degree of cognitive/creative engagement they require makes them more memorable (Silvis 2002). Winner and Cooper (2000) provide a theory base for a link between the arts and academic achievement. They state that there are three main arguments: 'the cognitive structure argument' (cognitive structures used in the arts, e.g. critical thinking, close observation, problem solving) can be applied to learning in other disciplines; 'the motivational argument' (arts stimulate motivational and attitude change that can help young people engage with education and boost confidence). Finally, there may be an 'epiphenomenal' link – the arts facilitate positive reforms in teaching and in the learning culture/environment that support academic achievement.

These concepts raise questions relevant to the evaluation of Pulse: what are the mechanisms by which performing arts and science projects might 'work' to engage a diverse range of young people? And how do the performing arts transform the environment for learning/ engagement?

3.3 Ethical learning in science and the arts

A recent parliamentary report found that students want to discuss controversial and ethical issues, but there are few opportunities to do so within the science curriculum, and science teachers do not have the skills to facilitate these opportunities (House of Commons Science and Technology Committee 2001–02). This is confirmed by Levinson and Turner (2001), who suggest that humanities teachers are not as confident when dealing with socio-scientific

issues as they are when dealing with general ethical and social issues. Teachers' difficulties in teaching controversial subjects include whether to present their own values, how to present a balanced view, how to get a correct balance between fact and values and how to help young people form opinions. Levinson and Turner assert a need for an "ethics of enquiry" to help students make judgements "on a rational and reflective basis" (15) and "to weigh arguments on the basis of values and principles rather than on opinion alone" (23).

This research identifies a need for teachers to support the development of critical skills, and to consciously use ethics as a tool for reflection (via exploration of ethical concepts such as free will, responsibility, language and thought, problems of representation and knowledge). However, it is clear that there is a skill/expertise gap here; there is a need for interdisciplinary professionals and partnerships to exist across the science and the humanities fields. The Pulse projects operate within a gap or fissure between social or cultural fields. As will be shown, the evaluation of Pulse raises questions about what combination of professionals, skills/expertise and models of education are needed to effectively engage young people in social and ethical debates. The skills required might be conceptualised as five categories (this will be further developed in the summary section of the report):

- creative/artistic – ability to explore subjects from novel perspectives and aptitude for taking risks
- scientific – interest in or fascination with science
- socio-scientific – interest in or fascination with the social and ethical implications of advances in science
- educational – ability to create enjoyable opportunities for young people to reflect on new concepts and information within creative processes (relevant to projects that take place in informal as well as formal educational settings)
- social – ability to engage with partners and inspire young people.

There has been a focus on ethics in drama-related research. In the UK, Winston (1998) and Edmiston (2000) have conducted research to explore how classroom drama can enable students to express, explore and develop complex conceptual moral understanding. For Edmiston, drama enables encounters with people in everyday life and in the imagination – children explore value and ethics via narratives, and rehearsal enables us to evaluate our actions from the viewpoint of those affected. Edmiston stresses the role of the imagination in facilitating ethical behaviour and an understanding of complexity:

> "In drama we can adopt multiple positions in addition to those of our everyday lives; in imaginary immediate prosaic situations we can explore how we might have acted if we had adopted such positions; and through drama we use imagination to shift positions so that we learn how to evaluate actions from the positions of those affected by the consequences of our actions" (2000, 67)

Edmiston asserts that drama practitioners need to avoid setting up dichotomous ethical stances via the dramas introduced within groups, and this is helped by positioning young people within workshops as actively involved in the ongoing action, engaged in the exploration of 'positions' of characters in roles (rather than remaining within a specific 'role'). The main thrust of Edmiston's argument is that drama has an ethical aspect to its form and process, but whether this is exploited or not can depend on the ability of the drama practitioner to see the subtleties of a particular content and process and their ongoing critical reflection. Again, the question of skills and expertise comes to the forefront.

The literature relating ethical education to performance raises further questions relevant to the evaluation of Pulse:

- What are the characteristics of ethical education described by participants of performing arts and science projects that have successfully involved young people in social and ethical debates?
- What skills/aptitudes are needed by performing arts practitioners and other professionals to facilitate this?
- What combinations of professionals, skills/aptitudes and models of practice effectively engage young people in social and ethical debates?

4. Quantitative summary of Pulse

This section of the report provides a quantitative overview of the Pulse initiative, including a summary of project activity, participation rates, art forms, types of organisation involved, and science issues addressed via projects and other project activity.

The 23 projects exhibit a range of responses to the Pulse brief. Projects have been carried out in both formal and informal educational settings, including schools, colleges, youth theatres, community centres, museums, science centres and gardens. Projects have had a variety of aims and objectives (from research and development to clearly specified educational aims), performing art forms (theatre, dance, music, digital media), outputs (large-scale performance, peer-led theatre-in-education, performance art installations, site-specific work, stand-alone workshops) and scientific subject matter (genetics, medicinal properties of plants, nanotechnology, treatment of disease, GM foods). Over 8600 young people have been engaged in Pulse across a range of dimensions including as performers, researchers, consultants, writers and audience members.

Pulse projects involved a total of 125 professionals directly in creative processes of projects. This included 59 professional artists, 20 youth theatre leaders or arts education workers, 21 teachers, 21 scientists or science communicators, and four hospital or medical staff. A large number of teachers were involved less directly, either as audiences of performances or in supporting workshops.

4.1 Summary of project activity and partnerships

There were approximately 80 performances (plays, film showings, work in progress or installations) over the course of the year. The initiative generated a total of 23 performance products and 410 workshops or rehearsals with young people. The initiative has engaged a variety of organisations across a range of dimensions, including:

- schools receiving performances/workshops (59)
- schools supporting pupils groups participating in a creative process (13)
- youth theatres/youth dance groups housing projects (12)
- independent arts organisations coordinating projects (11)
- higher or further education colleges supporting students involved in projects (four)
- museums partnering other organisations (two)
- hospitals partnering other organisations for projects (two)
- a botanic garden coordinating a project
- a science centre coordinating a projects.

In relation to links with schools and colleges, projects took place in and out of curriculum time, and may or may not have been linked to formal assessment:

- projects taking place in curriculum time, and linked to formal assessment (four)
- projects taking place in curriculum time, but not linked to formal assessment (eight)
- projects taking place in school, but outside of curriculum time (two)
- projects taking place out of school (eight).

One project incorporated school groups, as well as non-school groups, and was linked to formal assessment (including projects taking place inside of curriculum time).

4.2 Dimensions of participation

Table 1 gives a quantitative summary of participation of young people in Pulse, broken down into the following dimensions of engagement: full participants of a creative process (involved in devising, writing and performing plays), audience members **and** one-off workshop participants (that is, young people who attended a performance followed by a workshop), and young people who were audience members only.

Table 1. Participation of young people in Pulse, 2003–04

Pulse year one – total participants	Participants in a creative process	Involved in workshop following a performance	Audience members only
8665	712	3373	4580

Numbers do not take account of wider audiences that have been reached by video products (the Pathways film) and young people in audiences in non-school tours (for example, young people in Trestle Theatre Company public performances).

Involvement in a creative process includes a range of levels of participation. For example, it might mean participation in workshops to provide material and feedback for the development of performance products (for example, Double Vision's 'Left') or being thoroughly involved in researching, writing and devising for a script over the course of a year (such as the Eden Project and Truro College partnership).

4.3 Participant demographics

Detailed demographic information was available for approximately half of the groups of young people that participated in a creative process, including age, gender and ethnicity. Pulse participants spanned the age range of 5–22 years (one young theatre also included a small adult group in their work, and a college drama group also included adults). Most projects, however, involved young people within the age range of 13–18 years.

The following figures show gender and ethnicity balance across participant groups.

Figure 1. Gender balance within Pulse phase 1

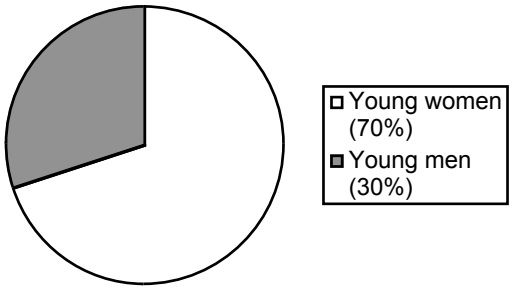
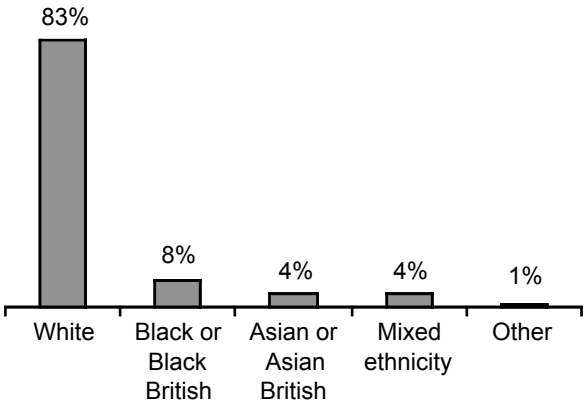


Figure 2. Ethnicity balance within Pulse phase 1



This breakdown does not reflect the balance across projects. For example, projects taking place in inner London and Manchester had a far greater ratio of black and minority ethnic participants, reflecting demographic make-up in those areas. In addition, the University of Oxford Botanic Garden attracted a higher proportion of black and minority ethnic participants, as they used the opportunity presented by the funding to invite the participation of a school that was both more culturally diverse and unlikely to access the garden provision.

The gender balance is similar to other research findings into young people's voluntary participation in performing arts: a ratio of two young women to one young man is expected from participation in performing arts projects (Hughes and Wilson 2004). This reflects gender differences in wider cultural preferences and opportunities in society.

4.4 Did projects reach young people who were not routinely engaging in science education?

In order to assess how successful Pulse was in engaging new audiences in science debates, it is important to attempt to quantify the extent to which Pulse projects provided access to populations of people not already engaged by science education or other initiatives. The limited information available makes this difficult; however, it is possible to provide a broad overview. Of the 23 projects:

- Eleven took place in schools with children under 16 years, so worked with young people who were participating in the school science curriculum. However, one project, with the University of Oxford Botanic Garden, deliberately sought out and forged a partnership with a school that had a history of low achievement in order to work within a remit of widening access. The group included people who were not high academic achievers: "it attracted a group of people who perhaps don't get enthused about things" (teacher, University of Oxford Botanic Garden).
- Nine projects worked with groups including young people who were post-16 and no longer accessing the science curriculum, so these projects succeeded in engaging young people who had no other access, other than their own interest, to discussing and debating issues relating to science (All Change, Eden Project, Riding Lights Theatre Company, North Warwickshire and Hinckley College, Y Touring, Hampshire Dance, Dynamic New Animation, Chipping Norton Youth Theatre, Oval House).
- Two projects worked with groups of young people and adults with learning disabilities to explore their responses to genetic science.
- Three projects worked with groups that included young people who were not high academic achievers and/or had a history of erratic school attendance (All Change, Dynamic New Animation, and North Warwickshire and Hinckley College). However, two of these projects experienced difficulties in sustaining the engagement of the young people, particularly in the science aspects, throughout the course of projects. This happened where the pressure to produce a public performance overwhelmed ongoing engagement with science. In addition, finding a successful way of engaging young people in debates emerged as an issue for some projects. These issues are taken up later in the report (6.3, 8.2, 9.3).

4.5 Performing art forms and models of practice

Of the 59 professional artists involved, 25 were theatre directors or actors, 13 were writers, ten were dance artists, nine were video and/or digital artists, two were musicians and one was a comedian. Projects employed a variety of performing art forms in the process of working with young people and in performance products (with most projects drawing on more than one art form). The following list shows the range of different art forms employed across the initiative:

- theatre/performance art (17)
- visual arts, including digital animation, puppetry, video/film (six)
- dance (five)
- stand-up comedy (one)
- radio play (one)
- musical theatre (one)
- multi-arts workshop (one).

As noted above, the initiative included a range of models of practice and projects attempting something innovative artistically, and projects that adapted tried and tested models to engage with new issues, themes, groups and audiences.

Four different models of young people's engagement in science via performing arts projects can be identified across the Pulse initiative. Each model engages young people in a different way and has specific strengths and weaknesses:

- Touring productions with an accompanying workshop can provide a short-term, intense and stimulating input into science learning in schools.
- One-off projects working with young people to create a performance for an audience of peers and local community on a selected scientific issue can provide an opportunity for participants' prolonged engagement with a scientific subject.
- Peer theatre-in-education projects can generate very attentive audiences; performances made by young people for other young people can quickly and immediately raise the status and relevance of the science for young audiences. Young audiences are provided with successful and exciting models of involvement in science education and learning through observation of peers.
- Research and development projects focus on experiment, exploration of personal responses and artistic risk taking – all of which facilitate innovative means of integrating science into creative processes.

4.6 Science, scientists and science mediators

The 21 scientists or science communicators involved across the initiative included six practising scientists, one retired scientist, nine science communicators (or science-related educators, not including teachers) and five hospital/medical professionals.

A range of science subject areas was explored. Projects varied in the extent to which they specified a scientific focus for their project, with some projects identifying a broad area for investigation (e.g. 'genetic science' and others focusing on a particular story (e.g. harvesting of African cherry for treatment of prostate problems) or subject matter (brain-cell communication). There were four broad groups of science subjects explored:

- projects exploring issues relating to advances in genetic science (11)
- projects exploring treatment of diseases or disorders (five)
- projects exploring brain patterning/neuroscience (two)
- projects exploring specific topics, namely the science of handedness, ageing, and light (three).

The majority of projects had not attempted to carry out a project exploring science issues before. A small group of projects used the funding to develop existing projects that related to science subjects (Riding Lights Theatre Company, Stan's Café, Double Vision, Theatre and Beyond, Devon Arts in Schools Initiative). One company, Y Touring, was experienced in facilitating performing arts and science projects for young people.

5. Research findings

This section of the report presents the findings of the evaluation, with specific focus on the impacts and outcomes of projects for young people, artists, teachers and schools, and scientists. The findings section is structured into two parts: exploration of impacts on young people and others participating in projects; and processes, that is, issues relating to successful planning and delivery of projects.

The report seeks to describe the overall responses of those involved in the initiative, in addition to highlighting mechanisms and processes that were particularly effective, and to give an account of how and why projects 'worked'. The evaluation is predominantly qualitative in character and there are few attempts to quantify impacts across the initiative. As described in section 2.3, qualitative data were analysed via coding segments of meaning in interview transcripts and other data, and developing links between categories, to work towards an overall theoretical schema to explain impacts, processes and mechanisms of projects. This interpretive work is based on a detailed reading and analysis of all the data and employs standards of validity and reliability such as 'fit' to artists and young people's experiences and 'thick description' (strong linking of findings to context).

5.1 Impact on young people

Semi-structured interviews with 75 young people (from eight projects, including case study projects) were carried out by the lead researcher over the course of the initiative. Interviews were carried out with individuals and small groups. The interview data were supplemented by questionnaire returns and interviews with young people supplied by artist-led evaluation (17 of the 23 projects completed questionnaires with participants and young people as audience members) and observations of processes by the evaluation team (see section 2.1 for more information about the interview method used during the evaluation).

The codes and categories relating to the impact of Pulse on young people are described below, culminating in a summary description of performing arts and science projects as a model of ethical education for young people. The main themes in findings relating to the impact of Pulse on young people are:

- motivations for involvement: an opportunity to participate in the performing arts
- shifts from low expectations to enjoyment, enthusiasm and commitment
- personal and social development outcomes; creating ethical environments
- learning about the arts via participation in innovatory arts projects
- increased knowledge and understanding of science
- increased sense of the personal relevance and significance of science: developing an 'authentic' engagement with science
- appreciation of complexity and broadening perspectives; problematising science
- fascination and amazement: cognitive and emotional dissonance
- lack of enthusiasm and confusion about science
- performing arts/science with young people: features of practice that 'worked' according to young people
- sustainability of outcomes
- impact on young audiences: 'click' moments, moments of confusion and moments of contemplation.

5.2 Motivations for involvement: an opportunity to participate in the performing arts

The majority of young people involved in projects in their own time reported that their motivation for involvement in a Pulse project was to participate in a performing arts project rather than an interest in exploring a science issue. For example:

> "I love acting, that's why I'm here" – participant, University of Oxford Botanic Garden.

> "When I found out that we'd be acting I thought yeah, I really want to do that" – participant, University of Oxford Botanic Garden.

Many young people reported that their 'best bit' of the project was the opportunity to work towards and be part of a public performance. Young people's descriptions of performance events testify to the social energy and enjoyment experienced by a group of young people working towards a shared goal, and the risky and challenging nature of performing in front of a public audience:

> "The enthusiasm from all of us, like all the hype has made it more memorable" – participant, University of Oxford Botanic Garden.

> "Everybody has so much energy to do the piece, it energises everyone and it's really good fun every time" – participant, Hampshire Dance.

The lack of attention to the 'science' in the projects may have resulted from a lack of awareness on the part of young people involved that what they were doing was 'science'; once prompted, their responses offered some detailed insights into the impact of exploring science subject matter. It is important to note that for many young people this is not an 'either/or' choice between science and the arts; interest in performance is not opposed to interest in science in young people's constructions of projects. Many reported that they enjoyed science lessons in school and were interested in science subjects (although had not necessarily thought much about the specific subjects raised during projects before). What is clear, however, is that young people associated involvement in the performing arts with high levels of enjoyment and energy and that for many, this was the main motivating factor for their involvement in projects.

5.3 Shifts from low expectations to enjoyment, enthusiasm and commitment

Despite this, some young people expressed anxiety and low expectations when first introduced to the topic they were going to explore. A trajectory from anxiety and confusion to shock, surprise, excitement and commitment was common in many projects. Thoughts and feelings expressed at the start of the project included confusion and lack of confidence and enthusiasm:

> "At first we were like, where is this going to go? Why do we want to learn about biology? Why do we want to do a play about biology?" – participant, Dynamic New Animation.

> "I weren't really too up for it…it was different, I didn't know what to expect, I thought that might be interesting but I don't have much clue about flowers and plants so the basis of it is different from what I've done before" – participant, University of Oxford Botanic Garden.

Most projects secured high levels of interest, commitment and enjoyment from participants after initial lukewarm beginnings, with many young people devoting a significant proportion of their own time to participate. Most participants reported feeling significantly more enthusiastic about the project by the end, and strongly recommended to other young people that they get involved in like projects:

> "We were all interested in the show so we all worked hard and had a laugh at the same time" – student, North Warwickshire and Hinckley College.

> "A bit sceptical at bringing the science in…will it actually work? Will it be good? But I think it has worked, we've been proved wrong' – participant, Hampshire Dance.

> "If they taught science the way they taught us science, kids in school would enjoy it…it was different, more creative" – participant, Dynamic New Animation.

> "The thing is, they're never this happy when they're in science lessons" – science teacher, Devon Arts in Schools Initiative.

5.4 Personal and social development outcomes; creating ethical environments

Young people and adults associated with projects report a wide range of personal and social development outcomes for young people. This finding supports other research on personal and social development outcomes from participating in theatre and drama (Matarasso 1997; Hughes and Wilson 2004). These types of outcome are an important part of young people engaging in a group process and may lead to ongoing engagement in socio-scientific debates in other contexts. The range of personal and social impacts reported by participants, arts workers and teachers connected to projects includes:

- cooperation and communication skills: "better ways of cooperating with others in groups because a lot of these people I wouldn't usually work with" (participant, University of Oxford Botanic Garden)
- trust/teamwork: "it was nice to know and trust the people around you and you feel safe with them if you make a mistake" (participant, University of Oxford Botanic Garden)
- ability to participate in a disciplined process and work hard: "you can't complain about the long hours of rehearsal because it's been fun" (participant, University of Oxford Botanic Garden)
- increased levels of confidence gained from praise and recognition received from others: "it's a great thing when you're standing there and the audience is looking at you and listening to every word" (participant, University of Oxford Botanic Garden); "I've gained a lot of confidence" (participant, All Change).

In addition, young people expressed a sense of being part of a well-functioning social group. The opportunity to access a space apart from normal roles and routines with positive norms, values and ideals was clearly important to them:

> "We only met a couple of months ago and now we're like a family, I think the best thing about this is meeting new people and combining, sharing thoughts" – participant, All Change.

> "All of them have bonded to be a really nice group and they look out for each other…that process of theatre in helping people explore and grow personally and discover things about themselves and know themselves better and challenge themselves" – teacher, University of Oxford Botanic Garden.

Performing arts processes create new social environments, both within participant groups and in wider environments of the projects (in schools, for example). An increased sense of value for each other's contributions and an ability to cooperate with each other, as well as the ability to explore subjects from different points of view, tend to be implicit to well-run arts projects with young people. These micro 'ethical' environments may provide a model context for science exploration, sensitising young people for an exploration of complex social and ethical issues. This is an important avenue for further research.

5.5 Learning about the arts via participation in innovatory arts projects

Young people appreciated opportunities to take part in arts processes that were new to them, and that challenged them to develop new approaches and skills:

> "We got into more street dance styles, whereas before we were more contemporary" – participant, All Change.

> "It was a different kind of art that we'd never looked at before…we know that can be art as well" – participant, All Change.

> "You learn you can transfer any theme or idea and make it into movement, transform it into dance" – participant, Hampshire Dance.

Artists also enjoyed working with groups to help them develop new technical skills and imaginative approaches, and to take risks, often confounding the artists' and young people's expectations of what the young people were capable of. This produced high energy and enthusiasm evident in many projects across the initiative:

> "Having to dance for a whole half hour, that's something that you don't actually do until college or university, that was quite something just to do that" – leader, Hampshire Dance.

> "As far as the drama was concerned they were brave and experimental in taking on very different abstract movements, not easily explored in lessons because not everyone is keen" – drama teacher, Devon Arts In Schools Initiative.

Some projects in schools and colleges provided an opportunity to experiment with form and content that was not available within the usual curriculum:

> "They were doing something really special and really unusual…they had a good drama process in the school but the site-specific performance and really working with their ideas and evolving them into something which could then be a public performance somewhere other than the school theatre, that was all pretty new to them" – project leader, West Dorset General Hospitals NHS Trust.

It is clear that young people's participation in innovative and unique arts experiences was an outcome of some projects. A question remains as to the extent to which the science aspects of projects stimulated more experimental approaches to artistic process and form. The complex relationship and transactions between science and performing arts are themes explored throughout this report, and it is difficult to be specific or certain about any cause-and-effect relationship. The young people often did not separate the 'arts' and 'science' aspects of their experience – and were more likely to report more openly about their 'experience'. This suggests that the encounter with science through the arts is what felt innovative and exciting, rather than an encounter with science or the performing arts *per se*. The search for a form or style to represent complex ethical issues and/or technical information, and to explore multidimensional subject matter, may have challenged young people's and artists' conceptions of arts process and form, as well as their existing skills, abilities and understanding of the relevance of science to art and vice versa.

5.6 Increased knowledge and understanding of science

Many young people reported increased general knowledge of the science issue or concept being explored as a major outcome of projects. In particular, young people described becoming more aware of personal, social and ethical implications and the general language/terminology connected to subjects such as genetics, rather than acquiring in-depth knowledge of complex technical information. They expressed a sense that they knew something about the subjects and indicated more awareness of the complexity of subjects:

> "I'll keep an understanding of medicines and where they come from, how they are developed" – participant, University of Oxford Botanic Garden.

"It makes you think about the different things in life that science is involved in" – participant, Stan's Café.

> "I never knew anything, I didn't know what an iron lung was or anything until we came to the museum" – student, North Warwickshire and Hinckley College.

> "I don't think most people that have done this project think about them things very often so it's probably been an eye-opener for us all, opened our mind to a different way of thinking about genetics" – participant, All Change.

> "I never knew nanotechnology existed, I never heard about it before this play, I'm not very good at science, I don't know a huge amount about it now but I know more than when I started" – participant, Dynamic New Animation.

Those young people that had come across subjects before via science lessons tended to characterise their learning about science as an enjoyable and memorable reminder that was more likely to enhance future recall as it incorporated active, emotional and imaginative engagement in subjects:

> "In science we were just talking about what diseases they could get, in Skin Deep we were learning about how people would react, how they would feel" – participant, All Change.

> "It helps you because it's like putting things in a way you can remember, it can trigger something in your brain so you think that goes with that and that goes with that and that must go with that" – participant, Hampshire Dance.

> "Actually putting the story of the plague into action is something that would perhaps reinforce the idea, when you're studying, you read things and they don't sink in, the more you do it, the more it makes sense, so in that respect it will reinforce what they already knew" – science teacher, Tricycle Theatre.

The evaluation did not collect any evidence to suggest that projects had an immediate impact on students' achievement in science in terms of school science curricula. However, increased interest and confidence may enable them to engage in science in the future. Science communication research (Burns *et al*. 2003) suggests that one intervention is unlikely to change overall attitudes or engagement in science, but leaves some residue that enhances engagement in the future. Pulse projects stimulated an interest in science that is taken up later rather than procuring an immediate change in attitude. Professionals involved in Pulse confirm this:

> "I think long-term the information that they got, the scientific information they got is much deeper than even they are aware of…in terms of where the science took them, I think that's about long term and that's why I think it's worth doing" – project director, Chipping Norton Youth Theatre.

> "It isn't about explaining science or instructing kids in the curriculum, it's about making connections, perhaps making connections between what they see in the media and learn in science lessons and their own experiences, it's about feeling involved in all that and giving yourself permission to have a response" – artist, All Change.

5.7 Increased sense of the personal relevance and significance of science: developing an 'authentic' engagement with science

An increased sense of personal relevance and significance of science was a commonly reported outcome of projects. Pulse projects introduced young people to new science subjects and made connections between science and personal/social experiences in new and surprising ways. This includes an increased sense of the personal, emotional, social and moral dimensions of science, as well as increased knowledge of science subjects:

> "We're acting out real people's lives and it gives more depth to what you're actually doing and makes you feel more into it, you feel it more knowing that real people are going through it and it's an amazing experience to know that…it's quite amazing saying that because like in a science class I would probably say just get me out of the science class because I don't care" – participant, University of Oxford Botanic Garden.

> "I often felt that the kids surprised themselves in their engagement with the issues and some of the questions that they asked of the characters and of the scientists felt

very genuine…there was a sense of I haven't thought about genetics before, for instance, I hadn't thought about the possible problems of free wheeling scientific research going on in the world, but actually I've got to stop and I've got to think, I'm a drama student but I'm a human being too and I've got to think about these things" – actor, Riding Lights Theatre Company.

The type of engagement in learning described here is qualitatively different – less about learning 'facts' or a body of knowledge and more expressive of an engagement with live, complex, human and social implications of science:

> "I think their learning was much deeper, they gained a proper understanding of the subject, not just facts and figures, because they developed the scenes themselves…it was not this is good and this is bad, they were shown the complexity of the issue" – drama teacher, Wyrd Arts.

> "The project helped us to understand cystic fibrosis in a way which we wouldn't have understood if we had learned it just during lesson times, we actually felt what it must be like to have to live every day with a genetic disease and what people with the disease deal with every single minute of their lives" – participant, West Dorset General Hospitals NHS Trust.

> "They've used the story to explore emotions and explore characters…it's not academic, this happened then that happened, it's 'well they did this because they were angry, they did that because they were scared'" – teacher, University of Oxford Botanic Garden.

> "It's a chance for people to take some time and have a personal response rather than having to write essays…engaging on a personal or more emotive level" – artist, Stan's Café.

> "It just really made you think and feel what they must feel like" – participant, All Change.

> "It makes it more human and more thinkable somehow to us…it just makes it feel more real to us" – participant, All Change.

As the descriptions show, young people and professionals involved in projects often characterise the learning experience in emotional terms, and frequently refer to a type of learning that is more authentic – 'real', 'deeper'. Young people's descriptions of participation express a sense of personal and social immersion in the experience of carrying out the project with artists and other young people, and imaginative/emotional immersion in the lived experience of characters in fictional scenarios and other worlds constructed within the creative process. The personal/social and imaginative/emotional immersion can bring science subject matter to life and within reach, and stimulate a more complex appreciation of issues.

> "I don't think they ended up with something where they could say well we learned this about genetics, I think it was a lot to do with the emotional side, there was a lot of bits of science in there but it wasn't presented ever in an orderly fashion which they could write down, like the way they might learn science in school or in the normal way that science is taught or presented to non-specialists, so there was a whole mix of different things to do with lived experience, actual science, the visuals of science, the look of equipment and the materials and the spaces of the hospital, the patients' very personal experiences…I think some of them or maybe even all of them found it a bit hard to put it all into some picture that was comprehensible but I personally don't think that matters, I think that's all in there and it will feed into a much bigger picture" – project leader, West Dorset General Hospitals NHS Trust.

The type of engagement expressed by young people and professionals involved in projects is very difficult to express in measurable terms and is not represented in the science communication/education literature. It can be characterised as participatory (and implicitly social), imaginative and emotional learning. The models of science engagement discussed in the 'context' section above, such as the focus on making links to context, problematising science, stimulating fascination and engaging in debate/discussion, have clear relevance here. However, many science education and communication models remain focused on developing science knowledge and understanding; the extent to which young people gain what science educators would understand as science knowledge and understanding as a result of participation in performing arts projects remains an open question. The participatory, imaginative and emotional type of engagement suggests that young people gain a kind of science knowledge that is not adequately described by current research/literature. This will be developed further in the summary section of the report.

It is important to note that not all projects were interested in exploring the personal, social and emotional dimensions of science. Hampshire Dance's 'Innervations' project exemplifies a different understanding of the relationship between art and science. Here the engagement with science that is expressed by artist and young people is more akin to absorption in and fascination with what scientific investigation can reveal about material dimensions of phenomena rather than social/ethical dimensions:

> "Maybe it's because this is dance and other projects were more theatre where you can take the human story, I really didn't want us to do that…I tried to keep bringing everything back to some of the technical ideas that the scientist had given us, things that had come from ideas on a molecular level, a cell level rather than an emotional state or personality, we really tried not to dwell on the emotional side" – dance artist, Hampshire Dance.

> "You got to know a lot of interesting facts about the brain, and then more general stuff about how to keep fit and healthy and generally how memories are stored" – participant, Hampshire Dance.

5.8 Appreciation of complexity and broadening perspectives; problematising science

Artists and teachers involved in projects noticed that young people tended to express strong and certain opinions in relation to subjects initially, and that, as successful projects proceeded, their appreciation of different or alternative points of view and more complex and diverse perspectives increased, encouraging them to re-examine their values and beliefs, "shaking up what they think" (teacher, Riding Lights Theatre Company). Rather than increasing knowledge of complex science, projects had the impact of increasing awareness of the complex issues involved in the application of scientific developments in society. Across the various diverse projects involved in the initiative this included increased appreciation of the value-laden character of science, different ways of interpreting 'fact' and increased awareness of the complex process of formulating opinion:

> "I still can't make a decision about what my views are on GM issues, I've got my good things and bad things about it, it's a grey area" – participant, Eden Project.

> "The more we researched, the more there was to research, it's such a huge topic and one thing leads you to another and then leads to another thing and it's also about who you can trust, because you can't trust the media all the time to give the truth" – participant, Eden Project.

> "There were no rights and wrongs, it was just presented and there were alternative ways of looking at the information…[they were] beginning to think around the issues, I thought it was very good, it was opening up their horizons a little" – museum education officer, North Warwickshire and Hinckley College.

> "Most young people see things as black and white – this showed how views are blurred in the light of experience" – teacher, Riding Lights Theatre Company.

> "How you read information, how information is presented to you, the misleading statistics or what you're meant to think about things according to how they're shown to you, it feels like that's a powerful lesson to learn and practice to be able to engage in" – artist, Stan's Café.

Such outcomes have clear links to science education and communication outcomes such as increased awareness and interest in science, enjoyment of science, and appreciation of relevance of science.

5.9 Fascination and amazement: cognitive and emotional dissonance

The way young people reported gains in knowledge or insight is interesting and worthy of further comment. Initial encounters with the scientific subject matter created a sense of fascination, disturbance and disruption in young people's ways of thinking about the world. Young people describe developing different perspectives on the world from a science perspective and a fascination with what science can reveal about phenomena. This disturbance stimulates emotional connections to the subject and may facilitate openness to social, ethical and cognitive dimensions of learning:

> "I now get interested in waves at the beach" – participant, Devon Arts in Schools Initiative.

> "When I turn on the tap I think about liquids" – participant, Devon Arts in Schools Initiative.

> "You can see a lit candle for ten miles when there is no pollution" – participant, Chipping Norton Youth Theatre.

> "It's quite amazing to know that bark can be used to help so many people" – participant, University of Oxford Botanic Garden.

> "I found it shocking how many people were dying of diseases…when you see that it shocks you…it's really quite amazing to see" – participant, Stan's Café.

> "The whole DNA thing when I found out that we were like 73 per cent like bananas I was so shocked" – participant, All Change.

> "When I saw the iron lung I couldn't look at it, it was really shocking" – student, North Warwickshire and Hinckley College.

Performing arts processes can provide different perspectives or conceptual frameworks for scientific information via representation of concepts or knowledge in surprising and three-dimensional ways – a talking tree, a pile of rice representing a population of people, a scientist speaking in tongues. These alternative perspectives and frameworks can create a sense of cognitive dissonance (have a disturbing, unsettling effect) that expands horizons and facilitates immediate emotional connections – widening young people's conceptual frame of what is known and what is possible:

> "Usually you'd see a statistic in numbers and it'd look big and you might think, oh yeah, that's quite a lot of people but when you actually see you think, it's a lot of people, it really sinks in, it really brings out a lot of feeling towards the people there, it's like seeing the people really…when you see the finished mounds of rice and you know that you've weighed it out, so you know it's really accurate then it's really in a way it's unbelievable, you know it's true but you just can't believe it when you actually see it yourself" – participant, Stan's Café.

Analysis of young people's descriptions shows that emotional, cognitive and social awareness are closely integrated – shock and amazement stimulate empathy, new insight, ability to appreciate different perspectives, and awareness of the social impact or dimension of the subject matter. The disturbance, surprise and intensity of the experiences recounted may have ensured that learning outcomes are more lasting, by triggering empathic responses. These themes in young people's accounts have clear relevance to understanding the kind of science knowledge and learning implicit in performing arts and science projects, and will be developed in section 10.

5.10 Lack of enthusiasm and confusion about science

Performing arts and science projects provide a space for personal and emotional responses to science subjects, including expressing amazement, confusion, anxiety and enthusiasm for science in a way that young people may not be permitted to do within the science classroom (as a result of the lack of excitement in traditional learning environments and peer pressure). However, where project leaders were unsuccessful in engaging young people in an ongoing process of exploration of the science, young people were less detailed in their descriptions of the science aspects of projects, and generally expressed less enthusiasm:

> "The science talks we had at first were boring, it worked well in the end because there wasn't as much science in the play as we had thought" – participant, The Theatre, Chipping Norton.

> "Sometimes I thought the science bit was there because it had to be" – participant, The Theatre, Chipping Norton.

> "The young people were interested in performing, it was really hard to get them to engage with the science, you could see their eyes glazing over as soon as we started talking about it, we had to work very hard to give them activities which would try and engage them with the science" – project leader, Dynamic New Animation.

There are a number of process/implementation issues that may be related this outcome, for example, artists' enthusiasm for science content, and confidence and ability to inspire young people.

Some projects did not manage to engage young people in a **process** of engagement in the science (that is, facilitating exploration of a variety of perspectives and of science as it is applied in the real world rather than in sensationalist or science-fiction scenarios), leaving young people expressing confusion, fear and anxiety about science:

> "I think they have made a clone already, the government, there's so much they keep from us all the time" – participant, Oval House.

> "Some people in the audience were going, 'this is bad, this is bad, this nano thing, these nanoparticles are everywhere'" – participant, Dynamic New Animation.

It is important to note that expressing confusion and anxiety is an important part of a learning process. However, where these initial responses are not worked through via a process of engagement, the outcomes may be resistance to science rather than increased engagement. Again, a number of process issues were relevant here, including lack of science collaboration, difficulties engaging young people, and artist lack of confidence with science subject matter:

> "Whereas we attempted to demystify the whole cloning thing, I think we made it even more of a mystery which was not really helpful…I think it's a huge amount of fear that they have around science, especially things as big as that because nobody explains it in real layman's terms for them to understand…we did do a lot of that, and we talked a lot about how it's actually done, but I'm not a science teacher, so me explaining it to them is difficult, I explain what I know about it, and I did a lot of research on it, and it's still really complicated to me in my head how it actually works" – director, Oval House.

These issues are taken up in the artists and process sections below.

5.11 Performing arts/science with young people: features of practice that 'worked' according to young people

In interviews, young people were asked to explore how their experience of doing the project was different from and similar to their experiences of learning in science lessons. Their feedback – their constructions of the performing arts as a means of engaging with substantive science and socio-scientific issues and debates – can be shown to express a model of ethical education and illuminate the mechanisms by which successful performing arts projects engage young people in exploring complex issues. Three key aspects of processes emerge as significant for young people:

- Explorative, participatory, interactive approaches:

> "It's a different way to learn it by dancing through it, you're not in a classroom…it's a different way of being taught, because teachers just dictate to you, you just answer questions and write things down, but here you have to experience it for yourself, you've got to like feel what you're learning, I can't really explain it… you get to feel it and go through it and know what it's about as well as just learning it" – participant, All Change.

> "In lessons they're not making sure we've absorbed it and we're taking it in but this way we actually get to do it, we get to experience it" – participant, University of Oxford Botanic Garden.

- Performance practice as research and exploration:

> "[In science lessons] we'd do a lot of answering questions, but not really put it into a real-life situation and try and understand how it is" – participant, University of Oxford Botanic Garden.

> "If you sat in a classroom and learned everything there is to know about it…it would just go in one ear and out the other, you'd be like, 'yeah, yeah, when is this going to ever affect me in my life, what a boring lesson'…because we're actually performing, we got into character and we're acting and like, 'oh yeah, this is how it feels, this is how it feels to be a villager'" – participant, University of Oxford Botanic Garden.

- An opportunity to play a responsible social role – projects that supported young people in playing a responsible role in a creative process secured high levels of commitment to processes:

> "You knew you were on about something that really touched people's lives, it had more of an aura to it, more excitement and wanting to do it" – participant, University of Oxford Botanic Garden.

Young people make a distinction between experiential learning, including physical and active involvement in the exploration of ideas, and passive consumption of knowledge. Their responses suggest that an interactive, participatory environment enhances understanding, motivation, integration and recall of learning as it provides opportunities for emotional and imaginative engagement. Participatory arts processes involve observation, listening, communication, imagining and embodiment of experience via movement, performing roles and manipulating objects. Artist willingness to share responsibility for creative processes with young people, and to ensure young people's responses were the centre of processes, enhanced the quality of young people's experiences.

Non-didactic approaches can incorporate a degree of information giving, but this is done within the context of an active and experiential exercise, and does not involve an end point of

a fixed and certain answer. This approach enhances autonomy and asks young people to take responsibility for their learning process; it can secure high levels of commitment to projects and an important sense of ownership:

> "Science is about living things...in school, it's hard to do a real experiment and provide a sense of not knowing what the answer is and be excited about finding out the answer whereas in drama, if you are making a narrative, it is your story and you do produce it" – drama teacher, Tricycle Theatre.

Many projects combined didactic with non-didactic components, but it is clear that the strength of participatory arts processes lies in creating spaces for young people to express responses to subjects in a more open, multifaceted and explorative way than in formal education (often, a contradiction or culture clash between constructions of learning in formal and informal education resulted from this, apparent in those projects that worked in school environments – this clash is explored in more detail in section 9):

> "You're interacting more…I think if you were sitting in a boring classroom just doing writing and copying I don't think you'd pay much attention, but if you're actually doing something like this you're going to learn more because you're paying more attention" – participant, Stan's Café.

Young people value opportunities for active involvement and exploration in the workshop setting and real-life scenarios:

> "This is like another lesson but it's more interesting and more amazing to do because it's, you're actually going and doing this" – participant, Stan's Café.

> "As soon as you put them inside the situation of actually if this was your little brother, what would you do? It's actually a much stronger way of getting them to talk about it than saying this boy has this condition he's epileptic and the drugs didn't work and da da da, you get this kind of non-connection, so for me it's always about getting inside the kind of emotional, imaginative head space that says what would you do? Who would you go to? How would you make choices?" – project director, Trestle Theatre Company.

Young people and artists conceptualised performance processes as providing opportunities to explore a wide range of differing perspectives and positions. The University of Oxford Botanic Garden participants described the research process in two important ways. Discovery comes about via being placed into a fictional scenario that provides imaginative freedom and a sense of autonomy but also involves discovering how 'real' people might think and feel, or making other discoveries about the 'real' world. It is important to note that there is no separation between the 'science' and 'art' component of projects in these constructions. In addition, researching experience via performance can be an extremely efficient way of exploring complex issues:

> "The play explores a lot of quite complex issues, when the audience come to the workshops they've picked all those issues up and they've realised all the things that are going on between the characters and ideas and the history, I mean how many lessons or textbooks would you have to read to get that across in one hour?" – participant, Eden Project.

Providing opportunities to perform to other audiences enhanced this sense of responsibility and gave projects an additional sense of rationale:

> "What we did was really fun, we got into other people's shoes and really explored the way they were feeling and what they were going through and tried to understand the situation and after learning everything just bring it to the script and make the audience understand what's going on to make the message really clear" – participant, University of Oxford Botanic Garden.

For some young people, the responsibility attached to the role they played within the project contrasted to the social role they played in normal routines outside of the project:

> "They saw each other in a different light, I saw some of the kids working really well, I was so impressed with them yet in the classroom they don't always give that impression, it was really nice to see them out of the classroom, you could see their talents and what they were capable of" – teacher, Stan's Café.

5.12 Sustainability of outcomes

Some participants and professionals involved in projects raised the question of sustainability of science outcomes for young people. There is strong evidence to suggest that participation left some residue that would support ongoing engagement in science. However, there may be a lack of opportunities – both inside and outside of formal education – to secure this engagement. This evaluation did not collect evidence relating to levels of engagement in science lessons. However, increased engagement in science learning via the school curriculum (although this may occur for some young people) may not be an appropriate indicator of a project's success. The need for alternative opportunities for engagement in science both within and outside of the formal science education curriculum is highlighted:

> "I don't think I want to become a biologist but I would like to keep up-to-date sometimes on what's happening in this present moment and what could happen in the future… [Interviewer: Were you interested in this subject before doing the project?]… If it was there and it was on the TV and I ended up watching it then yeah, I'd be interested in it because like I said it's knowledge but apart from that I don't think I would have went out of my way… [I: Would you go out of your way now?]… Only if it was a part 2 of doing the play" – participant, Dynamic New Animation.

> "To really root an ongoing interest in science there has to be more of an exit strategy or some way of engaging them on the edge or beyond school" – artist, Devon Arts in Schools Initiative.

5.13 Impact on young audiences: 'click' moments, moments of confusion and moments of contemplation

> "…having a moment when things 'click' enhances visitor experience and encourages further investigation and discovery. However, this connection is often determined by personal factors: pre-existing interest, experience and knowledge can help some visitors understand and engage with an exhibition. Others might not make the connection unaided, and as a result will have a less satisfying or 'enjoyable experience'" – Wellcome Trust and Arts Council England 2004.

Research into visitors' interpretations of science/art exhibitions has highlighted the complexities involved in how audiences receive and interpret science/art products. The 'Ask the Audience' research (2004, commissioned by the Wellcome Trust and Arts Council England) identifies strategies such as invigilation, signage and leaflets that aim to facilitate interpretation and provide information about the science context of artistic products. Evidence relating to how young audiences interpreted Pulse performances also raises the issue of interpretation. It is clear that some performances left some young people feeling confused, mystified or misinformed. Many scientists involved in Pulse projects identified the need for more supporting information (books, leaflets, advice as to where to go for more information) for young people and audiences in order to secure science outcomes of projects.

Most young people attending performances report that performances led to some increase in knowledge and insight into the issues explored:

> "I learnt that genetic engineering can be helpful and wrong, also that it's quite amazing what you can do with it" – audience member, Wyrd Arts.

> “The play was fun and also very interesting to watch, made you think about who you are and what’s in your body and how people who have got difficulties feel” – audience member, Wyrd Arts.

As with the participating groups, responses relating to emotional and cognitive dimensions of the learning were common, with some appreciation shown for the more complex areas of debate:

> “I wondered what it would be like to have polio” – audience member, North Warwickshire and Hinckley College.

> “It makes you think about why parents don’t want their child vaccinated” – audience member, North Warwickshire and Hinckley College.

> “It made me think about diseases and ways to prevent them” – audience member, North Warwickshire and Hinckley College.

However, some young people (in many cases audiences of the same performances), expressed a degree of anxiety or confusion around the themes of the play:

> “I learnt that you could die from having a jab” – audience member, North Warwickshire and Hinckley College.

> “I got more scared about polio” – audience member, North Warwickshire and Hinckley College.

> “I learnt that in the future everyone will be perfect” – audience member, Wyrd Arts.

> “I thought it was really complicated, I didn’t really understand” – audience member, Wyrd Arts.

> “The science bit was confusing” – audience member, Wyrd Arts.

> “Some of it was over their heads, if we’d have known the topic beforehand we could have prepared them” – primary school teacher, Tricycle Theatre.

> “It was a bit mad to understand, it was good though…I didn’t understand some of it” – audience member, All Change.

“I didn’t actually get any genetics ideas from that because when that came on it was just a load of people dancing” – audience member, All Change.

All Change audience members quoted here had taken part in the project as non-performers, and had come to see the performance. Interestingly, the company did organise an educational factsheet to be inserted into programmes for the event. However, these participants had only looked in the programmes to see their own names rather than read the information (there was evidence of other young people reading the information). These responses raise the question of what, if any, strategies are needed to support and guide young people’s interpretation of science information in performances. This issue is taken up in section 6 below.

6. Impact on arts professionals

The Pulse evaluation provided a welcome opportunity to carry out in-depth qualitative investigations of how science can be brought into a creative process to engage young people, via interviews with arts teams attached to each of the 23 projects and observation of sessions. The findings reported here provide points of comparison and guidelines that should be helpful to future practitioners. This section starts with an exploration of the impact of taking part in Pulse on artists. Where appropriate, information relating to process is included here. It is important to note that 'artists' refers to a range of arts professionals engaged in projects across the initiative, including professional/practising artists, arts education workers, and 'applied' or 'community' arts professionals.

The main themes in findings relating to the impact of Pulse on artists and artists' process are:

- an opportunity to experiment
- increasing artists' capacity to do performing arts and science projects
- ways of working with science; narratives of performing arts/science integration
- facilitating young people's engagement with science in a performing arts process
- facilitating young people's engagement with science in the transaction between performance and audience
- establishing a focus
- ways of presenting the 'science' to young people: participatory modes and limitation as stimulation
- artists' narratives of Pulse projects – trajectories of excitement, anxiety and confusion…moving towards confidence.

6.1 An opportunity to experiment

Motivations to apply for the funding varied across the initiative. Many organisations (11) saw Pulse as an opportunity to develop or extend the reach of an existing interest, idea or project involving science. Others saw the funding opportunity as a means of developing their work into a new, challenging and exciting area; many projects were facilitated by artists who had not worked with a science stimulus before. Pulse left many artists with a new sense of possibility regarding themes and issues of relevance to young people and wider communities that might be brought into future practice. In addition, the initiative provided opportunities to experiment with process: for example, some companies extended their capacity to carry out participatory work with young people, carry out research and development, and work with unfamiliar art forms and processes, as well as exploring new subject areas. Pulse projects left organisations and individual artists with ideas for exercises and approaches that they could incorporate into their ongoing work and increased confidence to try out new stimuli and models of practice.

The opportunity to work with scientific stimulus was seen as novel, surprising and challenging by many artists:

> "It's nice to have a really strong theme and be thinking about how to use your skills to express it, it's an interesting challenge" – artist, All Change.

For some artists, projects provided an opportunity to try out new models of practice and art forms; the scientific subject matter provided an opportunity to experiment with artistic form and process:

> "I think that's the first time we've actually had the opportunity to get young people involved to feed into that part of the creative process which has been great…it's something that we'd look at doing again absolutely, there were all sorts of changes here and changes to the project…this was a trial" – director, Trestle Theatre Company.

> "I'm a visual arts person so [live performance] was new territory for me…I found it very exciting and I think that way of working has huge potential" – hospital art coordinator, West Dorset General Hospitals NHS Trust.

The novelty and challenge presented by the initiative stimulated high levels of excitement, enjoyment and commitment to projects from artists involved (often many more artist hours went into projects than were budgeted for):

> "This was one of the most important pieces I have ever done because we were really trying to do something about which we didn't have the answers" – artist, West Dorset General Hospitals NHS Trust.

> "It was quite liberating to allocate that amount of time to research and not feel like you had to force things, but it was also quite scary…it made me work in a different way, it made me prepared to take risks" – artist, Double Vision.

6.2 Increasing artists' capacity to do performing arts and science projects

Pulse significantly increased participating artists' capacity for taking on future performing arts and science projects. The overwhelming majority of arts organisations and artists involved across the initiative expressed a desire to explore scientific subject matter in future projects. Almost half the organisations (11), all but two of which had previously been new to the area of science projects, were already beginning to plan their next science project at the time of the final interview. At least three artists connected to the initiative were exploring other avenues of support to explore science issues at the time of the second interview (via scholarships from the National Endowment for Science, Technology and the Arts).

In addition to these quantitative outcomes, many artists expressed a sense of having discovered a new perspective on practice, the possibility of taking professional trajectories in new and exciting directions, including being more innovative with aesthetic form and process. Again, there is a sense of excitement and possibility in artists' accounts:

> "What I got from the project personally was the sense that there is a wonder in this that I'd forgotten all about, I've been reading some stuff, and I'm not a scientist as I said, but it's been great reading some basic scientific books written for lay people…how it collides with the work of artists fascinates me, I think there's kind of a renaissance there, depending on how people push it, that meeting of disciplines…it's opened up a whole new vista for me and I'm now desperate to write this next play" – writer, Eden Project.

> "If you're a scientist you can apply that to artistic medium and if you're an artist you can apply those principles to scientific medium, it's all about being inquisitive and finding solutions to problems" – visual artist, Hampshire Dance.

> "For me this was an experiment, an experiment of something which I think can be bigger…I've never done anything quite like this" – artist, Devon Arts in Schools Initiative.

> "I became more and more intrigued…I was approaching something I had not done before and I was hopeless at science at school and suddenly I was finding this all riveting and was able to understand it which surprised me" – comedian, Double Vision.

> "There's so many incredible possibilities creatively, it seems like a new area and certainly it is a new area for us, so that's really exciting" – artist, Hampshire Dance.

The presence of artists who are inspired and enthused by the scientific subject matter is essential to successful projects. Projects that do not generate this interest in artists fail to engage young people.

6.3 Ways of working with science; narratives of performing arts/science integration

What is/are (the) science(s)?

"…the great achievement of the sciences, over the past three or four hundred years, has been to tell us interesting and important new things about ourselves and the world in which we live. They by no means tell us everything, or even the most important things we want to know about the world. But what they do, uniquely, is to offer a knowledge that can be relied upon for action. This reliable knowledge is much more than a compendium of things that happen to have been observed; it presents the world in novel and surprising guises, saying that things are in reality often not as they seem to be. Science tells us, for example, that diseases are carried by micro-organisms invisible to the naked eye; that heritable traits are carried by a chemical code; that all species have evolved from simpler organisms; that all substances are held together by forces which are electrical in nature; that the many varied substances that we see around us are made up of different rearrangements of the same few particles; that we live on a rocky ball with a hot interior which circles the sun; and that the universe had its beginning in a huge explosion. Acting on the reliable knowledge which science has produced, scientists have developed a staggering variety of artefacts and products, ranging from electrical motors to antibiotics, and from artificial satellites to genetically engineered insulin for treating diabetes, which have transformed our lives and lifestyles compared with those of past generations" – Millar and Osbourne 1998, 2007.

Science is multifaceted; the term is used to refer to a method for exploring the world, a set of attitudes and values, particular types of knowledge about the world, and technological development. There is similar plurality to the way 'the arts' refers to a diverse range of cultural practices. The arts and science take participants through processes of discovery about the world and our relationship to it. However, both 'art' and 'science' have culturally specific meanings, in particular, they are often constructed in opposition to each other: 'science' as hard, fixed, humourless, rigorous, disciplined, useful; 'art' as fluid, enjoyable, frivolous.

For any artist approaching science for the first time, the plurality of sciences, and the range and complexity of subjects and processes 'science' refers to, as well as culturally specific constructions of science and art, create formidable barriers and challenges as well as exciting opportunities. There are many pitfalls: for example, artists can easily become overwhelmed with the complexity of the technical information as well as ethical issues.

This section explores how artists have worked to bring science into a creative process with young people, with examples from Pulse projects. It is important to note that the integration of science was generally achieved in partnerships with science professionals – section 8 below explores in more detail the role of science mediators in this process.

6.3.1 Narratives of performing arts/science integration

Successful projects have integrated science into a creative process that engages young people and provides space for them to express personal responses. Analysis of the Pulse initiative has highlighted three models or ways in which science can be integrated into a creative process:

- narrativising and personalising science
- experiential or sentient science
- embodiment of conceptual science.

'Science' and 'art' can be constructed differently within each approach. All three models provide cognitive, emotional and imaginative points of engagement with science. There is no evidence to suggest one approach is better than the other, but some evidence to suggest that the outcomes of approaches across different projects may be slightly (although not widely) different. Many projects incorporate aspects of all three approaches.

6.3.2 Narrativising and personalising science

Narrativising science

"The writer did an awful lot of research on the issues coming out of the 19th-century story and the contemporary medical issues and I think particularly the first draft was very much closer to a lecture and a historical piece of writing more than a drama and so the process has been about moving that on to make it work as a piece of theatre…it has been all about saying yes this is really interesting medical journalistic material from the 1820s but actually, if you're trying to engage a young audience now, what do they care about? It's about the interrelationships, it's about how that little person with a very specific medical condition then didn't have a voice and in the contemporary story hasn't got a voice now and where does the responsibility lie?…I hope that it becomes quite an emotional story and so what you're giving to an audience is a story they care about, a story they are engaged with but hopefully enough questions in there are posed for them to go away thinking about the issues" – director, Trestle Theatre Company.

A number of projects provided points of engagement in science and socio-scientific issues via a narrative that sought to engage young people's interest and feelings. Audiences or participants would observe/create a story that was stimulated by a science issue and explore debates via identification with the shifting positions of characters in the narrative. Where these projects had a participatory element they tended to employ some kind of didactic presentation of 'the science' followed by creative and participatory exercises designed to encourage exploration of personal responses. For audiences, observation of performances tended to be followed by post-show discussions and workshops to highlight scientific concepts, explore scenarios from different perspectives and encourage young people to develop views and opinions about the relevant issues. Performance products and processes contained a mix of information giving and exploration of responses, thoughts and feelings via the arts content.

In this model, Pulse artists tended to construct the science aspects of the project as a fixed, solid base for the more explorative aspects of the project. Creative and participatory exercises tended to be structured around or be stimulated by didactic learning exercises:

> "[The science stimulus] is quite good to have there, because you have this baseline, it's solid, the students have something to come back to so I think it works particularly well as a drama exercise, whether it's from the science point of view of a student exploring the material and then with drama working out how to present it" – project leader, University of Oxford Botanic Garden.

Many artists experienced a difficulty with getting the balance right between science information (and responsibility for accuracy) and free exploration:

> "It was always a question of how much science? Because you start to talk about amino acids and the nature nurture thing and you could go off on one, there's a whole evening in itself…obviously it has to be accurate, we have a responsibility to that so those bits are set in stone…the comedian was more used to running with things really, I wanted him to interact and play with the audience but it still had to have those tight structures" – director, Double Vision.

Again, the science here is fixed ("set in stone"); in this and other similar projects, the performing arts were perceived as humanising, personalising and exploring science's relevance to social life:

> "It will start with the personal, so each dancer will bring in a personal story about being left-handed…then we will look at the myths of being left-handed and then we can look at the science" – director, Double Vision.

The dilemma of 'how much science?' is finally resolved by remaining in an explorative and playful mode while signposting routes to further information for audience:

> "The way the dancers were interpreting the science was personal…and my job was to comment on that, a bit like a Greek chorus…I wasn't as free to play with the audience as I would normally be, I had to serve the subject and keep things moving along…the first piece I wrote was much too serious and had too much information in it so as I said, this is kind of a Sunday supplement approach, to interest you rather than give you information which is absolutely supportable and correct" – comedian, Double Vision.

The strength of the narrative approach is its ability to spark an interest in science and highlight social and ethical consequences of the application of science in society. However, one pitfall of this model is that where young people are the end consumers (rather than active participants, involved in creating and refining the story) and are not given an opportunity to engage in an effective post-show activity, the artists have a more meaningful engagement in science than young people.

6.3.3 Experiential or sentient science

Some projects focused on providing an opportunity to explore science on a more emotional or perceptual level rather than via a direct encounter with science knowledge or issues. Here, the creative exploration was an end in itself, stimulated by science information but tending not to revisit the 'science', at least in a traditional format, during processes. In projects that took this approach, the process was weighted towards creating moments for personal response or contemplation that were subsequently expressed through the work that was produced. The stimuli opted for tended to be human experience – fictional and real-life scenarios – rather than science concepts:

> "We got them to imagine a time when they could reproduce asexually and you could actually morph your genes and then we stated that visually, using the laptop and technology to produce moving photo mugshots and they cut up the images and started morphing, someone's mouth, someone else's eyes, someone's earlobes, we just started doing it visually and then talking about how we can inherit earlobes, and we might be able to curl our tongue whether we like it or not and our features are genetically linked…so there wasn't loads of science, visual experimentation would start the activity" – artist, All Change.

These projects challenged conceptions of science education. In projects that took this approach, there was less of a balancing or weighing-up process between the science and the art – processes tended to be underpinned by a clear arts methodology and a commitment to exploring the responses of young people openly. One project focused on representing young people's emotional responses to their exploration of experiences of living with genetic disorders and hospital treatment. This project deliberately rejected any imposition of interpretive frameworks to support interpretation by audiences or to stimulate creative activities; issues were an implicit part of creative exercises exploring experiences and personal responses, without any additional science explanation required.

"The patient did a fantastic workshop with everyone about his breathing, he gave all of us a straw and said OK for 40 minutes you can't do anything but breathe in and out through that straw. And then we had to do ordinary things like run around the room and of course it's incredibly incredibly difficult to do and then he said how he dealt with his sickness, he said something like the way to keep my breathing regular is to read, and so one of the scenes ended up with the children reading to each other and one child breathing through the straw trying to keep calm and the other reading to him, that's the way that ideas evolved" – project coordinator, West Dorset General Hospitals NHS Trust.

"The project co-ordinator and artist have developed a strong value-based methodology. It is rooted in a clear framework and tight organisational structure creating a secure emotional and physical space. This is essential to enable artistic and creative freedoms and genuine emotional engagement. A strongly inclusive ethos underpins the process which aims to find a place for everyone's experiences and ideas. During this project as individuals contributed ideas, the artist responded by designing the next stage of the workshops to enable the whole group to work on these ideas…The performance process was democratic and rooted in personal testimony from all participants; it engaged artists, teachers and students in a genuinely innovative and experimental creative process" – excerpt from project report, West Dorset General Hospitals NHS Trust.

6.3.4 Embodiment of conceptual science

> "Scientists don't think about ethics, they just ask questions about the world" – artist, Devon Arts in Schools Initiative.

Only two projects can be said to exemplify an attempt to use physical theatre and dance to embody scientific concepts or ideas (Hampshire Dance and Devon Arts in Schools Initiative). In both, there was a conscious avoidance of social and ethical dimensions of science and a concentration on exploring patterns and processes in the material world. The focus is on exploring scientific concepts via physical theatre, dance, movement and objects. The Devon Arts in Schools Initiative project explored how creative activities could engage with science at a conceptual level, to physically and conceptually (imaginatively) involve young people in a process of enquiry into the phenomena in the world. This was more than representing technical information; it was a process of using participatory arts as an investigative and representational tool for learning about patterns in the physical world (as well as exploring learning itself and processes of consciousness):

> "I have experienced the difficulty with this integration and how powerful and domineering certain types of theatre can be, it can blow your science right out of the water, particularly naturalism, which can be OK for exploring ethical issues, but when it comes to the science concepts, I think naturalism turns them into a story about something" – artist, Devon Arts in Schools Initiative.

Importantly, both of the projects that took this approach had extremely good partnerships with scientists or science teachers and/or were facilitated by artists that had extensive knowledge of the science subject matter that was being explored.

"When they're given some information and asked to physically re-create it, they have to show some sort of understanding. So, you do the nucleus and the cell, in a cell is always a nucleus, with a membrane around it. You can produce a drawing of it, but maybe, if they're drawing it in 2D, maybe they think it's like a piece of cake and the nucleus could drop out, rather than being completely encased in the membrane, in a pattern workshop, you would see that" – artist, Devon Arts in Schools Initiative.

"I tried to keep bringing everything back to some of the technical ideas that the scientist had given us and the dementia, things that had come from ideas on a molecular level you know cell level rather than an emotional state or personality so that was kind of on purpose that we really tried not to dwell on the emotional side…in the dementia piece the only ideas we worked with were things going backwards and things being stopped and things breaking up" – dance artist, Hampshire Dance.

6.4 Facilitating young people's engagement with science in a performing arts process

"We learned quite a lot in the first session about the science but I think we gradually forgot it over the lessons" – participant, All Change.

Keeping the science focus 'on track' has proved a significant challenge for many projects across the initiative, whatever approach they have taken to performing arts/ science integration. As noted above, not all projects 'worked' in the sense that they achieved the aim of Pulse to engage young people in debates about the social and ethical implications of advances in biomedical science. Some projects only partially succeeded in managing the integration of the science focus with a degree of confidence and clarity that allowed them to stay 'on track' in terms of the accuracy and significance of the scientific subject matter, and to engage young people in an exploration. It is important to note that Pulse projects also challenged conventional understandings of science learning; the feedback of young people suggests that the experience of shock and surprise, or feeling moved or touched, is as important a science outcome as learning information. However, a small number of projects failed to engage young people either cognitively or emotionally in the science stimulus.

Artists explored the challenge of working to make the scientific material engaging and interesting for young people in interviews:

"How do you address genetics with young people? Do they know anything? Do they want to know anything? How can you tackle it and present it in bite-sized chunks so they can grapple with it and produce a creative experience that engages with the concepts?" – artist, All Change.

"The particular struggle was finding a way in, the subject matter was really interesting to me but the problem was engaging the young people…finding a way to push the buttons to make them actively care about what was happening" – writer, North Warwickshire and Hinckley College.

"We tried in discussion to talk about the most interesting, the most impactful stuff that we can think of to get us turned on and the artists start talking about the impact and what it means politically and society and everything like that and the young people were just not contributing to that discussion whether that's just because they feel that it's beyond them or they don't know enough or they just don't care, we're not sure, but we have to find other ways for them to engage with the subject" – project leader, Dynamic New Animation.

Artists' lack of confidence in managing the science sometimes included feeling under pressure to teach complex science that was beyond their own understanding:

> "Initially we were looking at this whole idea of genes and we got some information off the internet and it became a real in-depth thing…the genetic stuff became a too mind-blowingly in-depth subject for us to explore…maybe if we had someone else who was a bit more science-orientated that we could have brought in then possibly we would have more of an angle on that but at the moment we haven't" – project leader, Southport Arts Centre Youth Theatre.

This highlights a need for effective partnerships and mix of skills within partnerships to discover an appropriate and manageable science focus for both artists and young people. It also presents a dilemma for the management of Pulse. Some projects clearly could have benefited from greater direction in terms of accessing science support, clarification of the science agenda and, indeed, developing an understanding of 'science' as a concept. However, artists also appreciated the independence afforded to them within the funding initiative; this autonomy and flexibility facilitated innovation. The presence of artists with an interest and enthusiasm in the science (in its technical as well as social and ethical dimensions) was very important to projects' success. There is a need to engage artists with an interest in science, ability to learn and develop their ideas and ability to create and maintain relationships with science collaborators and others throughout projects.

6.5 Facilitating young people's engagement with science in the transaction between performance and audience

Pulse projects exhibited diverse, creative and unique ways of supporting science information in performances. In some projects, presentation of science information was incorporated into the performances via visual devices and presentations by actors in role. Other projects incorporated post-show discussions; however, it should be noted that these were not generally a success in generating a balanced and informed discussions where a science specialist was not present. The most effective and frequently used strategy for supporting science communication was use of a post-show drama workshop, employing participatory exercises and activities to develop young people's thinking about issues raised in plays.

Some artists felt the performance alone was not sufficient in facilitating an engagement in complex science debates:

> "It was a great luxury to write a show knowing that there's a workshop after it because you can't do everything in an hour's show, but what you can do is engage them imaginatively in the subject material, and then hopefully if the workshop is correctly pitched, they can then get more into the material, in more depth afterwards" – writer, Eden Project.

Eden Project participants (who devised and led a workshop for younger people alongside their performance) discussing the importance of the workshop

Participant 1: "You go into the workshop and you pick the play apart and you talk about the characters and their opinions, and it works really well as a whole, but the play on its own is probably not as good, we need to fill in the gaps."

Participant 2: "…the play itself is only half-hearted, you do need the workshop…"

P1: "You need time don't you? Because everyone interprets things in different ways…it's really important that there is that depth in the play so that we can explore that a bit more."

P2: "There isn't a lot of the science or anything else in the play but I love it when you've got a group and you give them a GM fact in a workshop and they go 'wow, I didn't know that', it's really cool."

P1: "…they always think that if it's in the play it must be true. And I think that is a really important thing to come out of this, realising that not everything you hear is true, they think it's true what you're telling them, they take that as fact, every time, all of them."

P2: "…they learn that people's opinions are their opinions. It's not fact."

Pulse projects span a variety of models of science communication/education. The question of what interpretive strategies are needed (in addition to creative processes and products) to support young people's engagement in science is addressed differently by different projects. It is important to note that the question of interpretation itself is linked with a more cognitive approach or understanding of engagement in science. As has been shown, some Pulse projects sought to stimulate an experiential or emotional engagement. Artists involved in such projects might reject the notion or principle of guiding the meaning that audiences make of artistic work, perceiving the arts as a means of stimulating and working with responses rather than providing 'messages'. The experience of engagement is enough in itself; indeed, the incorporation of didactic, non-participatory strategies might even turn young people off from ongoing engagement in the artistic product:

> "…the need to provide some explanation so people don't feel alienated or excluded should be balanced by the need to retain experiential integrity…enjoyment and impact come largely from giving the visitor space to make a personal discovery – rather than have interpretations and explanations imposed on them. Indeed, sometimes the absence of explanation can enhance the moment of connection or, 'click'" – Wellcome Trust and Arts Council England 2004.

One particularly innovative Pulse project focused on representing young people's emotional responses to their exploration of experiences of living with genetic disorders and hospital treatment. This project deliberately rejected any imposition of frameworks to support interpretation by participants or audiences. Audience responses reveal that the performance had a profound impact; audiences described the performance as unique, strangely disturbing, thought-provoking, unsettling, powerful, memorable, impenetrable, courageous, humorous and moving:

> "A sort of direct, even quite dangerous but very live experience that for me really encapsulated what the value of the live arts can be" – audience member, West Dorset General Hospitals NHS Trust.

> "One of the things I thought afterwards was walking through the hospital corridors whilst it was going on was like being in a carnival in the way it took over the space, it was wonderful but also a bit scary, it was strange, it wasn't simple, tasteful or easy, it

went over the edges sometimes and that was scary" – hospital arts coordinator, West Dorset General Hospitals NHS Trust.

Innovative projects can challenge formats of conventional science communication and education. Pulse projects highlight a need for further experimentation and reflection on the transaction between science stimulus, creative process and audience/ participant. The highlights the need for flexibility and openness to innovation in performing arts and science projects with young people, and the need for exploring strategies to support interpretation.

Performance is a medium that can have a powerful emotional impact and provide moments for personal response and contemplation. Successful Pulse projects worked to inspire powerful engagement(s) with science in a variety of ways. However, the evaluation suggests that there are at least two aspects of the transaction with an audience (and participants – this point also relates to 6.4 above) that are important in provoking engagement with the scientific subject matter: to contextualise the science and to problematise it. Young people need to be able to make connections between the science they are presented with and their own experiences (or experiences of other people), and their engagement is more meaningful when they are presented with a provocation in the form of a problem, risk or uncertainty.

6.6 Establishing a focus

"I put a pile of jeans on the chair and they were all different sizes, I wanted them to try and put the jeans on but not in the conventional way, so not how you would normally put a pair of jeans on…some put them over their head, wrapped them around their ears…the one who did the ears, it was like she couldn't hear anything, they were covering her head so she couldn't see anything now…I think that was a great moment actually and it was hilarious but also extremely potent because of you know the disability it gave them, it was a different one than the one they've got already" – project leader, Pathways.

Artists were faced with the challenge of establishing a focus or stimulus for projects from what were often broad areas of interest in project applications. This consisted of establishing a clear idea and developing practical participatory and creative tasks for groups that would engage them in the subject matter and secure commitment to projects:

> "The first discussions with the artists were fantastic but the project was just expanding beyond horizons and it was almost impossible to focus anywhere because everyone was getting too excited and we could have talked for a month…we sat down with the scientist and said if you were speaking to a group of people, what are the main points you would like to get across to them?...what's the most important thing you would want to get across about genetics?" – project coordinator, All Change.

Projects established different starting points, including:

- real-life stories representing a political or socio-scientific issue – a story of a "tiny, obscure tree used in tribal medicines that becomes linked to big corporations and medicine in the West" (education worker, University of Oxford Botanic Garden)
- personal experiences – Double Vision's project started with personal anecdotes from the dancers about being left-handed; the West Dorset General Hospitals NHS Trust project began by asking pupils to explore their birth stories
- future-oriented, science-fiction scenarios – Oval House started with the scenario of 'waking up at 16 years old and discovering you have a clone'
- fictional or metaphorical non-naturalistic scenarios, representing ethical dilemmas or scientific concepts – the Pathways project's use of the jeans metaphor; All Change's exploration of fictional genetic disorders via dance; Hampshire Dance's physicalisation of neural pathways.

6.7 Ways of presenting the 'science' to young people: participatory modes and limitation as stimulation

Many projects incorporated a formal 'presentation of the science' to young people in order to provide a scientific base and stimulation for explorations. These presentations included use of internet materials and articles, formal science lectures by scientists or science communicators, participation in workshops by scientists and science communicators (where they would take part in processes and make appropriate interjections), and participatory games and exercises. Most projects used a combination of these approaches.

Young people generally reported that the parts of projects that involved introduction of science without opportunities for active participation – science lectures and independent reading and research – were the least engaging aspects of projects. Participatory modes of presenting science including opportunities for active participation tended to be more successful with groups.

This was the case unless there was an excellent science communicator involved in delivering a lecture. For example, the Riding Lights Theatre Company performance and workshop toured to 18 schools and colleges and incorporated a formal science presentation. Responses in questionnaires that rated the success of different parts of the day varied greatly depending on which science communicator was responsible for delivering the lecture (a number of science communicators were employed over the course of the tour). Although each scientist delivered the same presentation (including the same content and visual aids), where one particular scientist was involved, the science presentation was consistently scored higher by young people than any other part of the day. Where other scientists were involved, the science input consistently scored lower than the drama workshop and performance elements of the day. The actors reported that this scientist had extremely good communication skills, was an experienced presenter and varied his presentation spontaneously in response to the changing mood of audiences.

Participatory modes of presenting science

"There was quite a nice exercise where they wrote down all the words they could think of that were connected with immunisation and how people felt about it, we gave them the words back and asked them to write a political speech about why they should and shouldn't have immunisation, passionately being for or against it, and we gave them characters and had a massive debate" – project leader, North Warwickshire and Hinckley College.

"The scientist did lots of practical things, quizzes, making a matrix out of wool using their bodies to show different connections in the brain, a *Who Wants to be a Millionaire?* quiz with basic facts about the brain and he did talk a bit about memory as well" – artist, Hampshire Dance.

'Limitation as stimulation' is another theme that emerges from artists' accounts when discussing ways of presenting science stimuli to groups of young people:

> "My role in the first session is to keep it as short and sweet as possible and just give them the nuts and bolts of the story and the different views people would have" – education worker, University of Oxford Botanic Garden.
>
> "I think sometimes one tends to kind of over-explain things and by the time you've finished talking there is nothing left for the kids to do, you've given them so much detail about what this is and what that is and how one should or shouldn't do it that where is their creative space?" – artist, Devon Arts in Schools Initiative.

Limitation as stimulation

"I started by saying 'we're going to look at patterns in science and we're going to do it over eight weeks so let's get going with the first one, get into groups of four and show me a wave in the sea and how it forms' and they went and did it, then it was interesting because you can say 'that's a transverse wave, you've accidentally created a perfect wave' or whatever and you can start to draw it out" – artist, Devon Arts in Schools Initiative.

Young people enjoyed free-flowing workshops that provided frequent intervals for practical activities where they could work together to explore material and formulate responses. The efficiency of participatory arts processes to engage young people in exploring complex ideas was a feature of successful projects across the initiative.

Finally, as has already been noted, artists found the process of translating complex information into effective participatory activities for young people enormously challenging:

> "I've done lots of research and I'm fascinated with the whole subject matter, I do keep up with science but I found it difficult transmitting the information in a hands-on way, so that they are engaged and creative, it's an extraordinarily difficult thing to do" – project leader, Dynamic New Animation.

The Pulse initiative has supported a diverse array of approaches, ideas and practical methods that exemplify ways of doing this, which could be used to inspire future practitioners.

6.8 Artists' narratives of Pulse projects – trajectories of excitement, anxiety and confusion…moving towards confidence

Involvement in performing arts and science projects can inspire a confidence crisis in artists – feelings of being overwhelmed by the depth and breadth of subjects and questioning of ability to grasp the complexity of the issues and communicate them effectively to an audience or group of young people. Practitioners have a range of responses here – including submerging themselves in vast amounts of reading, aborting any attempt to deal with the science, building networks with scientists and science communicators, and/or gradually finding their own 'point of engagement':

> "That is the hardest thing, for the artist to feel confident that they're going to go out and they've got enough resources with them to say, OK, genetics is this, and devise workshops effectively" – project coordinator, All Change.

> "I went to a lecture…they were talking about the pitfalls of presenting science on stage and that completely scared me, I was like, oh my god I've taken this on and I don't even have a degree in science, I'm only a dancer and why was I foolish enough to think I could dare?" – director, Double Vision.

> "I read [the science literature] several times through and there were bits in it I still didn't understand but then I had to decide, actually it's OK…what we were saying in the performance is I don't understand either, but it seems to me to be like this, it was saying this is how it makes sense to me and some of these things are really bizarre and some are really interesting and did you know this? And also saying if you really want to know more go to that website or read that book" – director, Double Vision.

> "There were times in meetings where you were explaining about what you were doing with the dance and then I'd be waiting for the scientist to say something about the science and I remember on this particular occasion he said well you've just explained the science perfectly there…it was never a kind of sense of distance in terms of him and the knowledge and the dance…actually it was understandable, and therefore I

> didn't feel overwhelmed or didn't feel alienated from it. But I was thinking this is neuroscience, Neuroscience!" – artist, Hampshire Dance.

There is a learning curve that in the above project culminated in a sense of some competence in the scientific subject matter. Where time, resources and appropriate science support are present within projects, this can lead to exploration to find points of connection with subjects and realisation of competence – finding a 'voice' within the science as well as drawing appropriate boundaries between different types of expertise and identifying other sources of support:

> "I don't feel that I am the person to teach them science…I wonder if a way round that would be to have more science teachers involved…it would have been interesting to run a parallel session, the first session with half an hour with the scientist was great, if you could do that in every session, a section of science and a section of creative stuff together that would be much stronger, that would be actually learning about science rather than just touching on it" – artist, All Change.

Where time and resources are not available, this can lead to a disengagement from socio-scientific or science content of projects for both artists and young people.

7. Impact on teachers and schools

Teachers generally provided positive feedback about Pulse projects, though the experience of working in schools raised some important issues for future Pulse practitioners (reported in section 9 below). Some 23 teachers participated in the creative processes of projects during the initiative (not including teachers that supervised one-off workshops), including nine science teachers. Of the total, 11 teachers participated in interviews with the evaluation team. Although nine of the teachers participating in Pulse were science teachers, this included seven from one participating school, which used the workshops as a professional development opportunity for science teachers. Most of the teachers involved in the initiative were therefore from a performing or visual arts background.

A number of unexpected positive outcomes occurred during projects, from a workshop programme supporting the start of a drama club in one school (Theatre and Beyond), to strengthening relationships between colleges, secondary schools and feeder schools (where a performance product was taken to primary schools as a form of peer education). One project provided an opportunity for young people to attend a conference in London to share their performance with an audience of science teachers (Stan's Café). Finally, one project took place at a time when teachers were re-designing the year 7 curriculum in order to explore possibilities of cross-curricular collaboration. The project gave teachers an insight into the possibilities for such work in the future.

7.1 Professional development – increased knowledge of and confidence in creative approaches to science and performing arts teaching

> "All of my science department except one have taken it in turns to come along as part of their professional development. We can evaluate this here, but you can't evaluate the amount of science that the kids have learnt as a result of that. When they're sitting their SATs exams and they get a question on particles I hope that number of those who were involved will think back, if there is a question on particles, will think back to what they did. Or on growth and cells dividing, you know, that sort of thing, or forces of pulling and pushing…you see opportunities that you hadn't thought of before…You see that the kids actually like doing drama, possibly more so than they like doing science, but that's OK, and if you can exploit the drama to help the science then why not?" – head of science, Devon Arts in Schools Initiative.

Teachers from a variety of projects reported that they intended to use the methods and exercises they saw being facilitated with their own groups at a later date. One school used the project as a professional development opportunity for science teachers (Devon Arts in Schools Initiative). The Head of Science reports that this was a useful stimulus to encourage the use of pupil modelling to explore abstract processes and patterns in science lessons. Science teachers attending the sessions commented that observing pupils' embodied performance of material processes and patterns in the world provided an illuminating insight into pupils' understanding of science concepts, and could be useful as a form of informal assessment. This project is an interesting example of professionals with very different skills/expertise coming together to find a method and language to inspire a different type of engagement in science, and bridge the social/cultural gap between the scientific and humanities fields (identified in section 3.3).

A science teacher involved in another project reported that one outcome was increased confidence to try new approaches in science lessons, as well as the opportunity to work with young people outside of the classroom – leading to improved relationships with pupils in the classroom:

> "It's given me the confidence to go on and try something new...it's opened up another realm of possibility" – science teacher, Tricycle Theatre.

> "I could use some of my science knowledge outside of the classroom and explore a different method, it was not just chalk and talk…it's brought out my creative side and I love that because science teaching can be a little bit regimented and prescriptive at times" – science teacher, Tricycle Theatre.

Performing and visual arts teachers and other educators involved in initiatives report a similar increase in knowledge of new approaches and models that can be used in the future:

> "The whole animation side, I enjoyed seeing what they did with the technology" – teacher, All Change.

> "I haven't worked on a theatre project before and I just thought that was brilliant and I learned loads and loads and loads just from working with theatre professionals, I have robbed loads and loads of ideas off them" – education worker, Eden Project.

7.2 Enhancing cross-curricular links and broadening opportunities for young people in schools

A cultural gap

Artist: "I would give them almost nothing, it would be – hey everybody, nice to meet you, we're going to look at such and such today, make me a wave. And my guess is that's a bit scary for a science teacher."

Science teacher: "I can see there is going to be a clash of thinking there because there is the kind of creative, open-ended approach which I think is interesting but science teachers are usually, fairly kind of closed in that way and say – right, this is what we want, after about ten minutes, and then move on…my goals as a science teacher are very much curriculum-driven, and while we are all short of time they will have to be curriculum-driven. So anything we did would have to have very clear learning objectives."

(Devon Arts in Schools Initiative evaluation meeting)

"When we started this project I had no idea where it was going to go, none at all…I'm not very good at drama personally, I went to see Othello and part way through I thought it had finished. I need to have a very clear plot with very clear ideas for me to feel happy" – head of science, Devon Arts in Schools Initiative.

There is strong evidence that the initiative strengthened cross-curricular links between arts and science departments in two schools. Where this happened, there was extremely positive feedback from teachers. The two schools that managed this successfully had established cross-curricular links in the very early stages of preparation. Both schools planned to run cross-curricular projects in the future.

There is a clear culture clash, or a clash of expectations, between science and arts teaching. The Devon Arts in Schools Initiative workshops were open-ended and explorative, and the learning objectives were not articulated in contrast, to school science where there is a focus on didactic learning and finding the right answer. Despite this, the link between the drama and science departments was reinforced during the project, with both sides prepared to take some risks and plans being laid for future projects. In addition, there is a clash of cultures between artists working outside the curriculum and teachers who are under pressure to use their contact time to deliver an already packed curriculum. These culture clashes are one of the obstacles that prevented more such collaborations happening across the initiative (this is explored in greater detail in section 9). However, they highlight the enormous potential of Pulse projects to begin to break down barriers and bring about a culture shift in ways of thinking about knowledge and learning methods and formats.

Many projects made the links between their project and the school curriculum explicit, while others operated entirely outside of the curriculum. Some teachers commented that the links to

the curriculum needed to be made clear by Pulse artists, especially for a project happening in class time, in order to secure teachers' cooperation. However, others valued the way projects provided an opportunity to young people outside of the normal curriculum and school day:

> "It wasn't greatly geared towards the curriculum and I think it would have been ideal if it had been" – science teacher, Stan's Café.

> "The normal performance project in the school is kind of like *Grease*, a real kind of show-stopper and everyone is pleased that this is going to be a completely different" – drama teacher, University of Oxford Botanic Garden.

> "It's something that I would not have dared look at with my understanding of genetic engineering, it's a scary subject and not something I would normally do" – drama teacher, Wyrd Arts.

Of all the projects, only four helped students produce work that was linked into formal assessment for students (three of these were further education colleges rather than schools). Two other projects reported that participation of young people provided a significant experience of drama that would greatly benefit those young people taking drama as a GCSE option.

8. Impact on science professionals

Of the 21 scientists or science communicators involved across the initiative, 13 were interviewed over the course of the evaluation. Scientists were asked to explore the impact of their participation on their professional development and to offer advice for how best to develop partnerships in future projects between scientists and artists, and between scientists and young people. It is important to note that 'scientists' refers to a range of science professionals engaged across the initiative, including practising scientists, retired scientists, health professionals including clinical consultants and nurses, qualified science communication experts, and relatively inexperienced science graduates.

Science professionals were very positive about their involvement in performing arts projects, expressing enthusiasm for finding new ways to engage young people in science and encourage wider debates. They found their involvement thought-provoking and worthwhile, though often limited due to being involved in only one element of a project, or a small number of sessions. All scientists expressed enthusiasm for doing similar projects in the future:

> "It was fascinating to understand how you make some sort of drama from genetics…I wasn't certain how it would all join up…in the final show I think they managed to represent some of the concepts beautifully" – scientist, All Change.

> "You can tell science stories through theatre and I think it's a brilliant way of engaging a new set of people" – science communicator, Eden Project.

8.1 The role and activities of the science communicator

Projects exhibited diversity in the ways in which they employed a science professional. Some projects incorporated a formal 'presentation of the science' to young people in order to provide a scientific base and stimulation for explorations – as a one-off encounter at the start of the process. Others facilitated an ongoing interdisciplinary engagement between science and arts professionals.

What role can a science mediator play in projects and what skills are needed to do this effectively? The role relates to safeguarding scientific as well as artistic value and integrity/significance of projects. It involves supporting artists to identify subtle and complex areas of debate within the broad areas identified initially as stimuli (moving from 'genetically inherited disorders' to exploring the experience of living with cystic fibrosis, for example). It continues with exploring social and ethical dimensions of the science focus, identifying areas of debate that might be relevant or provide a point of engagement for young people, and involvement in decision making regarding how much technical information to include in processes and performance products:

> "The two days with the scientist were just delightfully mind-boggling and we all felt a mix of just excited…heads were hurting because, wow…he was really challenging and put a lot of questions and different ways of thinking about it on the table" – project coordinator, Ludus Dance.

> "You have to make it digestible, the science, you can't just spew out a whole load of facts and figures, you need to take them by the hand and take them through the implications and highlight for them the dilemmas which you can imagine might be of more general interest, I think the scientist or the go-between has to do quite a lot of work intellectually" – science communicator, Ludus Dance.

> "Science communicators (mediators) may be thought of as mountain guides. They teach people how to climb (skills), provide ladders (media), to assist with the actual climbing assent (activities), and keep climbers informed about progress, possible dangers, and other issues related to the climb (dialogue)" – Burns *et al*. 2003, 194.

Activities across the Pulse initiative included formal presentations, participation in arts workshops, informal conversations and meetings with artists and young people, preparation

of research materials, viewing performances/workshop materials to discover inaccuracies, and providing access to other scientists and science laboratories. In some cases, the scientist became part of the final event or performance – involved in pre- or post-show activities, providing framing for the science information in performances.

8.2 How to communicate science to young people – advice from Pulse science mediators

"It started off with defining the words and the concepts at their most simple level. What is GM? What do we mean by GM? What do we mean by biotechnology? Is there a difference? To find out what they knew already, to find out what level we had to start from…We encouraged them to look around the subject, to look from all ends of the spectrum and try to get into the heads of people at all those different points and why they think the things they're thinking. I did a couple of hours on the practical technology of it. What are the different ways that you can genetically modify an organism? From micro-injections, like putting the DNA straight into the nucleus of the new cell to generational breeding and looking for different traits, identifying which genes are producing those traits, how all those genes are interacting, we covered everything I suppose at a fairly basic level…then we had quite an interesting day of speed dating, which was quite fun, so lots of the scientists and generally lots of staff from Eden met all the students and had a few minutes each with them, they got to find out what the different Eden staff thought about the issues and the science, that was very interactive" – science communicator, Eden Project.

It is clear from interviews with scientists that many of them found the task of communicating the science to groups of young people immensely challenging:

> "Within science you can be very important but you realise you have a pretty shaky foundation in some of the fundamental questions that children might throw at you…we have to rethink how we are going to communicate…it's so easy to put in complexity and occupy a higher-level platform and so difficult to become communal or idea-sharing and within communicative reach" – scientist, The Theatre, Chipping Norton.

> "It was daunting, trying to keep them under control as well as teach them" – scientist, All Change.

Many scientists reappraised their approach during projects and described their learning experience in interviews. There was much advice for future scientists and others involved in Pulse projects:

- Be open to hearing young people's views about science.

> "Acknowledge that young people have a point of view and allow them to put it across…it was hard work to get it right, you need openness to different ways of communicating, there is a need to try and see what is behind some of the statements about science young people come out with, which are normally based on fear and confusion…humility and openness is key for scientists involved in these projects" – scientist, Riding Lights Theatre Company.

> "At the end of the day GM is almost completely unknowable, we don't know what the problems are going to be, we haven't had long enough to explore them, we can guess at a few problems, we can guess at a few benefits but it's giving them routes into the subject where they could find where they stood on it themselves" – science communicator, Eden Project.

- Focus on provoking fascination in the mundane or familiar.

> "Remember that you don't need to be sensationalist, you don't need to look for the exotic, often the beauty and fascination is in the mundane, in the basics, ask the simple things, when you cut your finger why doesn't your finger keep growing?...my advice would be that you can keep it simple and put the concepts across in a clear and concise way and they are as fascinated to learn as you are to tell often" – scientist, All Change.

> "He brought in all sorts of practical things like how the science is used in the police, how DNA on cigarette butts solves something like 75 per cent of crime" – project leader, Collage Arts.

- Respect the principle of limitation as stimulation.

> "She wanted to tell them as much as she could as quickly as possibly at the start of the process and we had to gag her, that's what happens when you're full of knowledge, when you get the chance to say it you want to say it, as soon as we asked her to clarify something she would go off on one and the young people's eyes would glaze over" – project leader, Dynamic New Animation.

- Use personal stories and anecdotes.

> "One of the things that worked well was when people were able to tell the story of the science and include anecdotes and personal stories…for example, one of the scientists talked about a scare he had with one of his children when she was young and the pressure that put on his decision making and his ethical awareness" – project leader, Riding Lights Theatre Company.

- Join in the other activities.

> "The scientist, she was up on the floor and role playing with the kids" – project coordinator, Y Touring.

> "I went along every so often for an odd bit of fun…to get my head round the drama side of it…it was really helpful, when they were developing characters I was there to give some background about how they might behave during the devising and writing process, I also participated in the team building process at the start of the process" – science communicator, Eden Project.

- Present diverse opinions, possibly through involving more than one scientist, showing that there is more than one way of thinking about a subject.

> "Get the students to talk to as many experts as possible…the most important thing is to really really explore all the different aspects of the subject…get them talking to the people that really are involved daily with the real work" – science communicator, Eden Project.

- Focus on the human and social significance of the science (this clearly depends on the focus of the subject).

> "My major role was to make the issues understandable, that's really what it's more about, it's not about the ins and outs of the intricacies of the technologies and where they can be applied and that sort of thing, it's more about the bigger picture…to try to make firstly the science understandable then put that in a context of issues. So who does it affect? Why does it affect them? Are they right to be affected?" – science communicator, Eden Project.

8.3 A unique set of skills

Overall, the evaluation points to the importance of finding a person with the right communication skills and ability to engage with young people in helping projects secure effective science impacts on young people (this includes artists as well as scientists). These capacities come both from science knowledge – knowing the information well enough to see the interesting angles in it, and having commitment to and enthusiasm for the subject matter – and from communication skills – knowing when to shift focus when attention is waning, taking interest in listening to responses, and showing the ability to break down complex subjects.

It is clear that there is a need for a level of competence in mediation and presentation skills, and in knowledge of the science subject in its technical as well as social dimensions. The former set of skills relates to qualities such as enthusiasm/energy, clarity, ability to work with levels of anxiety and confusion, and ability to communicate with and engage young people. The latter set of skills relates to an ability to break down complex subjects for diverse audiences, and social as well as scientific knowledge and awareness. Once again, a skill gap arising from the bringing together of two different social and cultural fields – science and arts education – is emerging. It is rare to come across such a broad range of skills represented in one person, highlighting the importance of finding the right person and partnership working:

> "I've worked in the arts, I've been a trainer, I've done work on disability, I've done a lot of bioethics and I know some science…if I'd been a lab scientist or even a clinical geneticist and had no other skills I couldn't have done it, I could have turned up and talked about genetics for an hour but I couldn't have facilitated them through a process of discussion and discovery" – science communicator, Ludus Dance.

Do all projects need to involve a scientist or science communicator? Clearly, this depends on the focus for the project; in addition, it is clear that not all projects seek the same type of engagement from science representatives. For projects configured within the interactive model of science engagement (and taking an experiential and sentient approach to science), it was a case of encouraging participation in projects by as many people with a connection to the theme as possible, rather than recruiting someone with responsibility for communicating information. For other projects, it was important to include practising scientists:

> "It would have been quite easy to say oh well, we won't actually have a scientist with us, we brought all of these issues in the play and we'll get someone to collaborate with us on building of some kind of scientific presentation which actually is just a script which an actor delivers…but it would have undermined the key sort of ambitions of the project which was to say look here are scientists and artists working together, it's an endeavour I suppose of the play and of the day to acknowledge that we all have a part to play in this debate" – project coordinator, Riding Lights Theatre Company.

Pulse projects have involved a variety of personnel to support the science focus, from working scientists, recognised science communicators, science teachers and hospital staff. Specific projects have taken innovative approaches, for example, one project invited and supported a young man with a genetically inherited disorder to run a workshop with participants. Another project employed a comedian to convey the science information in a work-in-progress performance exploring handedness. There are no fixed guidelines here – there is a need for flexibility in order to respond to specific contexts.

8.4 Allowing time to develop partnerships

Building partnerships between artists and scientists (or science communicators/teachers) can take time and resources that may not have been budgeted for but are essential for adequate preparation of both artists and scientists. A science focus can stimulate high levels of enthusiasm, and can inspire, amaze, excite and enthuse young people and artists; equally it can mystify, confuse and provoke anxiety. Scientists or science mediators working with performing arts projects, equally, need support to understand the methods and rationale of a creative process. Time and resources are needed to develop confidence with scientific

subject matter, establish an appropriate and interesting (non-clichéd) scientific focus, compare different working styles and methods, and develop an approach that will engage participants. For many projects it was important to allow time to build partnerships between the artists and the scientists as well as between the scientists and the young people. Where scientists were not effective communicators, artists could then play the role of the science communicator.

9. Processes

This section reports on issues that arose during the planning and implementation of projects related to successful outcomes and impacts for young people, teachers and schools, artists, and others involved in Pulse projects. Issues explored here relate to format of projects, preparation of artists and schools, and working with the Wellcome Trust as a funder. This section seeks to provide a view of good practice in performing arts and science projects in order to inform recommendations for future practice. The areas covered are:

- the strengths and weaknesses of different project formats – what is the success of short-term intervention?
- the 'collapsed day' model in schools
- public performance or an open and explorative process? The pros and cons of working towards a public performance
- working with schools: what worked?
- partnership working
- resources
- working with the Wellcome Trust.

9.1 The strengths and weaknesses of different project formats – what is the success of short-term intervention?

Can short-term interventions be as successful as ongoing projects? It is very difficult to compare projects on this variable alone, as subject matter, methodology, art form, staffing and demographics of participants vary widely across projects operating within the same time frames. The following comments are based on the observations of the evaluation team and draw on feedback from professionals and young people involved in projects.

As a general rule, short-term projects – for example, performance and workshop packages such as the Trestle Theatre Company and Riding Lights Theatre Company projects – can be intensive injections that stimulate awareness of new ways of thinking about science and highlight the ethical issues very efficiently. Questionnaire returns from young people and teachers show these interventions to be relevant to young people and parts of the national curriculum. However, long-term interventions, where groups work with scientists and artists over a long period of time (for example, the Eden Project and Hampshire Dance) facilitate a more detailed awareness of and insight into science subject matter, a sense of the complexity, relevance and significance of the science, as well as engagement with questions of how to communicate science to other audiences.

For projects that met with young people in weekly sessions – where sessions took place outside of school and curriculum time – securing regular and ongoing participation of groups was difficult, especially at the start of processes. Groups came together well for final intensive weeks in preparation for performances but tended to drift during the process. There were a number of reasons for this, including competition for young people's attention due to range of other extracurricular activities on offer, and initial sessions focusing on the science input and thus feeling too much 'like school'. This highlights the need to prepare activities carefully in order to integrate science into creative and participatory processes.

9.2 The 'collapsed day' model in schools

Exploration of the 'collapsed day' model is interesting, as research has suggested it might be a good way of providing time off timetable for cross-curricular exploration (Levinson and Turner 2001). The collapsed day model refers to where the normal school timetable does not run for one day for a particular year group. Two projects offered a version of this (Wyrd Arts and Riding Lights Theatre Company), both of which provided a range of inputs, including (respectively): tutorial sessions, drama, visual arts and creative writing sessions; and performance, drama workshops and a science lecture. Questionnaire returns from young people and teachers show the interventions to be relevant to young people and the curriculum. Collapsed days helped young people make connections between different kinds of subject matter and raised important social and ethical debates that may inspire future

learning. The introduction of different specialists from outside of school, in both science and drama, led to a greater range of views and discussion than was normal in the school environment and different types of activity.

However, teachers' concerns about the collapsed day model were that the days did not allow enough time to do justice to complex topics: "students need to take more time over formulating their own opinions about this complex and controversial subject" (teacher, Riding Lights Theatre Company). In addition, many young people reported that these days felt too long. In particular, feedback about the Riding Lights project specified that there was too much time sitting and listening, and not enough opportunity for participatory activities and interaction. Finally, working as a whole year group created very different dynamics, as it brought people together who were less familiar with each other – might increase reticence in terms of getting involved and asking questions in front of each other.

This feedback highlights the importance of follow-up work. The arts organisations involved also emphasised the need for preparatory and follow-up work; Riding Lights Theatre Company prepared comprehensive teachers' packs for before and after the day. However, very few teachers had used the preparatory pack provided by Riding Lights prior to the day, though more stated that they intended to use the pack to follow up issues. Many teachers reported that they had not seen the teachers' pack, highlighting the need for visiting organisations to bring a number of packs for teachers in attendance on the day, send on more than one pack prior to the day and encourage link teachers to disseminate materials.

9.3 Public performance or an open and explorative process? The pros and cons of working towards a public performance

Projects that worked towards a devised performance with young people (other than those that incorporated a long lead-in or well-supported preparation time) often sacrificed an in-depth exploration of the science themes and issues to the need to create performance material. Therefore, short projects that aimed for a polished performance tended to have fewer science education and communication outcomes. The pressure of deadlines for performances, and the need to ensure young people were adequately prepared to go on stage, overwhelmed the science. In addition, in a small number of cases, the need to create a show meant that the responsibility for creative decision making was placed on the artist rather than the young people, limiting their participation in decisions about the subject matter of plays and causing disengagement with the scientific focus of projects.

Many teachers and other professionals, as well as young people, felt it was important to include a final performance event because young people need the excitement and shared goal of a performance: "that's where they get that buzz and the excitement from and that drives them on" (teacher, University of Oxford Botanic Garden). In addition, a performance was seen as a target or goal that made sense of the process to both drama and science teachers (used to operating in an objective and outcome-based culture). However, some artists were more ambivalent about the need for performance, suggesting that it limited risk-taking and innovation within the creative process:

> "When you decide, we're going to do a show, that solves a lot of problems for you because there are a lot of things you have to do whereas if you don't have that, you have to invent everything" – artist, Devon Arts in Schools Initiative.

Work-in-progress showings (the outcomes of research and development processes) tended to free artists to take risks creatively within processes and provide more room to experiment with science foci. Science education/outcomes for young people were more powerful within such contexts.

9.4 Working with schools: what worked?

Projects working in schools experienced a number of difficulties, including:

- initial lack of response from schools to offers from arts organisations with a low public profile
- difficulty accessing pupils at Key Stage 3 and 4 due to lack of curriculum flexibility
- demands on teacher time
- non-existent links between science and performing arts departments in schools.

On the positive side, where projects have successfully engaged with schools, they have energised both science and drama teachers, opened up new possibilities in terms of teaching science, and had positive outcomes for pupils that may be important for ongoing education in science and arts subjects. A more detailed exploration of these projects reveals a number of factors that were helpful in securing the success of projects in schools, including:

- Senior management support within schools. Arts organisations identified the need for senior teachers, with a strong awareness of the project and commitment to its aims, to play the role of 'champions' for projects; to make links between teachers and artists, arrange timetables and teacher support:

  > "We asked each school to provide a champion for the project and I would say that in future that person needs to be part of the senior management team…some of the teachers were not all that senior and ended up getting a bit stuck between our requirements and not wanting to upset senior management" – project worker, Eden Project.

- Building partnerships with schools prior to the application process. Projects that worked well emphasised the need for direct networking with specific schools and teachers very early in processes, ideally prior to making an application for funding and to coincide with planning the coming school year in the summer term. Where this happened, it helped ensure ongoing participation of schools and allowed time to make links to the curriculum and cross-curricular links, and for planning of the project into the timetable of the school year:

  > "We got their agreement before we applied for the money so they had lots of warning' – project worker, University of Oxford Botanic Garden.

  > "I think we did everything that we could do by getting the project into the timetable before it was set for the following year" – project leader, West Dorset General Hospitals NHS Trust.

- Flexibility. Arts organisations working in schools stressed the need for flexibility on the part of the arts organisations, and for appreciation of pressure on teacher time and constraints of the curriculum.

- Providing opportunities to for off-site visits. Projects that provided opportunities for off site visits offered added value. A visit to the laboratory, hospital or museum was often the point at which professionals involved in projects said that young people's commitment to and engagement in projects was secured:

  > '"Not being at the school made it real…it made it more important, they were doing something special, it wasn't just an after-school drama club" – teacher, University of Oxford Botanic Garden.

  > "It was nice to actually have the practical link and actually see how things work and how it happens actually at the lab…we could have just had the scientist come in and teach them things and it would have no context to relate it to so I think that was really wonderful" – artist, Hampshire Dance.

- Bringing external artists in to change the space and ambience of the school setting. The performing arts processes have the capacity to engage, play with narratives of spaces and reveal surprising new perspectives.

> "Each workshop started with students entering a space which had been prepared in advance and was visually and aesthetically surprising. On one occasion this was a circle of 25 pillows arranged in the centre of the room, on another, a simply laid out pair of pyjamas was collapsed, human-like, in the centre of the space. This signalled on each occasion that this was a space for the unexpected as well as engendering a sense of anticipation and excitement about what was to come. This was described by one of the teachers, 'it set up a particular kind of aesthetic…It also set up an expectation, a provocation, a secret which the work then sets out to unlock. This process was repeated through the process, whether in a drama space or a hospital room…'" – excerpt from final report, West Dorset General Hospitals NHS Trust.

One difficulty emerging from school projects was that the need to be flexible meant that many projects happened outside of timetabled hours. This automatically restricted project access to young people choosing to take part in extra-curricular activities.

Many projects made outstanding, innovative contributions to learning and development of children in schools, including projects that were not directly related to the curriculum. However, where access to curriculum time was used, it was important to ensure that meaningful educational opportunities were offered to young people (regardless of links to the curriculum). This included providing stimulating activities to explore themes and issues creatively, and allowing time for the exploration of complexity. It also included finding out what young people already knew about the science subjects covered in order to avoid covering old ground or patronising young people. When projects have worked they have brought exciting new dynamics into learning environments. Projects under pressure to generate material for a final performance or facilitated by artists who lack confidence in the science focus, however, can risk paying less attention to learning and development of pupils:

> "We were told what to do on the project, usually in lessons we have to give our own ideas and think about the next stage by ourselves" – participant.

> "Everything had to be done quickly because the show was going on in so many weeks, everything was a bit rushed so we couldn't do things to the best of our ability" – participant.

Projects that worked towards research and development and work-in-progress performances allowed themselves more flexibility as regards product, and freed up time for exploration of young people's responses as part of the process. These projects fitted more easily into school requirements than projects that took lesson time to work towards polished performances.

9.5 Partnership working

> "For all the push that we're getting from all directions to do cross-partnership work with different sectors it's actually a huge thing to take on and you shouldn't do it lightly" – coordinator, West Dorset General Hospitals NHS Trust.

Every Pulse project involved an arts organisation or artist working in partnership with professionals from other organisations, including schools, museums, hospitals, colleges and science centres. The experiences of partnership working across the initiative illuminate a number of good practices. It is clear that partnership working demands time and resources, including time for: establishing joint aims and objectives; aims and objectives of projects; understanding of each other's needs and styles of working; and developing trust and confidence of staff in each other.

The ability to step outside of institutional frameworks and try out new perspectives and ways of working can be important to the success of Pulse projects in particular, as the majority of

projects involve novel challenges for partners. Even with adequate preparation, performance can be a risky venture for young people and staff of organisations not used to the form, highlighting the importance of strong partnerships within the team responsible for delivery of projects as well as maintaining communication with and the support of senior staff from partner organisations:

> "It's a leap of faith, I had to have faith in the artist that we'd pull it all off, it felt very risky, but I think you have to expose yourself to risks in order to discover things" – hospital arts coordinator, West Dorset General Hospitals NHS Trust.

> "You can't really ever prepare people in the hospital for a performance because what a performance intends to do is transform a space and the whole feeling of a place, so it's going to have a quality of surprise, it's unpredictable" – hospital arts coordinator, West Dorset General Hospitals NHS Trust.

9.6 Resources

Many projects reported that they did not cover their costs, especially when taking on subject matter and aspects of practical organisation, such as booking tours, that were new to artists and companies. It is clear that for projects venturing into this arena a high proportion of contingency is needed in budgets. For example, many artists across the initiative found themselves putting a far higher degree of time into projects than they were paid for, simply as a result of enthusiasm for the subject matter and commitment to project development:

> "Sometimes it felt that I had to learn a GCSE course in the week before the session, a couple of times it got a bit crazy, and sometimes you had to over-prepare so you can go in different directions…I rather enjoyed doing the research but I did go over quite a bit on the amount I was paid for" – artist, Devon Arts in Schools Initiative.

The challenge of dealing with a science subject might need a greater amount of time and resources than conventional projects. Many arts companies exist via one-off grants, such as those provided by Pulse, and lack the financial infrastructure to help them deal with unexpected eventualities; they may be unable to support artists for extra time and resources spent on projects. This can militate against companies allocating time and resources for the development of partnerships and other activities that would support exploration and experimentation with subject matter and aesthetic form. There is a need for projects to develop a planned strategy and allocate significant resources to build partnerships with scientists and other partners, and to find points of engagement in the science subject matter for both themselves and young people.

9.7 Working with the Wellcome Trust

Funded organisations overwhelmingly offered positive feedback about working with the Wellcome Trust. Relationships with the project manager were reported as supportive, friendly, non-intrusive, accessible and dialogic, helping to facilitate artists' control over processes and direction, and their propensity to take risks in processes. Arts organisations also appreciated the funder's presence at final performances and workshops, and regular communication via email.

Some projects reported that they would have welcomed more opportunities for contact with other Pulse projects. However, this opportunity was provided by the Pulse conference in June 2004 (some interviews took place prior to this). In addition, there was a need for contact with projects to discuss practice and share ideas before being introduced to the evaluation; projects felt that starting the initiative with an evaluation day was the wrong priority. Some of the smaller arts organisations experienced difficulties claiming money via a system that involved them submitting receipts post-payment, as organisations' financial systems did not have large cash flows. These organisations identified a need for availability of some funds up front. One project reported that more proactive support from the Wellcome Trust in identifying appropriate science support would have been welcome.

10. Summary

The use of theatre to debate topical issues in science is not new; the performing arts have long been used to explain science to the public, including warning about threats involved in scientific development, educating the public about new technologies and celebrating scientific advances (Jackson 2004). The format, style and aesthetic of such ventures have changed along with the general shift in focus of science communication initiatives from providing 'unknowing publics' with information about science to engaging people in debates about the social and ethical questions, possibilities and problems of scientific advances. Aesthetically, this shift has led to a development away from modernist theatre practices of fixed and one-way relationships between audience, actors, scientists and educators, towards more participatory and empowering models of engagement. Pulse, with its focus on participation, exploration, innovation and engagement, sits perfectly within the current context of science communication and education. Pulse represents an open invitation to artists, scientists and young people to experiment with the forms, contents, relationships and boundaries between disciplines implicit in conventional science learning and communication formats.

The Pulse initiative has made a unique contribution to both the arts and science education/communication sectors by delivering a diverse range of live and dynamic projects, a proportion of which have exhibited innovation in terms of aesthetic form and manner of engaging young people. Where successful, projects have enhanced science knowledge and understanding, and engaged young people in experiences of science education and communication that they describe as inspiring, personally relevant, enjoyable and dynamic. Projects in schools have provided unique points of contact with the curriculum over a range of subjects, including science, drama, visual arts, citizenship, religious studies and personal, social and health education. Projects have also provided important opportunities to experience types of knowledge, practice and learning that cross the constructed boundaries between disciplines and learning formats in formal education. Pulse projects also challenge conventional understandings of science learning. The feedback from young people suggests that the experience of shock and surprise, or feeling moved or touched, can be as important a science outcome as information gain. For artists, Pulse funding permitted exploration of new subject matter and/or opportunities to try out new (to individual arts organisations) models, practices and partnerships that many artists feel will inspire future practice. Scientists and science communicators are similarly positive about their discoveries about what they can bring to the collaboration.

Young people's accounts of participating in successful projects express a sense of disturbance, shock and surprise at the new perspectives on the world offered by exploring science subject matter in participatory and creative ways. Performance methodologies and science concepts have come together to create contexts for exploring issues from a variety of perspectives, illuminating the social, emotional and ethical dimensions of a range of scientific subject matter. The science community has identified a need to develop 'scientific literacy' in young people, so that they can respond to the presence of scientific issues in daily life. Scientific literacy refers to skills and attitudes such as understanding of and engagement with science and scientific debates, appreciation of the significance and value of science, critical engagement with scientific knowledge, and recognition of the ethical and moral dimensions of scientific advances (Millar and Osborne 1998). Young people's accounts of participating in Pulse projects clearly support a link between participating in performing arts projects, fostering creativity and increasing scientific literacy.

The evaluation of Pulse has raised a number of interesting questions about aesthetic form and process in the participatory arts. For example, artists have suggested that naturalistic and/or narrative forms seem effective for communicating complex social and ethical information, as these forms provide opportunities for young people to explore issues via empathy for characters involved in imaginative scenarios. However, as the relationship between science and society has become more complex, non-naturalistic forms implicit in a 'live arts' approach have provided more cutting-edge, experimental art experiences that powerfully engage and involve audiences in the ethical questions raised by science. Non-naturalistic forms, for example, may be more likely to avoid giving a 'message' (avoiding premature formulation of opinion about science and encouraging exploration of complexity)

and can break down barriers between artistic products, audiences and participants; as a result they can change people's relationship to science. However, as this evaluation shows, an artist's capacity to experiment with form and content is affected by their own confidence in engaging with complex social and ethical debates raised by scientific development as well as their ability to inspire and enthuse young people.

10.1 Models of learning and engagement

> "Theatre is an event…that gives me a lasting impression that goes beyond the story, it affects me on a whole number of levels and then gives me the opportunity afterwards to begin conversations or to establish dialogue" – scientist, Riding Lights Theatre Company.

A theme emerging strongly across the evaluation relates to models of learning and engagement presented by performing arts and science projects employing participatory methodologies. Do particular art forms and methodologies inspire a unique form of engagement in science and new types of learning or understanding?

Pulse projects have made a unique contribution to the shift in science education/ communication theory, away from passive consumption of science and science as a value-free body of knowledge, and towards participation, experimentation and critical exploration of science in society. Increasingly, models of science communication stress multidirectional dialogues and interactive engagement with a range of participants in a debate about science. Both approaches emphasise the importance of contextualising and problematising science: making links between science concepts and real-world contexts and exploration of the uncertainties of science and social/ethical issues raised by scientific development.

Where projects have been successful, young people have explored the personal, emotional, social and moral dimensions of science subjects by means of participation and imaginative engagement. This method of engagement can bring science subjects to life and within reach. This is much more than a case of entertaining young people and then telling them important information about science; it is about providing young people with meaningful opportunities to engage with some of the most pressing, complex and controversial problems in contemporary society on emotional, cognitive and imaginative levels.

Young people's learning from successful Pulse projects is difficult to categorise adequately. Young people describe experiences of shock and amazement at new perspectives on the world, stimulated by representation of concepts or knowledge in surprising and three-dimensional ways. They describe emotional as well as cognitive responses, expanded horizons, and increased appreciation of complex subjects and social phenomena. Young people perceive such experiences as very different from their learning processes within formal educational settings.

Most Pulse projects (indeed, most creative activities) employ a mix of didactic and non-didactic, fluid and fixed, explorative and more predetermined processes, which prevents them from being categorised as one or another model or type of engagement. Young people who have participated in creative processes describe becoming part of a well-functioning social group; this brings a sense of caring and support for each other that can provide a micro-ethical environment sensitising young people to the consideration of wider complex socio-scientific issues. Projects that secured ongoing engagement of young people included: opportunities to perform; participatory and interactive activities; autonomy; responsibility for decision making; a social experience, transformation of spaces, roles and routines; opportunities to share personal responses and develop autonomy; and opportunities to learn new facts and information.

The participatory arts can be effectively employed to enhance young people's awareness and ability to engage with science issues in everyday life, as well as to introduce young people and artists to a multidirectional, ongoing debate with a range of communities about science. As such, the participatory arts can both facilitate the communication of science and

reconstruct science as a set of open, adventurous, inclusive, alive, enjoyable and dynamic processes and relevant (inspiring, shocking, emotive) concepts about the world.

10.2 Good practice

The brief review of science communication/education literature earlier in the report highlighted a skills/expertise gap in teachers' ability to stimulate (and confidence in managing) young people's engagement in social and ethical issues arising from scientific development. Pulse exists in between the science and humanities social/cultural and educational fields. The evaluation of Pulse similarly identified cultural gaps between performing arts and science education, and between formal and informal education. There is a need for professional practices that can bridge such gaps: not only particular skills and expertise, but also partnerships between professionals and different types of organisation, based on willingness to engage and participate in a creative process on a relatively equal footing. Performing arts projects can help here as they provide dynamic social settings that can change spaces and relationships, even in complex and constrained institutions such as schools.

As noted in the body of the report, the extent to which young people have gained science knowledge and understanding as a result of participation across the initiative remains an open question. Many projects used the funding to develop new models of practice and take risks. Some projects 'worked' better than others: those that worked did so because they took a risk that paid off; others that worked less well often did so because the experiment was less successful. However, other projects worked less well as a result of aspects of planning and delivery that could be improved.

The following list can be regarded as 'indicators of potential success' for future projects, based on the evaluation of the first phase of Pulse. This is in no way a tick-box list guaranteeing effective projects, but should be perceived as broad guidance based on feedback from a range of professionals and young people involved in previous projects. In fact, a key finding of this evaluation is the need to continue to support explorative and innovative practice in this area. Indicators of potential success that may be identifiable at application/selection stage include:

- A skills base contained within partnerships and/or networks of professionals engaged in projects – perhaps between an artist and a teacher alone, perhaps involving more people/organisations. This base will include: demonstrable creative/artistic expertise; scientific knowledge and/or evident fascination with science; evident fascination with the human or social dimensions of science; educational awareness (ability to create enjoyable opportunities for young people to reflect on new concepts within creative processes); and social skills, including an ability to engage with partners' agendas and inspire young people.
- Such partnerships should exist, at least in their infancy, prior to the start date of the project.
- An ability, exhibited by all partners, to step outside of normal institutional frameworks and try out new perspectives and ways of working.
- Effective budgeting that allows time for relationships to develop between partners (which include complex organisations with very different needs and agendas).
- Links with a range of scientists and others with a stake in the issues explored (rather than one 'science representative'), and the ability to pull such people into a dynamic, participatory process that puts them on an equal footing with young people.
- Where appropriate, careful planning to support and safeguard the scientific as well as artistic outcomes of projects, by devising the appropriate strategies to guide young audiences' interpretations of complex scientific information. This might simply be an opportunity to explore responses following a performance.
- Careful consideration of whether a public performance by young people is appropriate for the processes envisaged and, if it is, commitment to providing adequate preparation time and to extending opportunities for young people to take creative responsibilities within those processes.
- Facilitation within projects of a process of engagement, rather than one-off contact, with science subject matter.

These guidelines aim to support successful integration of the creative and scientific aspects of projects and encourage creative, risk-taking and innovative arts practice. The difficulty of identifying these qualities in a mere application form suggests that there may in some cases be a need to request further information prior to confirmation of funding.

10.3 Ongoing questions

Science engagement is an ongoing process that spans a variety of types of learning experience. This evaluation is based on short-term investigations of Pulse projects. The evaluation was based on young people's and other stakeholders' representations of their experiences in interviews, and it is difficult to assess correspondence between what young people say about the impact of projects and their subsequent behaviour and experiences of science. There is a need for studies that take a longer-term view, based on some of the concepts about how the arts engage young people in science learning generated by this evaluation. An important ongoing question for Pulse is therefore: what is the impact on young people's long-term engagement in science or citizenship issues and debates?

Other questions to have emerged from this study that require further, more focused research include:

- What are the different impacts of various performing art forms, models and methodologies on young people's engagement in science?
- Which approaches work best at communicating or securing engagement in various dimensions of science (for example, is dance better at representing abstract concepts than theatre)?
- What precise models of ethical education are presented by performing arts and science projects, and how do these connect to current thinking and research into ethical learning and moral decision making?
- What input is needed to encourage sharing or good practice across the arts and science communication sectors?
- What models of reflective practice or future evaluation would best support the needs of artists, and what models are needed to communicate the findings with other audiences?

11. Recommendations

The evaluation team makes the following recommendations:

11.1 Issues relating to planning and delivery of projects

- The timetable of projects must allow time for a learning curve for artists who are approaching complex subjects, including appropriate lead-in time and regular opportunities for reflection during the course of projects. Resources of projects need to be considered and planned carefully to allow for these opportunities (see sections 6.3, 6.8, 8.4).

- Performance-focused projects should attempt to provide or stimulate opportunities for preparatory and follow-up work with young people in audiences to help guide their engagement with the science aspects (6.5, 5.10, 5.13).

- Activities designed to support young people's interpretation of performances should be carefully planned and not be delivered by artists working alone. Post-show discussions need to be supported by non-arts specialists (scientists, science educators, nurses, doctors, patients) who can speak from a position of confidence regarding the science issues involved and manage audience questions that stray beyond the immediate issues raised (3.3, 8.3).

- Guidelines should be drawn up to assist project leaders in incorporating strategies that will aid the interpretation of science by young audiences. Innovative projects in this field of practice are capable of reconstructing effective science communication/ education. To this end, the good practice guidelines should be sufficiently flexible to encourage such innovation (6.5, 5.10. 5.13).

- The majority of funded projects have an arts base/applicant. The Wellcome Trust should explore ways of stimulating applications from science partners interested in new ways of working with young people (Appendix B).

- The Wellcome Trust should continue to ensure that projects are made accessible to diverse groups of young people and not just those young people that are deemed to be attentive audiences for science initiatives (4.4).

11.2 Transferability and sustainability of outcomes

- Funded organisations should ensure that performance products have as wide a social reach as possible (4.4).

- There is a need for all participating organisations to consider and to signpost what follow-on projects might need to be supported to sustain young people's ongoing engagement in science (5.12).

- Practice-sharing activities (to inspire and develop the skills of other interested arts professionals) will also help to extend the reach of projects. The Wellcome Trust should support opportunities for artists, teachers and scientists/science communicators involved in projects to come together in practice-sharing workshops and other professional development opportunities (6.2, 6.4, 8.4).

- There is a need to devise mechanisms to ensure that artists/professionals at the start-point of projects are involved in discussion about evaluation methods and reflection on practice (2.5).

11.3 Working with schools

- Project leaders seeking to work in schools should attempt to identify a member of senior management in schools to act as liaison and champion for the project at an

early stage of planning. Ideally, projects should involve a senior teacher in partnership schools in the planning stage, prior to an application to Pulse. Projects working with schools have been most successful where a long lead-in time has been planned (9.4).

- Project leaders planning to work in schools/other settings need to develop a strategy for actively engaging those organisations at an early stage, based on a thorough understanding of relevant science curricula, timetables and relevance/age-appropriateness of the scientific information, and the need for flexibility, clear plans and time to develop relationships/build trust (9.4).

11.4 Future evaluation

- Future studies should include a longitudinal design in order to assess longer-term impacts of participation on both science and art learning. Research design should include development of more rigorous assessment mechanisms to identify learning over time (based on the findings of this evaluation and other literature relating to models of learning in science and the arts) and should consider the introduction of control groups, if resources allow. However, tracking a small group of participants from selected projects, including follow-up qualitative interviews with young people and related professionals six months and one year post-participation would also generate insight into longer-term impacts (2.4).

- Clear, specific and simple guidelines for artist-led evaluation should be provided to allow for the evolving nature of projects. There is no need to evaluate all projects, although monitoring should take place and there should be a general encouragement to carry out reflective practice (2.5.2).

- Reflective practice models of evaluation (including regular opportunities to reflect, plan and process experiences of projects with other practitioners before, during and after projects) are likely to be more appropriate for artist-led evaluation than social-science-based methodologies. Reflective practice is much more akin to processes that high-quality artists already employ when assessing the value and success of their work, and facilitates a sense of ownership and control associated with innovative and creative practice (2.5.1, 2.5.3).

- Initial laboratory days and ongoing ‘reflective practice’ days for artists to share practice may inspire ideas for making connections between science and the creative process, and clarify the aims of Pulse to arts organisations. Reflective practice days can help develop artists’ confidence with scientific subject matter, create networks between artists, disseminate evaluation findings and generally help to keep projects ‘on track’ scientifically and artistically (6.4, 9.7).

- To complement the reflective practice, more detailed evaluation should be undertaken by specially commissioned external evaluation. Outcome evaluation – generating high-quality evidence of learning outcomes and how they transfer to other contexts in young people’s lives – is a very time- and resource-consuming activity (and rarely done well by artists), and demands a high level of research expertise. Arts organisations lack capacity and research expertise to carry out outcome evaluation; this can result in a degree of wasted time and effort and divert focus from practice (2.5.2).

- The Wellcome Trust’s management of Pulse has exhibited enthusiasm and care for the process and outcome of projects without being prescriptive or seeking editorial control. This management style has promoted artistic freedom, experiment and innovation. The above suggestions for improved planning and implementation of the initiative assume the continuation of this degree and style of support (9.7).

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Appendix A: Contact details of organisations involved in the evaluation

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Appendix B: Pulse projects 2003–04, descriptive summaries

Projects are listed in alphabetical order of organisation.

All Change – 'Skin Deep'

'Skin Deep' was a digital dance performance devised and created by young people, working with artists and scientists, for an audience of young people. The performance premiered at Sadler's Wells' Lilian Baylis Theatre in spring 2004. The project aimed to develop understanding of and promote dialogue and debate about the science of genetics and its impact on society. It was launched in November 2003, with local youth groups and schools invited to a dance workshop and science presentation by Dr Anand Saggar, a clinical geneticist (St George's NHS Trust). A devising and rehearsal schedule ran from January to March 2004, culminating in three performances for school audiences and friends/family. Participating organisations included Fresh Start (an alternative education project), Highbury Fields School, Richard Cloudesley School and Central Foundation School. Artists involved included a digital and video artist, a creative writer, two dance artists, a dance and video artist, and a musician. A second science consultant was Alf Linney, a medical imaging physicist from University College London.

Funding bracket: up to £40 000.

Collage Arts – 'DNA: The Facts and the Fiction'

Writer Karen McCarthy produced a short radio script with year 10 media studies students that explored issues surrounding the social and ethical implications of the use of DNA testing by forensic scientists. The script was a result of four two-and-a-half-hour workshops led by the writer, including internet research, narrative development and writing exercises. Sessions happened within curriculum time and were supported by two after-school talks attended by a wide range of pupils and teachers. Presentations were by Chris Truran, Senior Trainer in Forensics (Hendon Police College) and Samantha Weinberg, author of *Pointing from the Grave: A True Story of Murder and DNA* – about a crime solved after 20 years using forensic evidence. The script was never performed but a booklet was produced.

Funding bracket: up to £3000.

Devon Arts in Schools Initiative – 'Patterns in the Mind, Patterns in the World'

This was a research and development project, including a series of workshops in two schools, that sought to provide an accessible and interesting way to challenge and stimulate young people's interest in science. The artist wanted to explore the idea of 'dynamic patterns' and whether ideas about the brain's patterning of information could form the basis for a young people's performance or artwork. Researchers in the fields of mathematical biology and neuroscience were consulted by the artist. Eight workshops were run with an after-school group (years 9–11) in both schools and led to performance events. Each session explored a pattern or an idea relating to patterning in the physical or biological world: waves, optic flow, shapes in landscapes. Sessions were supported by drama and science teachers.

Funding bracket: up to £3000.

Double Vision – 'Left'

The aim of 'Left' was to research and develop a dance theatre piece underpinned by an investigation into the science of handedness. The project linked the physical, biological, social and artistic worlds in quirky, amusing and surprising ways. It culminated in two work-in-progress performances at the Laban Centre in London in January 2004. The performance was a result of independent research by the lead artist and devising sessions with three left-handed dancers and a comedian. In addition, workshops were carried out with two youth dance groups to explore young people's experiences of handedness. While there was no science consultant, the lead artist used Chris McManus's book *Right Hand, Left Hand: The*

Origins of Asymmetry in Brains, Bodies, Atoms and Cultures to support the exploration of the issues.

Funding bracket: up to £10 000.

Dynamic New Animation – 'Genie in a Bottle'

The project engaged a small group of young people in developing a theatre piece using puppetry, object animation and projections to explore their own responses to issues surrounding scientific advances in genetics and nanotechnology. The project involved a drama worker, a puppetry specialist, a video artist and an internet specialist. Workshops and rehearsals took place over a three-month period in Manchester Museum, leading to a tour of four venues in the North-west. The group worked with a volunteer science adviser from the museum, a recent graduate in biology. The final piece was performed by five young people.

Funding bracket: up to £10 000.

Eden Project – 'Signs of Life'

The Eden Project collaborated with twelve foundation degree in performance students from Truro College and an experienced creative team of theatre artists, over the course of an academic year, to create a performance and associated workshop exploring GM technology. The performance and workshop toured to year 9 students in six schools across Cornwall. The project began with a research and development period leading into devising and rehearsals. Truro College students were involved in every aspect of the process, including devising and running the workshop, planning the evaluation, performing, devising, script writing and research. The science team at Eden prepared a GM pack for students and carried out science communication/education activities with the students throughout the project. The performance was a pacy, powerful and intense piece of theatre, raising questions without providing answers about the application of GM technology in society.

Funding bracket: up to £40 000.

Hampshire Dance – 'Innervations'

'Innervations' was a collaboration between Hampshire Youth Dance Company and Dr Matt Cuttle from the Southampton Neuroscience Group. The outcome was an innovative and informative dance work inspired by the science of brain-cell communication. This powerful dance piece was performed at a gala evening in April 2004. Short excerpts from the piece were then performed at numerous venues, including a science centre and a shopping centre. The project was the brainchild of the scientist involved, who has an ongoing interest in how the creative arts can be used to communicate and explain science. The gala evening performance was supported by a pre-show demonstration to explain movement phrases (led by the lead dance artist) and an interactive presentation including a brain quiz led by the scientist.

Funding bracket: up to £10 000.

Landau Forte – 'Cell Out'

This project aimed to raise awareness of the science of genetics through music theatre created and performed by young people. The project comprised a series of workshops and work-in-progress performances, shown to local school and college audiences.

Funding bracket: up to £3000.

Ludus Dance – 'Perfecting Eugenie'

The project was a period of research and development, with four dancers working with two science consultants to explore moral and political issues surrounding eugenics and to

discover how these might be expressed via dance, music and film. The funding provided a space to test out the feasibility of creating a full-scale touring piece for schools. This period of research led to a full production and tour.

Funding bracket: up to £3000.

North Warwickshire and Hinckley College – 'A Shot in the Arm'

A research and devising period with 18 performing arts students led to a devised theatre-in-education performance created by students together with a professional writer. The performance toured to two local secondary schools (for year 9 pupils), and to a hospital museum and the college. The play looked at issues relating to and arising from the polio epidemics of the 1940s and 1950s. The overall project was developed in collaboration with The George Eliot Hospital Museum, whose education worker provided science education support. The final piece incorporated physical theatre, dance, comedy and drama. The play was supported by a short post-show discussion led by the drama lecturer from the college.

Funding bracket: up to £3000.

Oval House – 'Brand New Me'

This youth arts participation project explored the social impact of cloning. The project worked with two groups of young people – the youth theatre over a half term (25 young people aged 13–19) to develop ideas for the play, and then a cast of 11 young people to rehearse and perform a piece for local audiences. The process was facilitated by the youth theatre director and a professional scriptwriter. Two performances of the show at Oval House were followed by a half-hour discussion with the actors. The project did not involve a science consultant.

Funding bracket: up to £3000.

Pathways – 'My Genes Don't Fit!'

The project aimed to develop and provide a platform for the views of a group of adult learners with learning disabilities through drama exploration and the making of a film, which would in turn engage young people in ethical debates surrounding stem cell and human embryo research. The project happened over the course of an academic year and resulted in the production of a powerful short film, launched to an audience of friends and family in September 2004 and disseminated to local schools. The group, based at Countesthorpe Community College, was led by a drama worker and supported by a film maker. A science lecturer from the college supported the process.

Funding bracket: up to £3000.

Riding Lights Theatre Company – 'Science Friction'

A national young people's tour of 'Science Friction' went into 18 schools and a number of public venues. The play was supported by a lecture by a scientist and drama workshops exploring the themes raised. 'Science Friction' was a full-length play already in the repertoire of the funded organisation – Pulse funding supported a schools tour. The play follows the structure of a strand of DNA – two stories that intertwine around one another and that are connected by theme and human experience. The first story is that of Galileo and the conflict that still informs the relationship between science and faith in the 21st century. The second story is that of a geneticist working today, and the clash between her professional and private lives. The touring package covered a full school day and was offered to years 11, 12 and 13.

Funding bracket: up to £40 000.

Southport Arts Centre Youth Theatre – 'The Place Where I Live'

The project involved working with a range of age groups within the youth theatre to explore various issues. Starting with a focus on mental health and genetics, the project moved towards an exploration of stress and bullying. A workshop programme was run with five youth theatre groups, leading to a sharing in April 2004. Over 100 young people were involved over the course of the year.

Funding bracket: up to £3000.

Stan's Café – 'Plague Nation'

'Plague Nation' was originally a performance installation devised by the company for a general public audience. Its initial success raised the possibility of developing it to specifically explore the history of epidemics alongside biological theory and statistical effects of vaccination programmes. The project visited four schools over a period of six months and created an installation, using rice that modelled statistical information researched by students (with each grain representing one person in the world). Each performance was researched and performed by students, under the direction of Stan's Cafe, working in close collaboration with teachers.

Funding bracket: up to £10 000.

Theatre and Beyond – 'What Became of the Witch?'

'What Became of the Witch?' was a new play for young audiences (14–18 years old) that explored society's obsession with eternal youth. The performance toured schools and public venues, accompanied by a workshop programme challenging young people to engage creatively with the biological, medical, social, ethical and emotional processes of ageing. Pulse supported the workshop programme. The project experienced some difficulties booking the workshop, resulting in workshops happening in only three settings. The workshop explored young people's attitudes to age and ageing, plastic surgery, and longevity. Online research materials were used as starting points for the workshop, including www.newscientist.com, www.spiked-online.com and press websites.

Funding bracket: up to £10 000.

The Theatre, Chipping Norton – 'Enlightened'

The Chipping Norton Youth Theatre created a play entitled called 'Enlightened' through research workshops and a devising process exploring the bioscience of light with a professional writer and a retired scientist. The play was performed by approximately 60 members of the Youth Theatre. A film and video maker, a costume designer, a composer and a musical director were also involved in the process. The project lasted ten months in total, from initial brainstorming on the theme to three final performances over Easter 2004.

Funding bracket: up to £40 000.

Trestle Theatre Company – 'The Smallest Person'

The project commissioned, rehearsed and toured a new theatrical production, together with a schools workshop programme. The play tells the story of 'the Sicilian Dwarf', Caroline Crachami, a freakshow exhibit in Victorian London, and the struggle that ensued to gain control of her skeleton in the name of scientific progress. Juxtaposing Caroline's story with a modern character facing an ethical medical dilemma – a young woman who wants to protect her brother from the same fate – the production aimed to provoke debate surrounding the impact of biomedical science on society. The show went on a national tour to schools and public venues. The accompanying schools workshops explored mask work and ethical issues raised by the story.

Funding bracket: up to £40 000.

Tricycle Theatre – The History of Disease Project, 'Don't Bug Me!'

This project was a collaboration between Tricycle Theatre and a science and drama teacher from Copland Community School and Technology Centre in London. A group of eight year 10 students (self-selecting, and working in school time with additional rehearsals in their own time) worked with a dramaturg from Tricycle Theatre, a drama teacher and a science teacher to devise a play exploring the history of disease, focusing on modern and historical epidemics and their treatment, and how infection is passed on. They performed in four primary schools in the local area to year 5 pupils. The project has led to another drama project following the same model, exploring environmental issues.

Funding bracket: up to £3000.

University of Oxford Botanic Garden and Oxford Community School – 'The Rainforest Pharmacy'

This project was a collaboration between the University of Oxford Botanic Garden and Oxford Community School, also working with an actors' consultancy. A group of nine year 10 drama students worked with a professional theatre consultant and staff at the Botanic Garden to develop a promenade performance at the garden. The performance centred on the story of the harvesting of African cherry from rainforests for the production of Prostatin. The piece was performed to school audiences in the garden in June 2004. Each performance was followed by a tour of the garden led by garden staff. Devising sessions and rehearsals took place after the school day.

Funding bracket: up to £10 000.

West Dorset General Hospitals NHS Trust (lead applicant) – 'Visiting Time'

A collaboration between West Dorset General Hospitals NHS Trust, Sir John Colfox School (Bridport) and artists/arts educators, 'Visiting Time' was an exploration of the human, experiential and scientific dimensions of children living with genetically inherited disorders via participatory performance. The project team included 25 year 9 drama students and four A-level biology students, a patient of Dorset County Hospital, a drama teacher, the head of science and the assistant head of the school. From the hospital, sessions were attended by a consultant and a nurse from the genetics team and a community nurse, as well as the hospital arts coordinator. Twelve workshops (taking place in drama lesson time) included exploration of participants' own genetic inheritance, birth stories, hospital experiences and patient experiences. In addition, students visited the hospital, including visits to the ultrasound unit and children's ward. A site-specific performance was given at the hospital in April 2004.

Funding bracket: up to £10 000.

Wyrd Arts – 'New Genesis'

This project drew upon drama, living history techniques and digital arts to explore ethical issues surrounding genetics research. The company worked in Haydon Bridge Community High School and Sports College and in Oakwood High School. In the first school, the company ran a collapsed timetable day exploring genetics research with year 11 pupils, including a performance, drama workshops, creative writing sessions, visual arts workshops and ethics sessions (run by teachers with supporting materials supplied by the company). The second project comprised a series of workshops, in drama lesson time, leading to a work-in-progress performance for peers and family/friends.

Funding bracket: up to £10 000.

Y Touring – 'Genetic Futures'

Y Touring commissioned four experienced playwrights to write four plays exploring aspects of the impact of biomedical science on society, for young people and children to perform. The playwrights explored the issues with scientists and young people in a series of laboratory sessions. The plays had pilot productions by four London youth theatres, from August to November 2004; the play scripts will be published on Y Touring's 'Genetic Futures' website. Youth theatre partners included: Youth Music, Hillingdon Youth Arts, Questors Youth Theatre and the 'Art of Regeneration' project at Albany Theatre. The four plays explored the following themes: genes and eugenics, genes and mental illness, genes and risk, and genes and reproduction. Each process was supported by a scientist/science communication specialist.

Funding bracket: up to £40 000.

Appendix C: Evaluation proposal summary

Evaluation of Pulse – a performing arts initiative for young people funded by the Wellcome Trust

Background

Performing arts initiatives in the area of biomedical science can be a powerful and innovative way of engaging young people in debates about complex social and ethical issues. However, provision in this area varies in quality and methodology and has lacked financial support and other resources necessary for its development. The Wellcome Trust's Pulse funding initiative presents an important opportunity to develop provision, assess quality and generate guidelines for effective practice in the area of performing arts and education in biomedical science.

Aims and objectives

The evaluation proposed will identify the funding initiative's effectiveness in supporting high-quality performing arts provision and produce evidence relating to: the outcomes for young people and other stakeholders; the quality of creative processes and outcomes within performance projects funded by the initiative; the success of projects in reaching and engaging target audiences; and a detailed insight into the creative processes and outcomes of a representative sample of key projects.

Evaluation activities

The evaluation will consist of:

- capacity building and support/consultation for performing arts organisations evaluating their projects
- monitoring and evaluating each funded performing arts project, including case studies of key projects
- evaluation review and participatory research with funded organisations.

The research findings will be collated, analysed and written up by the research team at the Centre for Applied Theatre Research (CATR).

Research methods

The evaluation will include a combination of qualitative and quantitative approaches as well as participatory and creative evaluation. CATR will use a range of methods to monitor and evaluate all 24 projects funded by the initiative.

Initial survey of funded projects: the research will begin with an initial survey of the organisations that have been contracted to develop projects. This will include a review of all funded projects, including aims and objectives, project design, context, methodology, timescales, staffing and target audience.

Evaluation capacity building day: this event will provide a welcome opportunity for the research team to build relationships with project representatives and communicate plans/needs regarding the wider evaluation.

Monitoring and evaluation of 24 funded projects: CATR will monitor and support the project evaluation carried out by each of the funded organisations and make specific inputs to the evaluation of each project as appropriate. Evaluation of each specific project will include: monitoring rates of participation in each project; creative and participatory evaluation techniques with participant groups and audiences; standard questionnaires with young people, staff groups and collaborative partners of projects; and interviews with performing arts companies and collaborative partners. CATR envisages that each funded organisation will facilitate aspects of the evaluation independently. Specifically, projects will be expected to

deliver participatory evaluation and disseminate and collect questionnaire returns from groups and partner organisations. CATR will take up a monitoring role for these aspects of the evaluation. CATR will carry out the qualitative aspects of the evaluation as these are more time- and resource-heavy and demand more research expertise. The research team will carry out qualitative interviews with the creative team and collaborative partners, and, to this end, will visit each organisation approximately twice.

Case studies: case studies provide an opportunity to assess and describe examples of good practice and the impact of projects in more detail, generating a more intricate evidence and theory base for analysis. It may therefore be appropriate to evaluate a small number of projects (up to three) in more depth. Specific projects selected as case studies will receive more input from the research team than described above, in the form of additional visits to observe practice and carry out investigations with participants.

Research outcomes

The evaluation will provide detailed evidence of the impact of performing arts initiatives in the area of biomedical science on the knowledge, insight and attitudes of young people. It will also identify strengths and weaknesses of provision and clearly set out guidelines for good-quality practice in this area that can be used to develop future provision.

The research will generate both quantitative and qualitative outcomes. Quantitative outcomes will relate to numbers of young people involved in the Pulse initiative projects (indicating how successful projects have been in reaching target audiences) and quantified responses to questionnaires and creative evaluation exercises seeking to assess knowledge gain or attitude change. Qualitative outcomes will include young people's, performing arts companies' and collaborative partners' views of the impact of projects and issues relating to good-quality provision.

Appendix D: Semi-structured interview schedule

The following key questions were asked in some form to all involved in projects – young people, artists, teachers and science representatives. Additional and specific questions were asked that were relevant to the project and/or person being interviewed. Concepts, phrases and wording used by interviewees in their responses were used as follow-up prompts to elicit more information:

- What are your overall impressions of how the project went?
- What were your impressions of the final performance – what were the responses of the audiences?
- Can you pick out and describe some of the key moments of the project as a whole for you?
- What do you think the young people/you gained from taking part?
- What will they/you remember about the project?
- What did you already know, and what did you learn that was new, about [science subject]?
- The Pulse scheme funds projects that bring 'science' and 'performing arts' together with young people – from your experience of this project, do you think this works? If so, how? How is it different from learning science in school or elsewhere?
- Did the project meet its aims and objectives?
- What would you change for next time?
- What has it been like working with the Wellcome Trust – what would you change for next time?
- What has it been like working with CATR to do the evaluation – what would you change for next time?

Appendix E: ‘A priori’ codes for qualitative analysis

ART/SCI BAL: Balance between performance/artistic content of process and science for performers, audience and others. Look out for the degree of integration of science with performing arts – when it works, what happens? When it doesn’t work, what happens?

SCI SIG: Significance and relevance of science understanding gained – is it relevant to young people? What connections are there to contemporary social and ethical issues?

SCI TYPE: What type of science is addressed – technical information, human/social dimensions, ethical issues.

CURR: Relevance of science for the school curriculum.

TRANS: Transferability? Can the model be transferred to other contexts?

SUS: Sustainability? Capacity building? Are there any outcomes indicated that might last longer than the end of the project? For artists? Young people? Partners?

DEVPT: Any ideas for development of work, post-Pulse

CON INT: Any conflict of interest between provider of the project and Pulse? For example, providing a platform for debate about scientific development or providing a platform for expressing fear/concerns.

PART LEV: Levels of involvement of young people.

COMM SCI ART: Effectiveness of communication between scientist and artist – is reflection and communication time built in? Is there time for scientists to learn about the performing arts processes?

COMM DEV: Devices or strategies used to communicate the science, including variation in delivery style, addressing different intelligences or learning styles.

METH: Descriptions of methodology of the project, what specific strategies worked/did not work? What was the range and diversity of the method?

AESTH: Anything relating to the aesthetic of the project – art form used, its problems and possibilities in relation to debating about science…

IMPACT COG: Understanding, insight, perspective taking, literacy, appreciation of complexity, changing attitudes, asking questions, learning facts/information, making sense of something, deepening understanding, developing values, developing opinions, investigation/research, conceptualisation, experimentation, reflection, what questions and answers are people left with at the end?

IMPACT EMOT: Personal relevance, engagement, emotional insight, empathy, changing attitudes, confidence, inspired, excitement, developing feelings, developing values, motivation, surprise, amazement, enjoyment, investigation.

IMPACT SOC: Dilemma, debate, relationships, questions raised and discussed, building and using relationships, ability to operate in a public sphere, confidence in expressing own opinion, ability to understand and respond to others’ opinions, is a range of experience presented?

IMPACT OTHER: Other impacts, not accounted for by the above, on artists, young people or others involved in projects. Especially impacts relating to science learning, engagement, ethical debates…other things relating to the aims and objectives of Pulse.

RES: Any resource issues?

ART QUAL: Descriptions of artistic quality; this will be pretty subjective, but it will be interesting to compare our thoughts!

ART INN: Related to the above, but anything that seems particularly experimental or innovative in artists' descriptions of their work.

WELL: Issues relating to relationship with the Wellcome Trust.

CATR: Issues relating to the evaluation.