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Specific Support Actions

D28: CRITERIA OF INNOVATION AND QUALITY
WP3: RESOURCE CENTRE 1

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Executive Summary

This report presents eight criteria of innovation, which may be used to identify effective practice in science teaching and learning at the intersection between formal and informal learning contexts. The criteria are derived from the analysis and evaluation of the products and practices of the 14 pilot projects comprising Pencil, and as such build on findings presented in two associated reports, D10 and D31. This report has been prepared by researchers from King's College London, and the University Federico II, Naples.

To identify the criteria and their constituent indicators, researchers analysed data from the individual projects, but also referred to the academic literature wherein issues relating to science teaching and learning are discussed. In addition, the identification of the criteria was informed by the researchers' professional experience in the evaluation of formal and informal learning.

In developing the set of criteria, it is hoped that the innovative programmes pioneered by Pencil pilot projects may inform future partnerships between schools and informal science institutions.

1. Background

1.1 Aims

This report addresses the following aims:

- To construct a set of criteria of quality and innovation in museum / science centre – school partnerships
- To define the indicators which characterise these criteria
- To discuss the implications of these criteria and indicators for future practices

1.2 Why criteria of quality and innovation?

Science centres and museums, together with the schools with whom they partner, are keen to improve the ways in which they support science learning and teaching. Staff from informal science institutions seek to enhance their day-to-day practice and design of programmes and exhibits, whilst teachers continually look for ways to enhance their delivery of the curriculum. By working in partnership, museums / science centres and schools have the opportunity to address such objectives, and it is to this end that a set of criteria for assessing the quality of joint activities is offered. Such criteria of quality and innovation also offer a framework to inform the design of future projects.

The criteria presented here are derived from the assessment of the 14 pilot projects involved in Pencil. As such they build on the experiences of a wide range of contemporary European and Israeli initiatives, each with different issues, context and problems.

The broad criteria are exemplified by sets of indicators against which projects may measure their progress towards developing quality practices. To illustrate these indicators, and as a way of offering some pragmatic guidance, generalised examples from the pilot projects are given where appropriate.

Each criterion with its constituent indicators addresses a particular aspect of practice. However, when taken together, these criteria offer a framework for innovative or best practice for projects aiming to support science learning and teaching at the intersection between formal and informal learning contexts. The criteria can thus be considered to be a set of 'tools' for shaping the design of future projects.

1.3 What is meant by 'innovation' in Pencil

From the assessment of the Pencil pilot projects, it is clear that innovation and innovative practices can be associated with a desire on the part of partners to 'do things differently, to do things better'. For example, the action of a science centre in exploring ways in which modern technologies can support early years learning, may be described as an example of 'doing something differently'. Practices such as allocating finances to ensure the sustainability of a project, meanwhile, or working in a network, employing evaluation frameworks, or developing programmes with reference to contemporary research findings, may all be considered as incidences of 'doing something better'.

With reference to future practice, it is important to ensure, however, that 'innovative practices' are not simply replicated as a way of meeting a target standard. Truly effective innovations are those that find new ways of meeting existing needs and respond to those that are currently un-met. They are also the practices that harness the energies and motivations of teachers, students and educational professionals in order to solve problems as they arise, thus continually enhancing learning and teaching opportunities.

2. Methodology

The identification of the criteria and constituent indicators draws on findings and interpretations presented for two other reports, D10 and D31. As discussed in these reports, the data relating to the impact of pilot project initiatives was largely based on interviews with the pilot project coordinator(s) (PPC(s)), and other secondary materials. These findings, together with draft criteria were checked against the small but growing academic body of literature in this field, and then validated through discussions with the pilot project coordinators held at pre-Ecsite conference meetings in Mechelen 2006 and Lisbon 2007. The final draft was further refined during a workshop at the international Bay Area Institute – an institute convened by the US Center for Informal Learning and Schools to which over 100 respected researchers and practitioners working at the intersection between the formal and informal environments were invited – in August 2007.

Throughout this process, the six researchers from the two research groups constantly exchanged perspectives and refined meanings, and were supported by invaluable advice and guidance from colleagues at Ecsite, XPLORA and INDIRE.

3. Overview and structure of this report

3.1 Structure of this report

This report comprises a list of criteria, each exemplified by a number of indicators. The criteria are in no particular order.
Specific references to individual Pencil pilot projects are made if appropriate, but for the most part, the examples have been generalised to provide a set of non-specific illustrations applicable to many contexts and instances. The final section of the report discusses the ways in which the criteria and indicators may be used to help structure future practice.

3.2 Reporting conventions

In the whole text of this report, the following conventions are used:

- PPC(s) indicates the Pencil Project Coordinator(s) - those members of the museum or science centre staff who were responsible for the pilot project in their institutions.
- The term 'stakeholder' refers to individuals or organisations, other than the two primary partners of museum/science centre and school, who have an invested interest in the results of the programme, and as such may play an active role in the project.
- The references for specific quotes made by PPCs refer to interviews conducted by the university researchers.

4. List of criteria

4.1 Criterion 1. Teachers are involved in the design phase of museum / science centre education projects aimed at schools

Teachers' involvement in the design phase of educational projects emerges as a crucial criterion of quality when considering the development of a successful partnership between schools and a museum/science centre. In working in partnership, teachers are able to communicate their needs, share their expertise, and plan how the experience will integrate within their wider curriculum requirements. Such levels of involvement enhance the motivation of teachers. Museum / science centre staff, meanwhile, benefit from the curriculum knowledge of teachers, advice regarding practical issues, and the collegiality that such partnerships provide when facing new challenges and creating new educational ventures.

In summary, a fruitful partnership starts by building consensus and promoting a positive perception of the project from the outset. Working with teachers in the design phase of a project allows strong partnerships to develop resulting in highly effective project outcomes.

Success in this criterion may be judged using the following indicators:

- ***Museum / science centre staff commit time and resources to recruiting partner teachers.***
  Whilst teachers who are already known to the museum or science centre constitute a useful pool of contacts with whom communication is easy, it is important, given its public funding, that the resources of the informal institution are spread more widely among the teaching profession. To this end, the extent to which both existing and new populations of teachers become involved in the development of a project provides an indicator of a project's success. Furthermore, the extent to which teachers from disciplines other than science or mathematics are recruited (in addition to their science peers), provides an indication of the degree in which the project and its outcomes will become embedded across the curriculum. For example, teachers from the social sciences or humanities can help to highlight the historical or literary significance of particular science concepts and thus help students make further interdisciplinary connections to the project content.

Several of the pilot projects in Pencil found that time and effort spent in the early stages of a project to find and involve teachers from a variety of schools and variety of disciplines, served to ensure the success of the subsequent project.

- ***Museum / science centre staff work closely with teachers to ascertain their needs, requirements and expectations.***

  To ensure a good working relationship with teachers, many of the Pencil pilot projects planned preparatory activities. For example, they organised workshops to exchange basic aspects of their proposals, appointed dedicated Explainers to work closely with teachers, and designed teacher training materials to introduce and explain specific educational programmes. Such initiatives enable museum / science centre staff to respond to teachers' needs by providing teachers with an opportunity to make creative contributions, critiques and comments on project activities and their implementation. The preparatory activities also become a valuable space wherein teachers can share their knowledge of student behaviour, and suggest modifications to the planned programmes to enhance student participation.

  Initiatives allowing feedback between museum / science centre staff and teachers may not always meet all the objectives of the individuals involved. However, they provide a useful mechanism for developing a better understanding of informal resources on the part of teachers, and a deeper knowledge of formal sector requirements on the part of informal educators. In this way, rather than informal institutions being seen as selling ready-to-consume educational activities, science centres and museums may be understood as equal partners in the educational endeavour.

- ***Front end evaluation tools are used as a systematic way to collect teachers' views.***

  Front-end, or formative evaluation methods are essential for collecting the views of teachers (or other stakeholders) thus enabling the construction of a solid evidence base on which the subsequent project may be built. Such data informs museum / science centre staff about the changes that may be needed during project implementation, and provides a forum within which educators may reflect with teachers about ideas and plans.

  Among the front-end evaluation methods used by the Pencil pilot projects, the most popular were questionnaires and focus groups. Both techniques helped to determine the content areas that teachers were keen to cover, but also served to highlight concerns on the part of teachers relating to practical management issues, and questions of teaching and learning.

- *Discussions about pedagogy form an important part of project planning.*
  Joint discussions between teachers and museum / science centre staff about the nature science presented by the institution, and the approach to science teaching that this perspective engenders, provides a useful basis upon which to explore and develop new approaches to science teaching and learning. For example, it is well known that teachers' activities are often constrained by the pressures of formal curricula and a lack of resources. However, in acknowledging such difficulties and building on the relative freedom of informal institutions, teachers and informal educators may generate new ideas and innovative practices that may also be applied in a teacher's own classroom practice.

- *The professional development of teachers is an explicit goal of the partnership*.
  By introducing teachers to informal methodologies and providing opportunities for discussions around the benefits of particular pedagogical practices, the seeds for future, productive partnerships are sown. Moreover, new classroom practices are also supported, for in working with teachers, informal institutions are in fact responding to the need on the part of professional communities to support teachers in the development, consideration and refinement of their teaching strategies.

4.1.1. Summary criterion 1

This criterion highlights the importance of involving the intended audience in the design of an education resource. Whilst staff from the informal institution may be highly skilled in developing effective programmes for school groups, the long-term impact of such an initiative, in terms of the way in which any innovative approach becomes embedded into the school's curriculum, will be severely compromised if teachers are not intimately involved in the planning process. In this way, this first criterion underpins all subsequent criteria: the extent of teacher involvement, in project planning and development in particular, defines the nature of the partnership between school and informal education institution.

Table 1: Criterion 1 and its five indicators.

Teachers are involved in the design phase of education projects aimed at schools
• *Museum / science centre staff commit time and resources to recruiting partner teachers.* • *Museum / science centre staff work closely with teachers to ascertain their needs, requirements and expectations.* • *Front end evaluation tools are used as a systematic way to collect teachers' views.* • *Discussions about pedagogy form an important part of project planning.* • *The professional development of teachers is an explicit goal of the partnership.*

4.2 Criterion 2: Evaluation forms an integral part of the educational project

From planning and project design, to implementation and the reporting of results, evaluation processes are essential for ensuring the success, and continuing enhancement of educational projects linking museums / science centres and schools. Both formative and summative evaluation processes help to ascertain teachers' needs, leading to better understandings of what kinds of learning should be fostered. In employing these processes, informal institution educators have the opportunity to reflect upon their practice and disseminate their results with greater clarity. Evaluation processes also provide a line of reasoning, or mechanism by which to improve communication between museum / science centre staff and teachers, and with external partners such as university academics or expert scientists. At the same time, evaluation processes also constitute a source of evidence for making decisions about areas for improvement, future partnerships and target audiences. In addition, they can inform museum / science centre staff on how to better allocate human resources and money for future projects.
Success in this criterion may be judged using the following indicators:

- *Regular reflection on use of tools, and on advice from experts in evaluation.*
  Regular discussions about the use of evaluation techniques can help museum / science centre staff to consider the occasions in which particular tools should be used. In addition, by continuing to review the nature of evaluation during the process of a project, methods and tools may be refined to suit the needs arising. Such discussions can also serve to identify the instances when multiple evaluation techniques are necessary. Within Pencil, some pilot projects modified their evaluation programmes to include an observation protocol, whereby they invited participants to reflect on the activity as it was happening, or asked the accompanying teachers to comment on what

they saw their students doing. The feedback from these techniques then led to changes in the latter stages of the activity. Finally, by regularly reflecting on evaluation techniques, and by accepting advice from academic or expert partners, museum / science centre staff are able to overcome any initial resistance to the use of such tools. Concrete actions, such as decisions to include qualitative approaches (in addition to the more traditional, and marketing-based focus on quantitative measures), can be seen as evidence of reflecting on evaluation tools and intentions.

- ***Barriers to success are communicated in evaluation reports alongside achievements.***
  Scholars in the field of informal learning have long noted that the culture of evaluation as practiced by informal science institutions is skewed towards reporting success, rather than documenting barriers to success (Rennie 2007). Whilst achievements are important to acknowledge, the experience of barriers, such as inappropriately chosen topics, or unsuccessful teacher training courses, immediately highlight areas for improvements and promotes honest and effective partnerships between schools and informal learning institutions.

- ***Project budgets are strategically apportioned to evaluation.***
  In order to conduct effective evaluation, which in turn informs the design of ongoing or future projects, appropriate levels of staff time and money need to be allocated. Given that the questions to be addressed by evaluation techniques vary across projects and require different time frames and levels of staff commitment, there can be no clear rule about the amount of money required. However, by considering evaluation to be an integral part of a programme, requiring staff time and attention in the same way, for example, as face-to-face teaching, an appropriate budget may be developed.

- ***Evaluation results from across the field of science learning are shared.***
  When developing a project, it makes good sense to learn from the experience of others. Whilst mistakes can provide rich learning opportunities, most organizations do not have the resources for their staff to regularly reinvent the wheel. Thus the experiences of other museums and science centres must be reflected upon, and evaluation findings used to inform the design of the project (if contexts or audiences are comparable), or the design of the evaluation programme (if contexts are different). Of course, the corollary of such a recommendation is the need for museums and science centres to disseminate their evaluation reports more broadly, and to be open about their findings. By disseminating the results of evaluation processes, sharing innovative practices, and by ensuring that other institutions sidestep potential problems, the broader field of science learning at the intersection between formal and informal contexts will benefit.

4.2.1 Summary criterion 2

This criterion addresses the extent to which the projects developed by museums / science centres in partnership with schools apply methods of evaluation to ensure the success of the project. Although the allocation of appropriate resources for evaluation forms an important indicator, the key theme for this criterion is the extent to which project partners engage in reflection upon: other project findings; the advice of experts with regards evaluation; the ongoing processes of evaluation with a view to refining methods used; and on the failure of projects, or barriers to achievement, in addition to any successes.

Table 2: Criterion 2 and its four indicators.

Evaluation forms an integral part of the educational project
• *Regular reflection on use of tools, and on advice of experts in evaluation.* • *Barriers to success are communicated in evaluation reports alongside achievements.* • *Project budgets are strategically apportioned to evaluation.* • *Evaluation results from across the field of science learning are shared.*

4.3 Criterion 3: Contemporary understandings about learning and facilitation techniques are incorporated into projects.

In developing joint educational projects, both teachers and informal institution staff need to consider how best to foster students' opportunities to learn, Such opportunities require an understanding about different modes of learning and facilitation techniques, clear ideas about the science which underpins the initiative, and a knowledge of the ways in which the science content may be linked to the curriculum.

In responding to this challenge, museum and science centre staff build on their knowledge of how the institution's objects or exhibits may enhance students' experiences, whilst teachers rely on their understanding of curriculum links and the abilities of the student group. When successfully working together, both partners bring their respective areas of expertise to develop an enriched programme of activities and pedagogical actions in order to best facilitate student learning.

Success in this criterion may be judged using the following indicators:

- ***Approaches to teaching and learning employed by museum and science centre educators complement those used at schools.***
  Approaches to teaching and learning employed by museum and science centres are distinctly different to those used in schools (Tran and King, 2007). However, whilst such approaches are more suited to the particular environments of informal education spaces, this does not mean that they are better than those used in schools: the different contexts suit different approaches. However, to help students make connections between different aspects of content, it is important that the two approaches complement each other, and that the educators respect each other's pedagogical skills. In addition to being complementary, it is also possible that techniques developed in the informal science institution - for example, enquiry based or experimental learning, and qualitative (rather than quantitative) forms of student assessment - are modified and applied to the formal learning context. Thus, an indicator of success in a project at the intersection between formal and informal learning, is therefore, the extent to which teaching approaches are made explicit by each partner, and then discussed to ensure that the respective learning opportunities are compatible rather than in any way contradictory.

- ***A range of facilitation techniques are employed by museum / science centre staff and teachers.***
  Contemporary research has identified a range of innovative teaching approaches used in museums and science centres (cf Ash & Klein 2000). Whilst some of these approaches are only appropriate in the informal space, others may be applied to classroom contexts (for example, student-centred enquiry). However, it has also been noted (cf Cox-Peterson et al, 2003) that many informal education practitioners are still using methods dating from the early years of museum educational work, such as the use of educator-designed worksheets. To make the most of the opportunity presented by the museum / science centre partnership, staff at the informal science institution should research and employ new methods of facilitation identified by fellow practitioners and the research community. Such methods may also be developed for use in schools.

  Methods used by the Pencil pilot projects include the include dramatic role-play, training of students to act as peer-to-peer teachers, the involvement of practising scientists as mediators between the classroom and the lab, and providing opportunities for enhancing the artistic and emotional aspects of science learning activities. Further approaches include the providing students with opportunities to follow their own interests (rather than a set curriculum), involving students in the design of informal exhibits, and the use

of ICT tools which offer a wide range of learning platforms to support a range of teaching and learning styles.[1]

In employing such techniques, however, it is important that facilitators (be they informal educators, or teachers) explain what is expected of the students, and how such methods can support their learning. For example, if the students are more familiar with teacher-centred lecture style of teaching, they may be uncomfortable in engaging with the different language and style of learning presented in the informal environment

- *Target content is combined with other topic areas.*
  By addressing the target content through other topic areas – for example, exploring the historical context in which Galileo lived as an introduction to Galilean physics – students are given the opportunity to make additional connections thus strengthening their understanding. Furthermore, by highlighting the ways in which scientific content connects to other disciplines, the social, cultural and political significance of science is made more explicit.

  Several of the Pencil pilot projects combined science with other disciplines. For example, one project specifically promoted a cross-curricular approach to issues of sustainable development by helping teachers from both the science and the humanities to explore the broader issue through topics in their respective disciplines.

4.3.1 Summary criterion 3

In promoting connections between learning environments and between disciplines, in conjunction with the use of new facilitation techniques, this criterion examines the extent to which the projects acknowledge contemporary theories of learning, For example, Vosniadou and Ortony (1989) argue that forming connections between different concepts and learning experiences is arguably one of the most important factors in learning. Thus the indicators for this criterion address the need to make explicit the relevance of different principles or concepts wherever they are encountered.

[1] Detailed descriptions of the teaching and learning approaches and methods employed by the pilot projects are provided in the case studies documented in D10 and in the internal reports produced by the pilot projects.

Table 3: Criterion 3 and its three indicators.

Contemporary understandings about learning and facilitation techniques are incorporated into projects
• *Approaches to teaching and learning employed by museum and science centre educators complement those used at schools.* • *A range of facilitation techniques are employed by museum and science centre staff and teachers.* • *Target content is combined with other topic areas.*

4.4 Criterion 4: Contemporary views about the nature and practice of science are promoted by projects

Science is a specialised practice whereby people use evidence to construct, evaluate, communicate and reason about phenomena in the physical world. To support students' learning of science, activities developed by museums and science centres in partnership with schools need to highlight both the practice of science and the way in which scientific knowledge develops.

Success in this criterion may be judged using the following indicators:

- *The 'nature' of science forms a key part of the topic(s) addressed in the project.*
  In order to present the contemporary view of the nature of science, student activities should promote engagement with and evaluation of evidence based-claims. In addition, students need opportunities to practice the communication of science and engage in the process of argumentation whereby knowledge claims are questioned and defended. In this way, students learn about both the epistemic (why we believe what we believe) and the social (how we communicate what we believe) practices of science. Furthermore, the historical basis of scientific knowledge needs to be discussed. Several pilot projects in Pencil noted that project development meetings between museum or science centre staff and teachers offered invaluable opportunities to discuss ways in which to present the nature of science. This helped to raise the awareness and understanding among partners about the processes of science, the skills developed in conducting science, and the role in society – both currently and in the part – that science plays.

- *Scientific content is contextualized: science is a human endeavour.*
  In addition to promoting the nature of science, museums and science centres have a responsibility to present the practice of science in context. By virtue of their exhibits, or specialist staff, museums and science centres offer an opportunity for students to see science in context: as an occupation; as the basis for technological developments; as the solution to social problems. Furthermore, a project which emphasizes the practice of science as a human endeavour helps learners understand that science is a body of knowledge which is constantly changing, and not a set of immutable facts which individuals cannot change.

4.4.1 Summary criterion 4

This criterion addresses the importance of supporting student understanding of contemporary views of science practice. Integrating both scientific content and the view of science as an evidence-based body of knowledge is a key task for both teachers and informal institution educators. Programmes and activities developed in partnership between museum and science centres with schools offer an invaluable opportunity to support this task and to provide an expanded cultural perspective on the nature of science in society.

Table 4: Criterion 4 and its two indicators.

Contemporary views about the nature and practice of science are promoted by projects
• *The nature of science forms a key part of the topic(s) addressed in the project.* • *Scientific content is contextualized: science is a human endeavour.*

4.5 Criterion 5: Changes in attitudes and motivation towards science are included in measures of efficacy alongside knowledge gain and levels of enjoyment

Recent research studies have commented on the low popularity of school science across Europe (cf Jacobs and Simpkins, 2006). Museums and science centres offer resources and activities which could help to reverse this trend, by, for example, designing programmes which seek to enhance students' motivation towards science. Museums and science centres also have a tradition of valuing the interest of learners rather than simply noting their performance (as is required by the formal education system). Thus partnerships between museums / science centres and schools, can help to promote an approach

whereby enhanced attitudes and general interest in the application of science are valued as much as increments in knowledge.

Success in this criterion may be judged using the following indicators:

- ***Interests of students are actively solicited when designing content of the project, or aspects of the activity.***
  In criterion 1, gaining the views of teachers was viewed as highly important in ensuring that a project is embedded into the school curriculum. Soliciting the views of students, however, in the design of a project, helps to enhances students' motivation and interest towards the initiative, and in turn, facilitates deeper understanding of a science content and practice.

  The Pencil pilot projects employed many different methods to solicit student views including questionnaires and focus groups conducted in the formative evaluation period, and the use of student diaries as a way of collecting comments and ideas for project improvement.

- ***The project aims to enhance attitudes towards, and interests in, science.***
  A partnership between museums/science centres and schools ensures that learning continues over a longer period of time than would be the case during a one-off visit by the school to the informal institution. However, given time constraints, and other competing agendas, time spent participating in the project activities is still relatively short. Thus the levels of conceptual learning which may be attributed to the activities of the project will be relatively small. Nonetheless, museum-school partnerships offer ideal opportunities to enhance students' motivation and develop positive attitudes towards science. By developing programmes whereby students become directly engaged in the processes of science, including the design of science exhibits, the communication of science, and research in science, students learn at first-hand about the range of science-related occupations and skills. And by being more informed about the nature of science, students' attitudes towards science are less negative.

  Furthermore, by promoting a general understanding of science as a specialized human practice, students learn to appreciate the role of evidence in decision making, and the importance of communication skills for sharing findings and defending claims. Indeed, within one of the Pencil pilot projects, a primary aim of the project was to develop communication skills on the part of the learner as this would not only be interesting and motivating to students who had previously reported minimum interest in science, but it would help students to learn that science embraces a range of specialized skills and practices.

4.5.1 Summary criterion 5

This criterion highlights the importance of noting changes in student motivation and attitudes as a worthy outcome from a learning experience. By enhancing student motivation, a student is more likely to make connections and construct meaning about a particular piece of content.

Table 5: Criterion 5 and its two indicators.

Changes in attitudes and motivation towards science are included in measures of efficacy alongside knowledge gain and levels of enjoyment
• ***Interests of students are actively solicited when designing content of the project, or aspects of the activity.***   • ***The project aims to enhance attitudes towards, and interests in, science.***

4.6 Criterion 6: Impact of project is enhanced as a result of involvement with networks or communities

Museums and science centres across Europe have long been committed to working in close partnerships with schools. Whilst some initiatives are publicised and shared more widely, many remain within individual institutions and isolated from the view of their professional peers. In this way, their potential audience is limited and so is the possibility to improve as result of peer's suggestions. By participating in professional networks, however, the insights, and lessons learnt in one institution can be shared more broadly, and effective programmes can be replicated elsewhere. In addition, by widening links with local communities, the impact of the original programme is extended to reach many new audiences supporting the enhancement of the initiative.
Success in this criterion may be judged using the following indicators:

- ***Museums / science centres are involved in professional networks.***
  Involvement in networks with colleagues from other institutions provides a mechanism for sharing ideas and insights that can save money, prevent the repeat occurrences of less favourable experiences, and foster the continued development of existing activities. Participation in forums, chat rooms or face to face meetings, as well as contributions to cooperative websites are all examples in which project teams may build, support and maintain professional networks.

  The projects involved in Pencil benefited from weekly chat room meetings and biannual face-to-face meetings, both of which helped to establish a network of peers. All the participating institutions are also members of ECSITE, and the experiences of

other institutions reported at the annual conference were also utilised by Pencil pilot projects.

- ***Local networks comprising schools, education authorities, centres for higher education and informal institutions are established.***
  In building local networks, the work of the partnerships may become more embedded into the educational fabric of the community. Proposals from one member of the network can be refined by another, whilst shared initiatives reduce the costs and efforts of all involved. Furthermore, as discussed in indicators above, it is important for educators to highlight the connections between environments in order to help students construct meaning, and evaluate their own ideas.

4.6.1 Summary criterion 6

This criterion highlights the importance of local and professional networks in the dissemination of project outputs, in finding solutions to common problems and in creating a synergy with both the local educational communities, and the international community to which informal science institutions belong. Developing, strengthening and supporting networks helps to enhance the quality of projects and fosters a culture in which barriers can be anticipated and lessons learned applied to other contexts in order to inform new initiatives.

Table 6: Criterion 6 and its two indicators

Impact of project is enhanced as a result of involvement with networks or communities
• ***Museums / science centers are involved in professional networks.***
• ***Local networks are established.***

4.7 Criterion 7: The initiative is sustainable

The extent to which an educational project may be sustained in the long-term is an important factor for gaining the support, commitment and motivation of both teachers and informal educator staff. Whilst the availability of money and staff time inevitably impact upon the sustainability of any venture, other components in a project's design also play an important role. For example, decisions about the target audience, or how aspects of the project may be transferred or repeated in other future initiatives impact upon a project's long-term success. The sustainability of a project is also affected by the choice of activity, the topicality of content area chosen, and the degree to which new expertise is

developed as a result of the programme. Both the informal institution and partner schools are in a position to affect these aspects and to make strategic decisions to foster the sustainability of a project.

Success in this criterion may be judged using the following indicators:

- ***Lessons learnt during one project are applied to other projects.***
  By reflecting on both the successes and failures of previous initiatives, project partners are able to avoid the repetition of mistakes, and thus design activities with greater chance of success. Although lessons learnt are usually only considered at the end of a project and as such may only be applied to subsequent activities, continuing reflection throughout the course of a project serves to increase the opportunities for modifying actions in order to improve ongoing projects.

- ***New audiences are reached.***
  Extending the impact of the initiatives beyond the original school audience serves to embed the project more firmly, thus imparting a degree of sustainability. For example, by presenting the work of the project at meetings, through web pages and through other forms of dissemination, the benefits of the project are enjoyed by a greater number of people, allowing them to get involved and become future users or designers of project activities.

- ***New expertise is fostered by the project.***
  By developing new materials, new approaches, or enabling new areas of individual or institutional expertise to be fostered, project initiatives will be valued and thus more likely to be sustained. In addition, by developing new approaches, a project and its host institution appears in a positive light from the perspective of schools and teachers looking for an informal institution with whom to work, In this way, the sustainability of a project is ensured.

- ***Core/high impact areas are addressed by the project.***
  By addressing content areas of contemporary interest and concern, the project is more likely to gain greater support as indicated by audience size, and receipt of further funding. Furthermore, by demonstrating the ability of a museum/science centre – school partnership to respond to social, and indeed global, needs, the importance of these partnerships is secured.

- ***Opportunities to extend the initiative beyond the initial funding period are researched and fostered.***
  To achieve greater value for money, it makes sense to attempt to extend the original project beyond its initial funding period. This can be done by committing staff time to

researching ways in which the impact of the project could be extended via dissemination, by applying findings into future projects, and by replicating the activity in a new (or more topical) content area.

- ***External funding is received.***
  The search for additional funding sources to extend or enlarge the project should comprise a core task from the outset for all involved in the project. The separate partners in the project have access to different sources of funding, thus effectively doubling the pool of resources available to the initiative. To support calls for further funding, the evaluation findings from the project should be used as a valuable source of evidence.

4.7.1 Summary criterion 7

This criterion addresses the extent to which a project develops activities to supports its continuation as an educational venture. Although the crucial role played by financial support is clearly recognized, this criterion also highlights the importance of strategic decision-making on a wide range of aspects, from applying lessons learnt to new proposals, to ensuring that new audiences are targeted. The criterion also focuses attention on the importance of considering the issue of sustainability throughout the different stages of a project's development.

Table 7: Criterion 7 and its six indicators

Initiative is sustainable
• ***Lessons learnt during one project are applied to other projects.*** • ***New audiences are reached.*** • ***New expertise is fostered by the project.*** • ***Core/high impact areas are addressed by the project.*** • ***Opportunities to extend the initiative beyond the initial funding period are researched and fostered.*** • ***External funding is received.***

4.8. Criterion 8: Issues of social inclusion and gender equity are addressed by the project

As publicly funded institutions, museums and science centres have a responsibility to serve all members of the local public. Traditionally, museums were the preserve of the middle and upper classes, and visitors from immigrant communities or less wealthy neighbourhoods were rare. The image of science that such museums presented was one of authority and elitism. The original science centres, on the other hand, were designed to present science as a democratic and universal pursuit, and hoped to welcome individuals from all parts of the community.

Today, both museums and science centres share a common commitment of supporting the public's intellectual access to their programmes. Many informal institutions have also made considerable efforts to facilitate the physical access of visitors creating large text panels for the visually impaired, building lifts, ramps or widening doorways for the mobility-impaired and so on. Whilst such efforts are to be applauded, it is relevant to note that the social class of the majority of visitors to such institutions has not changed (Arts Council England, 2007: MORI, 2001)

Museums and science centres, together with schools need to actively address the imbalance. They need to consider ways of engaging or serving new audiences, and responding to the needs of all learners.

Success in this criterion may be judged using the following indicators:

- ***Target audiences are selected with deliberate reference to issues of social inclusion and equity.***

  In determining target audiences, projects need to consider current audiences and reflect upon the local (or if relevant, national) communities within which they are located, but may not effectively serve.

  Within Pencil, some projects sought to recruit partners from the technical schools who, in contrast to the academic gymnasium schools, rarely visited the institution. In this way the project was able to serve a wider-cross section of students, and as a result developed resource materials that addressed a wider range of learner needs.

- ***Methods of learning and teaching should reflect contemporary views with respect to equity and inclusion.***

  In order to respond to the varied needs of learners, and ensure equity of access to knowledge and experience, project activities need to be learner rather than teacher-

centred. Furthermore, efforts should be made to consider the views and ethics of different cultures and explain that scientific explanations afford particular benefits but that other perspectives have cultural significance. Finally, it is important that students learn that both men and women, of all cultures and ages, are involved in science.

- ***Evaluation strategy seeks to capture issues relating to social inclusion, equity and gender differences.***

  In addition to measuring changes in knowledge gain or student motivation, evaluation protocols should be designed to capture the impact of the activity with respect to issues of social inclusion and equity. Such issues include the differential engagement of male and female students: the differential engagement of school groups (or individuals) from particular ethnic or social groups: and the extent to which themes of social inclusion and equity presented in the course of the project were understood by students.

  Evaluation protocols should also be designed to identify the presence of gender-biased communication approaches and/or impact of the activity. For example, the views and self-perception of female students should be considered in conjunction with their results in an activity. In this way, the activity design could be addressed to promote greater female engagement and confidence.

- ***Project findings and insights are shared broadly across a range of dissemination channels.***

  In addition to making use of professional networks in order to extend the impact of the project, partners need to take steps to ensure that new audiences learn about the value and impact that such partnerships can have. To this end, new dissemination channels should be sought, including publishing findings in minority languages, or developing outreach programmes which serve as a 'taster' of the value that a partnership with an informal science institution can afford.

4.8.1 Summary criterion 8

This criterion explores the ways in which projects may support learning across a range of audiences, and indeed build on the programmes already developed by museums and science centres to support different learning styles.

Table 8: Criterion 8 and its four indicators

Issues of social inclusion and gender equity are addressed by the project
• *Target audiences are selected with deliberate reference to issues of social inclusion and equity.* • *Methods of learning and teaching should reflect contemporary views with respect to equity and inclusion.* • *Evaluation strategy seeks to capture issues relating to social inclusion , equity and gender differences.* • *Project findings and insights are shared broadly across a range of dissemination channels.*

5 Conclusions

5.1 Summary of main findings

Following the analysis and evaluation of the products and practices of the 14 Pencil pilot projects, eight criteria of quality and innovation have been identified. These generalised criteria build upon specific instances wherein pilot project activities attempted to 'do something better, or to do something differently', and, as such, reflect the experiences and lessons learnt by the Pencil partners.

The criteria, together with their constituent indicators, offer a framework for ensuring a degree of consistency in the identification of good practice at the intersection between formal and informal contexts across Europe. Whilst local and cultural differences between countries may mean that what is innovative in one context is commonplace in another, the generalised criteria provide a framework against which individual institutions may assess their own progress in enhancing their support of science teaching and learning. In using the criteria, however, it is important to note that they should be considered not so much as standards to meet, but more as a framework for addressing existing needs and responding to those that are currently unmet.

The eight criteria are presented in full on the next page.

Criteria of quality and innovation

- **Criterion 1:** Teachers are involved in the design phase of education projects aimed at schools
- **Criterion 2:** Evaluation forms an integral part of the educational project
- **Criterion 3:** Contemporary understandings about learning and mediation are incorporated into projects
- **Criterion 4:** Contemporary views about the nature and practice of science are promoted by projects
- **Criterion 5:** Changes in attitudes and motivation towards science are included in measures of efficacy alongside knowledge gain and levels of enjoyment
- **Criterion 6:** Project impact is enhanced as a result of involvement with networks or communities
- **Criterion 7:** Initiative is sustainable
- **Criterion 8:** Issues of social inclusion and gender equity are addressed by the project

5.2 Implications for wider practice

In providing a framework to identify good practice in the design of joint activities between museums/science centres and schools, the criteria of quality and innovation can also support the day-to-day work of the individual educators involved. For example, staff from the informal science institutions may use the criteria in order to improve the design of exhibits and public programmes, whilst teachers may use the criteria to enhance their delivery of the curriculum and their approach to the teaching of science. In addition, the criteria offer a common point of reference for educators – in either the formal or informal sector – engaging in discussions relating to innovative practice in science teaching and learning. Furthermore, whilst the criteria are worded in universal terms, their origin in the 14 Pencil pilot projects means that they will be especially useful for practitioners wishing to address issues and constraints relating to science learning and teaching which are peculiar to the European context.

Finally, it is important to recognise that the criteria are not a definitive or exhaustive list. Additional criteria may, and should, be added in the future to further enhance the practice of museum/science centre partnerships with schools. Indeed, a criticism of the

pilot project analysis, which led to the current criteria, would be that the findings were based almost solely on data collected and reported by the informal institution partner and that teachers' voices were relatively unheard. A final recommendation, therefore, would be that further partnership projects are evaluated using the Pencil criteria of quality and innovation as a benchmark, but that the views and experiences of teachers are collected more systematically, and the criteria subsequently expanded as necessary.

References

Arts Council England (2007) *Final report of PSA target 2 on the take up of cultural opportunities* [online] available at http://www.culture.gov.uk/NR/rdonlyres/44881017-F67C-4C13-96B9-0A99C7C9C80A/)/ACE_FINALPSA2target.pdf

Ash, D., & Klein, K. (2000) *Inquiry in the Informal Learning Environment*. In Inquiry into inquiry learning and teaching in science Minstrell, J. & van Zee, E. (Eds) Washington DC: AAAS

Cox-Peterson, A.M., Marsh, D.D,. Kiesel, J. & Melber, L.M (2003) Investigation of guided school tours, student learning and science reform recommendations at a museum of natural history. *Journal of Research in Science Teaching* 40 (2): 200 - 218

Jacobs, J.E., & Simpkins, S.D. (2006) *Leaks in the Pipeline to Math, Science and Technolog Careers: New Directions for Child and Adolescent Development*. San Francisco, Ca: Jossey Bass

MORI (2001) *Visitors to Museum & Galleries in the UK – report to the Council for Museums, Archives and Libraries (MLA*), [online] available at: http://www.mla.gov.uk/resources/assets/M/mori3_pdf_6872.pdf

Rennie, L.J. (2007). *Learning Science outside of school*. In Handbook of Research in ScienceEducation. Abell, S.K. & Lederman, N.G. Editors. Lawrence Erlbaum Ass. Chapter 6 pp 125-165.

Tran, L. and King, H. (in press) The professionalization of museum educators: the case in science museums. *Journal of Museum Management and Curatorship*

Vosniadou, S. & Ortony, A. (1989) *Similarity and analogical reasoning*. Cambridge: Cambridge University Press