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Supporting science teaching in out-of-school contexts

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Introduction

In recent years, researchers and policy makers have increasingly called for greater attention to be paid to the educational potential of out-of-school settings, citing the many benefits, and indeed, the necessity, of learning in contexts other than the classroom. For example, UK Education and Skills Select Committee stated that:

> Education outside the classroom is of significant benefit to students. Academic fieldwork clearly enhances the teaching of science and geography, but other subjects such as history, art and design and citizenship can also be brought to life by high quality educational visits. Group activities, which may include adventurous expeditions, can develop social skills and give self-confidence. Furthermore, outdoor education has a key role to play in the social inclusion agenda, offering children who may not otherwise have the opportunity the simple chance to experience the countryside, or other parts of our heritage that many others take for granted.

(House of Commons, Education and Skills Select Committee, 2005:7)

In November 2006, following the recommendations outlined by the Select Committee, the Department for Education and Schools launched a Manifesto for Learning Outside the Classroom (LotC) (DfES, 2006) resulting in the creation of the Council for Learning Outside the Classroom (www.lotc.org.uk). The basic premise of the Manifesto and the Council are that education is not only about ‘what we learn, but importantly how and where we learn’ (Manifesto, DfES, 2006: 3, emphasis in the original). Although recent changes in the National Curriculum for England have resulted in a less overt message concerning the requirement for learning outside the classroom, clear support from the current coalition government remains in place (Michael Gove, January 2014, FSC Parliamentary 70th anniversary reception).

The purpose of the paper is to present an overview of the research literature concerning the benefits of and opportunities for learning outside the classroom. We offer two examples of how such opportunities might be realised in different contexts, before discussing how learning might be managed in order for the experience to be maximised. However, we are aware that learning outside the classroom means different things to different people and so begin by sharing our working definitions.

A few definitions

We define opportunities for learning outside the classroom to include experiences in
school grounds, streetscapes and local nature reserves. Further afield, opportunities include fieldtrips to farms, the wider countryside and sites of industry. In addition, they include visits to zoos, botanic gardens, museums, science centres, cultural sites and even fieldwork trips abroad. The timeframes for these experiences may be in the order of a single lesson, a day-trip, or a week-long residential course.

With regards to the nature of learning during such experiences, we note that the term ‘informal’ is often used to contrast out-of-school experiences with the ‘formal’ practices inherent in classrooms. Wellington (1990), for example described formal learning as compulsory, structured, close-ended and teacher-centred. Informal learning, meanwhile, is described by Wellington as voluntary, non-structured, open-ended and learner-centred. We argue, however, that such definitions create a false dichotomy and are unhelpful in exploring the ways in which the experience in one environment may complement an experience in another. Furthermore, we note that whilst classroom based activities are undoubtedly constrained by timetables, space, and resources available, the learning may indeed be open-ended and learner-centred. In contrast, we have observed many school visits to museums and nature reserves that are highly structured and offer little opportunity for students to follow their own interests.

Rather than attempt to categorise the type of learning, therefore, we argue that different environments offer different types of opportunities, which together impact on the three domains of learning. Building on the original work by Bloom et al. (1956), we identify those domains as the cognitive, the affective, and the physical and behavioural. By cognitive learning, we refer to the conceptual skills of recalling facts, analysing and synthesising information and applying knowledge. Traditionally, learning in the cognitive domain has been promoted by the school system where it has been necessary to enable students to pass exams based on retrieval and application of content knowledge. By affective learning, we refer to the way in which students come to take a personal interest in a subject and learn to express and defend opinions and values. Affective learning also encompasses attitudes towards a topic and self-perception of oneself as a learner. Finally, in referring to physical and behavioural learning we mean the ways in which students gain skills in manipulation and planning, but also learn to work both independently and alongside others in teams.
The benefits and opportunities offered by experiences outside the classroom

**Supporting science learning in the cognitive domain.**

Concepts in science are often abstract and complex. To help students make sense of these concepts, Driver (1989) argued that teachers need to present new concepts through a range of ideas and across a range of experiences. In this way, a learner’s construct of a concept will be tested and refined leading to a more solid understanding. Environments outside the classroom offer authentic and first-hand opportunities to engage with scientific concepts that are located within particular contexts, and are furthermore addressed outside the traditional boundaries of biology, chemistry and physics. Thus, visits to sites of industry provide students with the opportunity to consider integrated industrial processes, whilst field-trips to nature reserves, countryside locations or even to local green spaces offer a resource for exploring the cross-disciplinary issues which define the environmental and geological sciences. In addition, many of the activities promoted by settings outside the classroom allow students at both primary and secondary levels to engage in processes of data collection that are more akin to the genuine practices of science. In other words, experiments conducted and data collected in real-life settings give students an insight into the ‘messiness’ of science and challenge many of the myths about science propagated by the standardised experiments of school laboratories (Hodson, 1998). Whilst understanding the nature of experimentation in controlled laboratory conditions is important, experiments outside the laboratory such as, for example, studying the speed of vehicles, support the development of broader and more speculative observation and interpretative skills. Similarly, when students are able to handle unique objects, from museum collections or from unfamiliar habitats, new skills of observation and categorisation are afforded (Leinhardt and Crowley, 2002). Indeed the opportunity to compare objects, artefacts or organisms presented in museum-type environments supports the identification of patterns and trends and, in turn, promotes an understanding of the way in which knowledge and our scientific culture has developed.

Finally, it has been shown that experiences gained outside the classroom actually promote long-term learning. For example, Mackenzie and White (1982), in their study of 141 Australian students in the eight and ninth grade, tested student learning and retention of
facts following three different programmes: active excursion; passive excursion; and no excursion. All three programmes covered the same objectives, however on comparing the results from students’ post-test scores (immediately following the programmes) and delayed post-test scores (12 weeks later), those involved in the active excursion showed 90 per cent retention of content (where retention is expressed as percentage of the initial achievement test mean). This compared significantly to pupils who experienced a passive excursion and who showed a 58 per cent retention, and no excursion who showed a 51 per cent retention. The active events involved students using a range of senses, and being active rather than passive participants in terms of generating their own data. The authors argued that this marked retention was due to the role that ‘active’ events have in constructing conceptual links. Whilst it is acknowledged that teachers often include ‘active’ elements in their classroom-based lessons, we point to a finding by Nundy (1999) that experiences conducted outside the classroom are more effective than similar experiences conducted in class. For example, Nundy in his study of 85 upper primary students (aged 9-11) found that students studying a particular curriculum topic during a five-day residential course achieved greater cognitive gains than those studying the same topic for the same period in what was described as an ‘active’ classroom context. Like Mackenzie and White, Nundy attributed some of the learning gains to the novel setting, but also concluded that the students’ cognitive learning had been positively impacted by gains in the affective learning domain. In short, the gains resulted from experiences afforded by the residential course that were not available to the classroom-bound pupils.

**Supporting science learning in the affective domain**

Learning outside the classroom automatically involves a change of scene. It may even involve an entirely new environment, and in addition, engender high levels of excitement in response to the mode of transport employed to travel to the venue. Furthermore, it is perceived to be fun: as Cerini, Murry and Reiss (2003) found in their review of the science curriculum for ‘Science Year’, students rate ‘going on a science trip or excursion’ to be the most enjoyable way of learning science. The consequence of novelty, fun and excitement is that student learning in the affective domain is supported as interests are piqued and enthusiasm for a topic is enhanced.

An affective experience offered by settings outside the classroom may also support the development of positive attitudes towards science. For example, most readers will
remember their sense of awe and wonder at the diversity of the natural world when they first saw a display of tropical fish in an aquarium. Others will recall their surprise and amazement at examples of technology displayed within a science museum which bear witness to the ingenuity and tenacity of scientists and engineers both today and in the past. Whilst such information may also be presented in books, on TV or online, the sense of scale and authenticity provided by out-of-the-classroom experiences, makes them much more memorable. Indeed, as Mackenzie and White (1982) note, a memorable experience – whether it be falling over in the mud whilst learning about woodland fauna, or being awed by a full-sized model of the blue whale – improves long-term knowledge recall (also see Piscitelli and Anderson, 2001). Moreover, a shared memorable experience offers teachers a ‘hook’ upon which they may hang further experiences back in the classroom.

Lastly, experiences outside the classroom offer students an opportunity to address some of their preconceptions regarding the nature of careers in science. It has been suggested that the current decline in the uptake of post-16 science courses could be due to negative attitudes towards science and negative perceptions of those who engage with science (Osborne, Simon & Collins, 2003; Bennett and Hogarth 2005; DeWitt, Archer & Osborne, 2013). Indeed, Hill and Wheeler (1991) have suggested that students do not have a well-rounded appreciation of the work that professional scientists undertake. As a result, it is reasonable to assume that the stereotypical view of scientists as bearded old men in white coats will prevail. Thus, visits to sites of industry, to museums with resident scientists, or to nature reserves staffed by conservation officers, provide students with an unique opportunity to meet and talk with professional scientists and in turn gain a greater understanding of what a career in science involves and requires in terms of qualifications and training.

**Supporting science learning in the physical and behavioural domain**

Experiences outside the classroom provide a range of opportunities for students to experience different structures and different sorts of social interaction than those that they are used to in school. No longer constrained by timetables, the physical space of the classroom, or even the expectation of what a lesson should entail, students and teachers can forge new ways of working. Dillon and colleagues for example note the ‘transformative experience where new relationships form e.g. student-student, student-teacher, student-environments, student-community’ (2005: 60). Cramp (2008), meanwhile, noted a range of
positive changes for student and teacher relationships as a result of residential experiences. In addition, researchers have highlighted the ways in which fieldwork activities develop teamwork skills and note that the positive relationships built during such activities are maintained back in school. For example, in their study of 2,706 11-14 year olds attending a residential science/outward-bound activity course in the UK, Amos and Reiss (2012) found that student self-esteem was boosted by the experience, and that general levels of trust in others rose significantly. Findings revealed that students’ collaborative skills improved with strengthened interpersonal relationships being observed on return to school. Finally, it should be noted that in gaining greater familiarity with contexts beyond the classroom, students will develop confidence in visiting similar settings, as well a richer identity, security and sense of belonging (Jack, 2010). Indeed, Glackin (2007) found that even short experiences conducted in the school grounds or local neighbourhood played a key in supporting a student’s understanding of their local environment.

**Realising the opportunities offered by contexts outside the classroom**

Experiences outside the classroom include those that take place within the school grounds or local community – they do not necessarily require transport and time away from other classroom lessons. For example, the Thinking Beyond the Classroom programme (http://www.pstt.org.uk/resources/continuing-professional-development/thinking-beyond-the-classroom.aspx) developed a key stage 3 (ages 11-14) lesson on forces that can be taught in the school grounds or a local open space. The lesson involves students working in collaborative groups to consider everyday objects in their local environment – a children’s swing in the park, a basketball hoop, a tree – and then attaching arrows of different lengths and appropriate key words to indicate the types of forces acting on the object. The relative positions of all the arrows placed by the students are then discussed by the class, and then amended if necessary. The activity ends with the students sketching or photographing the objects together with their arrows in order that findings can be discussed further when back in the classroom and linked with previous or future classroom-based work.

Such an activity addresses the key content area of forces and clearly serves to illustrate the ways in which forces are interactions between objects and in turn affect an object’s shape and motion. In addition, the outside the classroom setting provides students with the
opportunity to assess issues of risk and to work safely in the field. Moreover, the lesson is arguably more effective than traditional classroom-based lessons on forces in a number of ways. Firstly, in most classrooms, the concept of forces is addressed through the use of two dimensional diagrams or photographs. Where practical work is included, many of the examples, such as the use of large springs, are removed from the reality of students' everyday lives. In considering objects and phenomena outside the classroom, students are given the opportunity to see how the concept of force applies in everyday settings. As a result, students see the 'point', or real-life application, of science. The lesson also supports collaborative learning as small groups discuss and agree on the types of forces before placing their arrows. Finally, the activity supports cognitive, physical and behavioural, and also affective development. Cognitive development occurs with a practical understanding of the nature of forces; physical and behavioural development is supported by the practical activity and group work; whilst affective development is afforded by a richer appreciation of the local environment as the consequence of regarding it in new and different ways.

A second example of a learning opportunity beyond the classroom involves a visit to a local museum with natural history specimens, or to a national museum of natural history. Such an experience can be tailored to suit learners of all ages and begins with students observing and examining a range of natural history objects from the museum's collections and exhibitions. The students then use their skills of observation to compare specimens and to speculate on the phylogenetic (evolutionary) relationships between the specimens. They also observe the physical features of organisms and speculate on their ecology. Finally, they use the collections to answer specific questions about the natural world that they had prepared individually or in groups prior to their visit.

This activity provides an opportunity for students to obtain, analyse, evaluate and record observational data from primary sources. It also provides a context for students to develop scientific explanations based on available evidence. In focusing attention on a range of specimens, which are rarely available in school contexts, students may come to appreciate some of the similarities and differences between the diverse array of species that comprise the natural world. In addition, if museum staff are available, they may be able to offer a detailed insight into the process of collecting, classifying, and storing specimens such that they may be used to further our understanding of the natural history of certain habitats, countries or continents. In this way, students will gain a greater understanding of the
scientific discipline of natural history. Moreover, by studying various displays of natural history – from Victorian dioramas to contemporary interactive exhibits – students will gain an insight into the ways in which our knowledge of natural history, and the ways in which the discipline is presented, have changed over time. Finally, such an activity affords cognitive development with respect to the acquisition of new skills in observation and classification, together with a deeper understanding of ecology; physical and behavioural development in that it requires team work within small groups; and affective development in that the experience provides a memorable introduction to the discipline and profession of natural history.

Managing learning outside the classroom

In order to maximise the learning opportunities outside of the classroom, it is important to consider how best to support the learning in advance, during and post the experience.

In advance of an experience

In planning an activity it is important that the teacher makes an explicit connection to the topic being studied in the classroom. This is to ensure that the learning outside the classroom is complementary to the learning that occurs inside the classroom (Hohenstein and King, 2007). Secondly, if the activity is to take place in a new environment, the teacher should take care to provide students with information about what to expect. As Falk, Martin and Balling (1978) have shown, excessive novelty can distract learners. However, if pre-orientation to the new environment is provided, students will be better equipped to cope with the new space and in turn be stimulated by it (Anderson and Lucas, 1997; Orion and Hofstein, 1994). Pre-orientation can be provided by the provision of maps or slides, a review of the institution’s website, and detailed information about the facilities at the venue and the tasks for completion. Where possible, pre-visit resource materials developed by the host organisation should be used as such materials will have been developed by education staff who are highly knowledgeable about the environment and its contents. Furthermore, it is likely that such materials will have already been tested by others teachers.

In addition to considering the cognitive tasks associated with the activity, it is also important to prepare for learning in the affective, and physical and behavioural domains.
Such preparation may include encouraging students to develop a set of questions based on their own interests that may then be answered during the activity (Griffin and Symington, 1997). In addition, the grouping of students should be planned in advance to allow such groups time to agree suitable rules and working arrangements to foster learning.

**During the activity**

Upon arrival at the new location, students may need time to orient themselves to the novel environment. Following this, it is recommended that the unique resources provided by the location – the objects within a museum, or the organisms in a natural ecosystem – constitute the primary focus rather than the completion of a worksheet. As McManus (1985) noted, by solely concentrating on a worksheet, students are likely to miss many inspiring objects. Furthermore, as Griffin and Symington (1997) have argued, the completion of worksheets promotes task-oriented behaviour rather than learning-orientated behaviour. As the latter authors note, learning-orientated behaviour supports greater motivation for a topic, and thus engenders both affective and cognitive development. The key role for teachers, meanwhile, should be one of facilitation and of asking questions to stimulate and develop thinking (Black et al., 2004). Where education staff or science related professionals are available, it may be possible to team-teach (Glackin and Jones, 2012). Tal and colleagues (2014), following an analysis of 62 field visits identifying exemplar practice, suggest that good collaboration between education staff and teachers is fundamental to high quality outdoor learning. They also note the importance of providing students with a sense of freedom and extended time to explore and engage in meaningful social interactions.

**Post the activity**

To ensure that the learning from activity is maximised, it should be integrated within the classroom curriculum as soon as possible. As DeWitt and Osborne (2007) have demonstrated, photographs or film can help to prompt student recollection of their experiences. Moreover, such materials provide an appropriate ‘hook’ upon which to pin further content. In addition, any data that was collected during the activity should be analysed, interpreted and reported. In this way, students will realise that their experiences outside the classroom are just as significant as those that occur inside the classroom. However, integration of experiences back into the classroom requires thoughtful planning.
Tran’s (2011) findings suggest that teachers must pay close attention to students’ interests and their experiences before positive attainment outcomes related to out-of-classroom learning occur. Finally, it is important that students reflect on how any ground rules or the group structure that they themselves had established either enabled or hindered their learning. In this way, student development will also be supported in the physical and behavioural domain of learning.

Conclusion

Learning experiences outside the classroom offer students the opportunity to develop across the cognitive, affective, and physical and behavioural domains of learning. However, such experiences need to be managed by the teacher, before, during and after the event to ensure that the learning is complementary to classroom-based instruction. We acknowledge that teachers in England and elsewhere are undoubtedly faced by a number of real challenges in planning and managing experiences outside the classroom, but, we argue, the value of such experiences are invaluable. In reflecting on the impacts of a residential field course, the head of science at one London school had this conclusion:

Most of the students loved it. A few hated it, but they all came away with a real sense of achievement. They will probably not do anything like it ever again in their lives. It’s a real experience, and one that introduces young people to the world of science,

(Teacher, quoted in Glackin, 2006).

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References


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