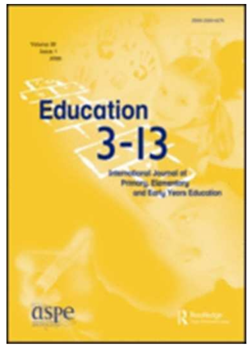

Getting more from getting out: increasing achievement in literacy and science through ecological fieldwork.

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Abstract

This paper demonstrates the positive impact of learning through ecological fieldwork upon children's ability to write and to write about science. Specifically we have carried out a relatively large-scale study (involving 379 children aged 9-11 from eight primary schools in North East England) comparing intervention classes (involved in fieldwork) and comparison classes (no fieldwork). Pre intervention assessments revealed no differences between classes in mean literacy scores; post intervention assessments revealed that significantly higher literacy scores were achieved by children who had carried out fieldwork (girls consistently out performed boys in all classes). Intervention class children achieved higher scores in science (ecology) assessments than their comparison class peers before and after the intervention. We suggest that this may be an effect of these children thinking as scientists throughout the project. Our work confirms that a child-centered outdoor learning experience focused upon science can result in learning benefits across the wider curriculum.

Introduction

The view that children should be enabled to learn outside of the classroom and to connect with the natural world in both formal and informal settings is a commonly held one. In the United Kingdom recent changes to the National Curriculum for Primary Schools (DfE 2013) require that '*pupils should use the local environment throughout the year to raise and answer questions that help them identify and study plants and animals in their habitat*' and suggest that '*pupils, through direct observation, where possible, should classify animals*' (notes for guidance, page 172). As field biologists who advocate the use of the outdoors as a laboratory for the teaching of ecological concepts and species identification we welcome this development enthusiastically. However, we recognise that advocacy is in itself insufficient and that it is important that we heed the warning of Rickinson et al. (2004) who have stated that if fieldwork is to be effectively promoted then it is vital that the practice is underpinned by an evidence base that clearly demonstrates its value.

The many barriers to participation in fieldwork based learning that primary teachers face have been discussed extensively in the literature (e.g. Dillon et al. 2005; Dillon & Dickie 2012; Fägerstam 2012; Howarth and Slingsby 2006; O'Donell et al. 2006; Rickinson et al. 2004; Blinded et al. 2014). The broader array of barriers discussed by these authors is not the focus of this paper. Here we concentrate upon the fact that several authors have suggested that two things that may help teachers to increase fieldwork provision are firstly to situate it at sites on or close to the school grounds (minimising costs and timetabling constraints and ensuring site familiarity) and secondly to link fieldwork to curriculum areas that are perceived by school managers to be particularly important by virtue of their linkage to formal national assessment (e.g. literacy or numeracy in the context of English National Assessments) (Blinded et al. 2014).

The broader aim of this paper is to evaluate the impact of a learning task which integrates ecological fieldwork and an authentic task (the production of an ecological fieldguide) upon the ability of children to write generally and to write about ecology specifically. It is important to remember that this is not an example of experiential learning in the strict sense of the term but that it is an example of learning through active participation and self-directed discovery. The children undertaking our intervention were not *taught* more ecology, rather they were enabled to *learn* more (see below). We have framed the project in the context of Hapgood and Palinscar (2006) who have stated that 'learning about the world and sharing one's own discoveries can be powerful motivators for learning to read, write and speak effectively'. Specifically our aim is to confirm that participation in self-directed ecology fieldwork and a related classroom based task has a positive impact upon the ability of children to write about an aspect of science (ecology) to which the tasks were very clearly aligned and to demonstrate a wider curriculum benefit in that children who have undertaken fieldwork will achieve higher literacy scores on average than those who have not.

The wider value of learning out of doors

Through direct experience fieldwork enables deeper learning; enhances personal interest and motivation to learn; and, results in higher levels of cognitive engagement and achievement (Randler, Ilg and Kern 2005; Rea 2008; Stokes and Boyle 2009). Waite (2007) suggests that an experience of plants and animals in their natural setting enables the development of particularly strong memories that interact positively with learned material and enhance subsequent recall. Blinded (2014) have also suggested that children are able to use personal familiarity with the natural world to access and apply informal prior learning to formal learning tasks in a way that enhances academic outcomes. It has also been shown that pupils are better able to acquire new fieldwork techniques, and build effectively upon their understanding of ecological concepts (e.g. environmental adaptation; feeding relationships) (Prokop, Tuncer and Kvaničák 2007). There is strong evidence that topics taught in the classroom are enhanced through the in-situ study of particular habitats (Vaughan et al. 2011) or individual species in their natural habitats (Magntorn and Hellden 2007). For example Gambino, Davis and Rowntree (2009) found that a short excursion to a nature park to see first hand the habitat of the endangered Greater Bilby was enough to significantly increase the knowledge of Australian children (4- 5 years old) about this animal. Similarly Drissner, Haase and Hille (2010) found that pupils who had a first-hand experience of nature through learning in a 'green classroom' displayed greater intrinsic motivation towards learning and were able to demonstrate a higher level of scientific knowledge about small invertebrates when compared to a group of pupils who had not had the same fieldwork experience. Prokop, Tuncer and Kvaničák (2007) found that children who had attended a field trip demonstrated greater levels of ecological knowledge than children who had only been taught indoors. Learning about nature first-hand may also enable children to develop a personal connection to the natural world (Phenice and Griffore, 2003), and Chawla (1999) and Ballantyne and Packer (2002) have demonstrated a lasting benefit of learning outdoors in that children who have an opportunity to do so are likely to develop a positive attitude to the natural world that persists into adult-hood.

The combination of personal experience, interest in a topic and the motivation to learn can also have a positive impact upon the affective domain. Simply being outdoors may encourage positive learning behavior on the part of those pupils, (often, but not exclusively, boys), who may not learn best through sitting down, listening, reading and writing. This was found to be the case by Carrier (2009) who demonstrated that elementary school boys scored better, in terms of environmental knowledge and attitude, when learning outside compared to when learning inside the classroom. Carrier (2009) also found that because their behaviour improved they were also better able to focus on their learning. A similar observation has been made by Randler, Ilg and Kern (2005) who have shown that involvement in a program of conservation activities focused on amphibians resulted in heightened interest and well-being and lower levels of anger, anxiety and boredom amongst elementary school pupils. Blinded (2013), have demonstrated that the relationship between teacher and student was positively re-aligned through a shared experience of outdoor learning.

Methods

Scope of the Study

The research involved 379 pupils from year 5 (5 schools) and year 6 (3 schools) (9-11 year olds) attending eight primary schools in the North East of England (North Yorkshire, East Yorkshire and Humberside). Because not all children attended school on all of the days that data were collected, and because not all children contributed data to every variable considered, sample sizes for individual analyses vary. In seven of the schools two classes (two year 5 or two year 6, never a mixture of the two) were involved in the project: one intervention class (which took part in our integrated fieldwork and classroom based task) and one comparison class (which did not take part). The remaining, smaller, school had an intervention class but no comparison class. At the time of the project all class teachers were delivering the ecological content of the UK National Curriculum. The head teacher of each of the participating schools nominated a class as either the intervention class or the comparison class. We had no influence over this decision.

The Learning Task

Each intervention class teacher chose a local habitat (on school grounds or a short walk from school) as the location for a half-day (morning) fieldwork session. Habitats chosen included school playing fields and gardens; a school pond; a local woodland, the hedgerow along a local bridleway; and, the local rocky shore. At each habitat children were provided with some basic safety instruction, the limits of an area to explore and a simple pictorial identification chart to the plants and/or animals that they were likely to encounter (charts used were all produced by the Field Studies Council and can be sourced from them: www.field-studies-council.org/publications/fold-out-charts.aspx.). During the course of the session children were encouraged to explore the habitat and to identify as many of the organisms that they encountered as possible. They were then asked to photograph species that interested them and to make some notes about the appearance and location of the organism. They were also encouraged to write down questions that their encounter with the organism made them think about (e.g. what does it eat? what eats it? how long can it live? Why did I find it here?). During the fieldwork the pupils were not actively taught by the adults present because another element of this project that is not the focus of the current paper was an evaluation of the affective benefits of shifting the pupil/teacher dynamic by allowing the pupils to take control of their own learning and to learn along-side their teachers rather than be taught by them (Blinded et al. 2013). The focus in the current paper is the impact of our task upon literacy and writing about ecology and we believe that this can be adequately assessed via this study design.

After the fieldwork session (within a day or two) the pupils carried out a related classroom based task involving the use of ICT. They were asked to use their photographs and the observations that they had made in the field to produce a field guide that would be useful to other children visiting the site. They were provided with a pro forma page outline that asked them to insert their own photograph(s) and then to use the notes that they had made in the field to write a short description of the animal/plant and provide some notes about where it had been found. They were asked to use the internet to answer the questions that they had generated in the field and to write additional notes (they were directed towards a selection of appropriate websites). They were also asked to add to each page a “Wow Fact” about their organism – something that they had learned that amazed them. Many of the children completed their page during the timetabled session, but in all cases the teachers enabled completion by all children during a follow up session at a later date (usually within a week).

The pupils in the comparison classes did not take part in this activity, but within a school both intervention and comparison classes were taught the ecological content of the relevant stage of the UK National Curriculum (e.g. food webs, adaptation and the classification of plants and animals) in a classroom setting during the rest of their learning time. Because the teachers in the paired classes within a school coordinated their teaching we do not believe that the children in the intervention classes were *taught* any more ecology than the children in the intervention classes. However, we acknowledge that our intervention/comparison design does mean that children in the intervention class were *exposed* to more ecology learning during the exercises.

Assessing the Learning Impact of the Task

To assess the impact of participation in the integrated classroom and fieldwork activity, each child in the intervention and comparison classes was asked to complete two pre-task written assessments and two post-task written assessments. One pre-task and post-task assessment were paired to assess literacy and the others were paired to test the pupils' scientific (ecological) knowledge. These written assessments were similar in format to tests issued as part of the English national assessment system for pupils age 11 with which the pupils were familiar (colloquially known as SATs or Standard Assessment Tests). Typically the interval between a pre-test assessment and the intervention was 2 weeks and the interval between the intervention and the post-test was four weeks (although this did vary slightly from school to school).

Literacy pre-test

The pre-test literacy assessment required pupils to complete a written description of a woodland animal that we expected them to have some familiarity with (they had the choice of a bird, a worm, a snail or a rabbit). They were asked to detail its adaptive features and its feeding relationships within its particular habitat. We evaluated pupils literacy skills via APP (Assessing Pupil's Progress), a structured approach to assessment (linked to the UK National Strategy) which enables teachers to assess pupils' work in relation to assessment criteria benchmarked against national standards (National Archives acquisition 2011); This assessment results in a standard score or level, measured and expressed on a 1 to 5 scale. A level 5 is the usual upper limit at UK primary schools. Within each level there are sub-levels; c, b and a, where c is lower than b, which in turn is lower than a; for example work being awarded a level 4a is of a higher standard than work awarded 3b. For statistical analysis of our data we allocated a number ranking to each sub level (from level 2c = 1; to level 5c = 10). It is important to note that in ascribing ranks to enable quantitative analysis we are not assuming that the progression through levels and sub-levels is linear (this has not been demonstrated to our knowledge). In effect we are treating these data as a categorical scale and have chosen appropriate analytical tools accordingly (see below).

Science pre-test

The pre-test science assessment measured the pupils' ability to write about (and demonstrate a level of understanding and knowledge of) the ecological aspects of the science curriculum appropriate to their level of study, using questions extracted from previous SATs papers. For example in one question the children were provided with line drawings of a range of animal species and then asked to identify which was a predator of which, and to identify a herbivore. In another they were asked to answer an extended question: "Some children collected animals from a pond. They found a lot of animals amongst the water plants, why was this?"

The assessments were marked according to the mark scheme accompanying the relevant SATs papers and a total raw mark was awarded. The questions ranged from level 2 to 5 (see above). In this case total raw marks awarded were used in the analysis rather than levels because only the ecological components of the science curriculum were being assessed, not the entire curriculum.

Post Fieldwork assessments

Following the fieldwork activity the classes resumed their normal teaching schedule. After approximately six weeks pupils from both the comparison and intervention classes were again asked to complete two assessments, one literacy task and one assessing their scientific knowledge. The content and layout of the tasks were similar to those taken prior to the fieldwork activity. The only difference in the literacy task was that this second assessment presented children with images of animals and/or plants that their class had encountered during the fieldwork experience (although of course only one or two of the children in a class would have concentrated upon the organism personally when writing the field guide). Pupils in comparison classes had been taught in the classroom about the same habitat and types of organisms as the intervention class in their school (e.g. trees or invertebrates but not necessarily the same species), but they had not experienced them first-hand during an outdoor learning session. Both of the post-test written exercises were assessed in the same way as the pre-test assessments.

All statistical analyses were carried out using SPSS (SPSS 2009). Because examination of qq plots prior to comparative analysis revealed that the data conformed to normality nested Analysis of Variance (ANOVA) was used to compare intervention and comparison class populations. Each of our analyses employed a nested ANOVA (unbalanced because classes did not all have the same numbers of children or the same numbers of boys and girls) with the variable to be compared (ranked literacy level or science score) as the main fixed factor, and gender nested within class (intervention or comparison) within school as random factors. Gender was included in our analysis because it is recognised nationally that boys and girls often differ in their level of literacy at this age (Jama and Dugdale 2012). School was included because we needed to control for the fact that the children in the different schools were not the same age when we carried out our research (some were in year 5 (9-10 years old), others in year 6 (10 – 11 years old); within a year group children from whom data were collected in September would be 9 months younger than those in the same school year from whom data were collected in June).

Results

Pre Fieldwork Assessment of Literacy

To establish that literacy levels of pupils in comparison and intervention classes within a school were similar prior to the involvement of intervention class pupils in our field based exercise we carried out a nested ANOVA (unbalanced) with pre-intervention literacy assessment (PRELIT) as the main fixed factor and GENDER (male or female) nested within CLASS (intervention or comparison) nested within SCHOOL as nested random factors. This analysis revealed no statistically significant effect of either school or class (SCHOOL $F_{1,306} = 1.59$, $p>0.05$, CLASS $F_{1,306} = 2.31$, $p>0.05$) but did reveal a significant gender effect such that girls on average demonstrated higher literacy levels than boys (GENDER $F_{1,306} = 9.66$, $p<0.05$, means ± s.e., girls 5.4 ± 0.2 and boys 4.6 ± 0.2).

Post Fieldwork Assessment of Literacy

To compare the literacy levels of pupils who had engaged in our fieldwork exercise and pupils who had not done so we carried out a nested ANOVA (unbalanced), this time with post-intervention literacy assessment (POSTLIT) as the main fixed factor and GENDER (male or female) nested within CLASS (intervention or comparison) nested within SCHOOL as nested random factors. This analysis revealed statistically significant differences between schools (SCHOOL $F_{1,337} = 7.85$, $p<0.01$), between classes (CLASS $F_{1,337} =16.0$, $P<0.001$) such that pupils in intervention classes on average achieve higher levels of literacy than those in comparison classes (POSTLIT mean ± s.e. intervention 5.6 ± 0.1 and comparison 4.6 ± 0.1; figure 1) and between boys and girls (GENDER $F_{1,337} =8.92$, $P<0.01$) such that girls achieve higher levels of literacy than boys (POSTLIT mean ± s.e. intervention 5.2 ±1.2 and comparison 4.6 ±1.8).

[INSERT FIGURE 1 HERE]

Pre and Post Fieldwork Assessment of Science

We used an unbalanced nested ANOVA to compare the science scores of the pupils in intervention and comparison classes who completed our pre-intervention science assessment (PRESCI), and a second unbalanced nested ANOVA to compare levels of achievement of the pupils in intervention and comparison classes who completed our post-intervention science assessment (POSTSCI).

Analysis of PRESCI data revealed no SCHOOL or GENDER differences in the level of achievement recorded (SCHOOL $F_{1,350} = 0.46$, $p>0.05$; GENDER $F_{1,350} = 0.25$, $p>0.05$), but did reveal a statistically significant difference in the mean level of achievement recorded by pupils in intervention and comparison classes, intervention class pupils scored higher (CLASS $F_{1,350} = 10.27$, $p<0.0$, PRESCI mean $\pm$ s.e.; intervention 18.3 $\pm$ 3.9 and comparison 16.3 $\pm$ 5.3). Similarly the results for POSTSCI revealed no effect of SCHOOL or GENDER (SCHOOL $F_{1,345} = 2.19$, $p>0.05$; GENDER $F_{1,345} = 0.01$, $p>0.05$), but did show that the pupils in intervention classes exhibited higher levels of achievement than the pupils in comparison classes (CLASS $F_{1,345} = 24.01$,$p<0.001$ POSTSCI mean $\pm$ s.e.; intervention 19.6 $\pm$ 4.2 and comparison 16.7 $\pm$ 4.9; figure 2).

[INSERT FIGURE 2 HERE]

Discussion

Drissner, Hasse and Hill (2010); Klingenberg (2014); Luckmann and Menzel (2014); Maynard, Waters and Clement (2013); Porkop, Tuncer and Kvasničák (2007) and Strgar (2007) have all shown in a range of educational contexts that when allowed to have a first-hand experience of the natural world children and young people are motivated to learn and as a consequence achieve a wide range of positive learning outcomes. Our findings corroborate those of these authors (and others). However by focusing upon cognitive gains in one area of the curriculum (Literacy) through an experience of another (Science) we are in a position to highlight an additional value of learning through fieldwork to school leaders and policy makers.

We have shown that average literacy levels achieved by pupils who have taken part in our integrated field and classroom learning activity are higher than those of their peers who have not taken part in the activity and that this can be generalized across a number of schools. Our demonstration that we were unable to distinguish between the average literacy levels of pupils in different classes within a school prior to the activity gives us confidence that our task has had a direct (and positive) impact upon the assessment outcomes of the intervention class children. We do not suggest that our intervention has taught the pupils to be better at literacy; rather we believe that it is likely that the first-hand outdoor experience of the topic to be written about enables them to access their prior learning and as a consequence achieve higher literacy levels. Our findings confirm at a relatively large scale the previous results of a small scale pilot project (Blinded et al. 2011) and those of a related project (Blinded 2014) in which we have shown that when children are allowed to choose to write about organisms with which they are familiar (rather than those that they have not encountered) they perform better in literacy assessments. We suggest that personal familiarity with the topic at hand and the strong positive memories associated with the novelty of learning outdoors described by Waite (2007) combine with the interaction of learning within the cognitive and affective domains during authentic fieldwork as described by Stokes and Boyle (2009) to enable the children to access higher literacy levels. We observed that the gender gap in literacy commonly reported in the UK (e.g. Jama and Dugdale 2012) was evident in our study population in both intervention and comparison classes before and after our intervention. We found no evidence that we had narrowed the gap in spite of the fact that class teachers noted that the boys were particularly engaged during the field exercise (see also Blinded et al. 2013). Our science comparison did not reveal a gender gap in the context of the children's ability to express their ecological understanding and we did demonstrate that intervention class pupils scored higher on average than comparison class children in post-intervention science tests. However we also recorded that intervention class children scored better than comparison class children in pre-intervention science tests. Given that intervention and comparison classes had been taught the same material prior to our intervention this is difficult to explain, but we suggest that it may be a consequence of the fact that intervention class children had been told that they would be doing ecological fieldwork as part of the project and perhaps as a result had already started to “think like scientists”. We are unable to confirm this hypothesis with our current data set but suggest that it may be an interesting area for further investigation.

Conclusion

- We have shown that a short fieldwork based intervention can result in a statistically significant increase in the literacy scores of children who take part when compared to their peers who did not take part.
- We have recorded a gender difference in the literacy scores of boys and girls (girls scoring higher than boys) that is present before and after our intervention. We therefore found no evidence that learning our intervention enabled boys to close this achievement gap.
- We found no gender specific differences in ability to write about science (ecology) in either intervention or comparison classes.
- Children taking part in our intervention achieved statistically significantly higher score in both pre and post intervention science tests than did children in comparison classes. We believe that it is possible that this reflects a benefit of children thinking as scientists pre, peri and post intervention rather than being linked to participation in fieldwork per se.

Our findings add to the growing body of evidence that there are benefits to learning out of doors and that in this case those benefits may extend beyond the core subject at hand. We believe that this work and the results of other similar projects provide compelling evidence that could be used to influence school managers and policy makers and to promote learning out of doors in both the primary school and wider learning contexts.

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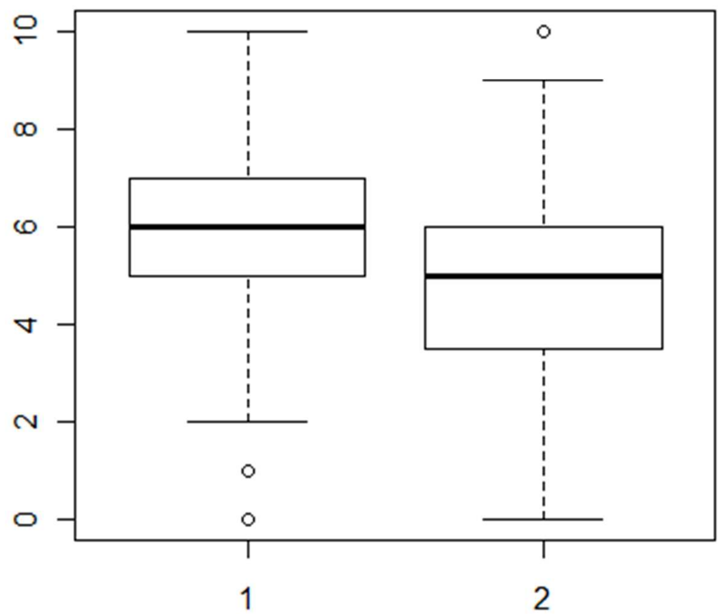

Figure 1. Boxplot comparing POSTLIT (Y axis) of pupils in intervention (1) and comparison (2) classes. (The dark line in each box represents the median, the box occupies the area between the 25th and 27th percentile, T lines indicate 95% intervals, outliers are indicated as circles).

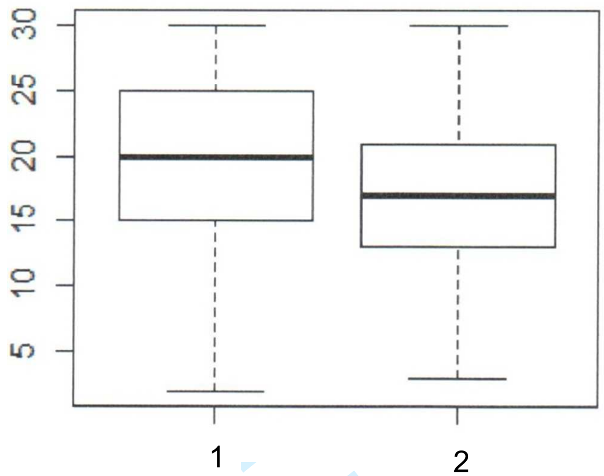

Figure 2. Boxplot comparing POSTSCI (Y axis) of pupils in intervention (1) and comparison (2) classes. The dark line in each box represents the median, the box occupies the area between the 25th and 27th percentile, T lines indicate 95% intervals, outliers are indicated as circles).