Peak into the past: an archaeo-astronomy summer school

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ABSTRACT Our landscape has been shaped by humans over millennia. It still contains many clues to how it was used in the past, giving us insights into ancient cultures and their everyday life. Our summer school uses archaeology and astronomy as a focus for effective out-of-classroom learning experiences. It demonstrates how a field trip can be used to its full potential by utilising ancient monuments as outdoor classrooms. This article shows how such a summer school can be embedded into the secondary curriculum. We provide advice, example activities and locations to visit, and outline the impact this work has had.

How it all began

Over recent years, initiatives have been brought forward to encourage learning outside the traditional classroom environment, especially in topics such as physics and mathematics. These new approaches are used to illustrate how science, technology, engineering and mathematics (STEM subjects) relate to everyday life. Traditionally, locations associated with physics- and mathematics-based activities have been planetariums and science parks. National Parks and ancient monuments were related to ecological, biological and geographic fieldwork (Braund and Reiss, 2005).

Given the recent interest in astronomy during the International Year of Astronomy (2009), the five-day summer school focused on the topic of archaeo-astronomy. This topic acts as an ideal melting pot for many subjects covered in school: astronomy, physics, geography, biology, religious studies, information and communication technology, and archaeology. Many of these subjects are STEM related and include aspects of citizenship.

The summer school took place in 2009 and was carried out together with Meden School and Technology College, Worksop, to support student transition from primary to secondary schools. Twenty-seven gifted and talented (G&T) students participated, covering age groups from years 5 and 6 at primary school (age 9–11 years) and years 7 and 8 at secondary school (age 11–13 years).

What needed to be planned?

The initial planning of the summer school activities was supported by working closely with a core group of four G&T students in the months before the actual event. They were given the topic of 'What is archaeo-astronomy?' to research. Their results were used to assess their knowledge and initial misconceptions about archaeology and astronomy. This allowed us to develop activities that were more suited to the age group.

From their feedback, it soon became clear that the larger and unique ancient monuments (such as Stonehenge) were well known by the parents and the teachers. However, local and equally impressive monuments were unknown. This led to the exploration of sites that were only an hour's drive away from the school, as outdoor classroom environments.

Additionally, the movement of the rising and setting locations of the Sun during the seasons was not well known or was merely generalised to east and west. This is a common misconception and a result of our modern lifestyle with light pollution and built-up areas obstructing the view of the horizon. Therefore, determining of the alignment of some sites would be required. The results would then allow the students to compare the orientation of the sites with the varying rising and setting points of the Sun during the seasons. This involved the introduction of *Stellarium*, a simple and free planetarium software package (see *Websites*), and the use of a magnetic compass.

It also allowed the students to understand how able ancient civilisations were with regard to construction and observations.

Two local sites were chosen, around which the summer school was developed: Arbor Low and Nine Ladies (Box 1). The UK has an abundance of such sites and other examples can be located using Burl (2005).

The size and structure of Arbor Low lent itself to developing activities that incorporated area and volume calculations. These could then be used to determine the weight of stones and estimate the time it took to build the site. Also, the site shows clear evidence of its changed use over the millennia as well as signs of the earliest excavations by the first archaeologists

BOX 1 Interesting Peak District monuments

The Peak District National Park is Britain's first national park and is located as shown in Figure 1 between the two metropolitan areas of Manchester and Sheffield. Its landscape has been changed by humans from the early Bronze Age up until now. For the summer school, two sites were selected that not only offered impressive stone monuments but were also situated in different landscapes.

When visiting any sites on non-public-access land, care should be taken to inform the landowner beforehand; Arbor Low is such an example (contact: B. Walley of Mosar Farm, Ashbourne Road, Monyash).

Arbor Low

Arbor Low is a large stone circle constructed in multiple phases and consisting of limestone stones (some 4 m tall) now fallen over and surrounded by a large ditch and embankment (Figure 2). The monument is nearly 100 m in diameter and lies within a meadow. It shows clear evidence of former archaeological digs by the antiquarian T. Bateman.

Nine Ladies

Nine Ladies is a smaller stone circle made of gritstones and only 10 m in diameter (Figure 3). It is located in the burial area on Stanton Moor. It shows some signs of a Victorian wall surrounding it and is linked to recent protests against quarrying close by.

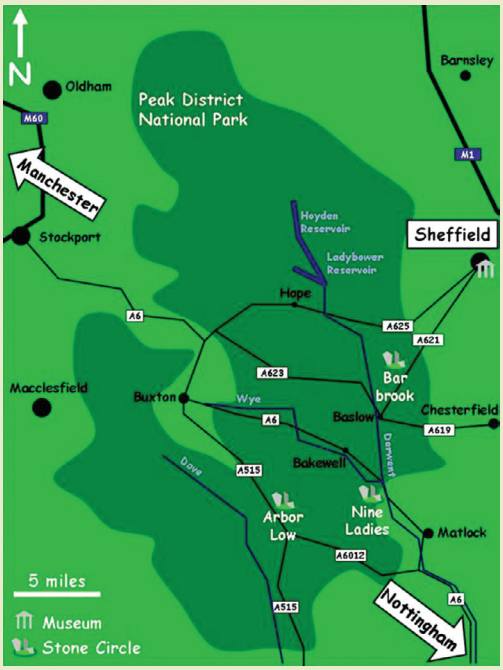

Figure 1 A map of the Peak District National Park indicating its general location and points of interest

Figure 2 A panoramic view of the central part of Arbor Low

Figure 3 The summer school group at Nine Ladies

(antiquarians) in the eighteenth century (McGuire and Smith, 2008).

Its location within a field used by sheep was in stark contrast to the site of Nine Ladies, which is in the middle of Stanton Moor. Ecological comparisons were made between the two sites using methods such as quadrat and transect sampling, soil pH, exposure and temperature. A pre-visit was required to establish the current usage of the land and to understand the land usage during the past, to develop appropriate activities supporting such work. Additional knowledge of the flora of the area was required to assist the pupils with the identification of species during sampling.

Pre-visits were also undertaken for both sites to assess any risks and to help to comply with out-of-school activity guidelines. This included establishing a meeting point in case of bad weather and determining the required (specialist) supervision ratio. More details on the logistics around Nine Ladies at the village of Stanton in Peak can be found in Box 2.

Making it all come together

The summer school itself consisted of five days. During the first two days, activities based at Meden School were carried out. These were designed to introduce the topics covered in the summer school and develop the required skills. These two days incorporated some teacher-focused sessions but were overall student focused, using many practical experiments and competitions. Day three was dedicated to visiting the two ancient monuments. The collected data were then analysed on day four during a workshop at the Centre for Effective Learning in Science (CELS) at Nottingham Trent University (NTU). During this time the group also visited the observatory at NTU and experienced a planetarium session.

Day five was a presentation day at which the students presented the results of their work to their parents at a specially booked conference venue within the working day. They planned the event, designed the displays and invited guests. Furthermore, they prepared the required props for their presentation. During this phase they were in total control of the creative process, which allowed assessment of the impact that the summer school had had on the entire group.

Some of the activities related to the topic 'How much work was needed to construct an ancient

BOX 2 Nine Ladies

The Nine Ladies site can be reached via the village of Stanton in Peak. A bus can park in a wider area along the village street indicated in Figure 4. It is not easy to turn in the village and it is advisable to take a route through Birchover to rejoin the B5056 again (see inset). The group can walk to the village hall, which provides toilet facilities and a large open space both inside and outside to relax and have lunch. Bookings must be made before the trip. There are no eating facilities in the village except for a small pub.

The actual site is only a short 1.5 km walk away. Some of the walk is along quiet roads that in parts do not have dedicated pavements. However, half of the walk is over public footpaths off road that are uneven and rocky in places, and can be muddy. Therefore sturdy footwear is advised. Keep following the main footpath and you arrive at Nine Ladies to your right.

Stanton in Peak and the Stanton Moor region are frequently visited by tourists. However, if other sites are visited, care should be taken to ensure the support of the local community.

At the time of writing, bookings for Stanton in Peak village hall can be made for a charge of £4 + VAT per hour for non-residents (contact: Mrs Corran, Middle Street, Stanton in Peak; telephone: 01629 636915).

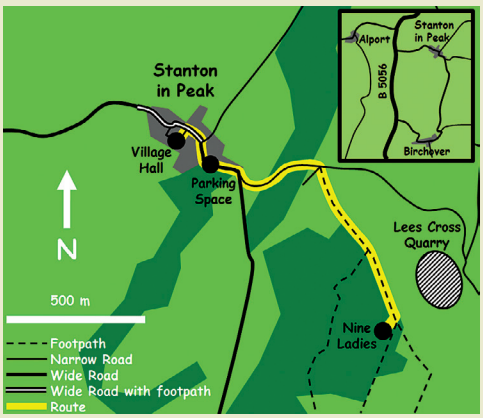

Figure 4 The Stanton in Peak area and a possible route to access Nine Ladies

monument?' and how they make use of the outdoor classroom environment are described below.

- **Stone Race**
  Move a stone a given distance.
  Best method of transporting a stone determined by the duration of travel.
  Methods tested: pulling with ropes (Figure 5), dragging, pushing.
  The modelled stone consisted of a plastic box filled with sand.
  Results are scaled up to realistic masses and distances.
- **Dig a Hole**
  Dig a hole of given dimensions.
  Best method to dig ditches determined by the duration of the digging.
  Dig a hole of fixed dimensions (that is, given the volume) in a sandpit.
  Methods tested: bare hands, replica cow scapula (shoulder blade), small plastic spades (Figure 6).
  Results are scaled up to realistic volumes.
- **Surveying Arbor Low**
  Survey dimensions of site (selected stones as in Figure 7 and ditch).
  Ditch was assumed to be circular and its cross section a triangle.
  Discuss the simplifications and results: ditch was much deeper in the past.
- **Density Workshop**
  Determine the density of limestone (similar to Arbor Low).
  Volume and mass were measured using displacement vessels (Figure 8) and scales.
  Calculation of density = mass/volume.
  Apply result to surveyed stones at Arbor Low to determine their mass.

These activities illustrate how basic numeracy can be used to scale up results and apply them to tangible monuments. The outdoor classroom

Figure 5 Using the pulling approach for the Stone Race in the school grounds

Figure 7 Measuring the volume of a central stone on site at Arbor Low

Figure 6 Digging a hole with a replica of a scapula in the school grounds

Figure 8 Using a displacement vessel to determine the volume of a piece of limestone in the CELS science laboratories

and ancient monument is transformed into a mathematics laboratory. The experiments carried out at school illustrate how to simplify problems and test initial assumptions. Furthermore, applying their results in the outdoor classroom environment allowed the students to experience the simplifications of the models developed in the lab.

How it all fits in

Archaeology

A further aspect targeted was how humans have changed their environment in the past (Barnatt and Smith, 2004). At the sites, this could not only be seen in the multiple construction phases of the monument itself but also by the ecology on site. The history of the monuments was explored by introducing basic concepts of archaeology, including relative dating and stratigraphy as well as the now-outdated but intuitive three ages of Stone, Bronze and Iron Age. Owing to the modern scientific nature of the profession, it is easy to find areas that can be used within the confines of the National Curriculum in England. At key stage 3 (age 11–14 years), stratigraphy can be used in the context of geological activity caused by chemical and physical process (3.4a) that is part of 'The environment, Earth and the universe' programme of study. Furthermore, at key stage 4 (age 14–16 years), archaeobotany can be integrated into the 'Organisms and health' programme by exploring how organisms are interdependent and adapt to their environment (2.1a). Archaeobotany also fits into the 'Environment, Earth and Universe' programme when seen in the context of the effects of human activity on the environment (2.4a). This link is well illustrated in the archaeobotany workshop (Box 3).

Ecology

The ecology studies on site were used to hypothesise how the use of the land influenced the flora present. The students were able to investigate the land use by sampling and identifying the species at the site and linking their results to the soil pH. Quadrat and transect sampling was simple for the students to organise and carry out themselves with little support. The students concluded that the pasture land usage at Arbor Low caused (or allowed) fewer shrubs to develop, in contrast with the land at Nine Ladies that has not (perhaps never) been grazed and where, for example, gorse and trees were found. Students also became confident in making their own observations and placing their findings into the context of the higher number of visitors at Stanton Moor and Nine Ladies compared with Arbor Low. The different exposure to light and wind at both sites could also be linked by the students to the greater diversity of species at Arbor Low.

Overall, the activities fit in to the National Curriculum in England at all key stages, particularly under Sc2 'Life processes and living things', from key stage 1 (age 5–7 years) Sc2 5a 'Find out about the animals and plants that live in local habitats' through to key stage 4 Sc2 5b 'How the impact of humans on the environment depends on social and economic factors'. The skills employed by the students in taking measurements and recording data apply across the age groups to the investigative skills section of the curriculum.

Citizenship

The Nine Ladies site is ideal to introduce the problems of quarrying in the Peak District as well as aspects of citizenship related to the programme 'Rights and responsibilities' in key stage 3 (1.2b) (see McGuire and Smith, 2007). The site was the location of a protest from 1999 to 2008 about quarrying and was covered in the media (Ward, 2005).

Astronomy

The topic of astronomy was addressed by revisiting basic concepts related to shadows covered in the Sc4 3b 'Physical processes' topic at key stage 2 (age 7–11 years), as well as seasons mentioned in 'The Earth and beyond'. Many activities can be found in Kibble (2010).

The students applied their knowledge to explain how Stone Age burials (Schmidt-Kaler and Schlosser, 1984) or other ancient monuments were aligned. During their work they were introduced to the prehistoric method of the 'Indian circle' in a workshop using a miniature sundial. This method is explained in Figure 10 and allows the determination of the cardinal points. This activity consolidates the material covered in 'The environment, Earth and the universe' at key stage 3 (3.4b), since it provides insight into the nature and observed motion of the Sun. The alignments from the centre of Arbor Low towards the openings in the ditch were checked to see whether they relate to any seasonal positions of the Sun on the horizon. This activity was targeting the misconception of the constant rising and setting position of the Sun, since Arbor Low does not show any clear alignments.

BOX 3 Archaeobotany workshop

This workshop allowed students to reconstruct the changing landscapes during the transition from Neolithic hunter-gatherers to semi-sedentary communities and on to the first farmers.

Students built up a picture of the ancient landscape by analysing charred seed assemblages, remains of which are often found on archaeological sites. (Care should be taken not to ingest plant remains.)

A simplified visual identification key was provided (Figure 9), together with a basic environmental categorisation table (Table 1) that allowed students to associate certain species of plant with key types of environment (forest, meadow and farmland).

The transition from hunter-gatherer to farmer is one of the pivotal moments in the prehistory of Britain and one that had long-lasting effects on the culture and environment of the country.

Creating a reference collection

Plant remains need to be dry, collected at the point of harvest and wrapped tightly in aluminium foil. Wrap wood sections individually, and seed/nuts in small quantities. Place into a laboratory furnace or kitchen cooker at 220–240 °C for 4 hours. Unwrap the cooled packets wearing laboratory gloves.

Table 1 The environmental categorisation key

	Forest	Meadow	Farmland
Hazelnut	●	●	●
Wheat			●
Hawthorn		●	●
Oats			●
Grass		●	
Oak acorn	●		

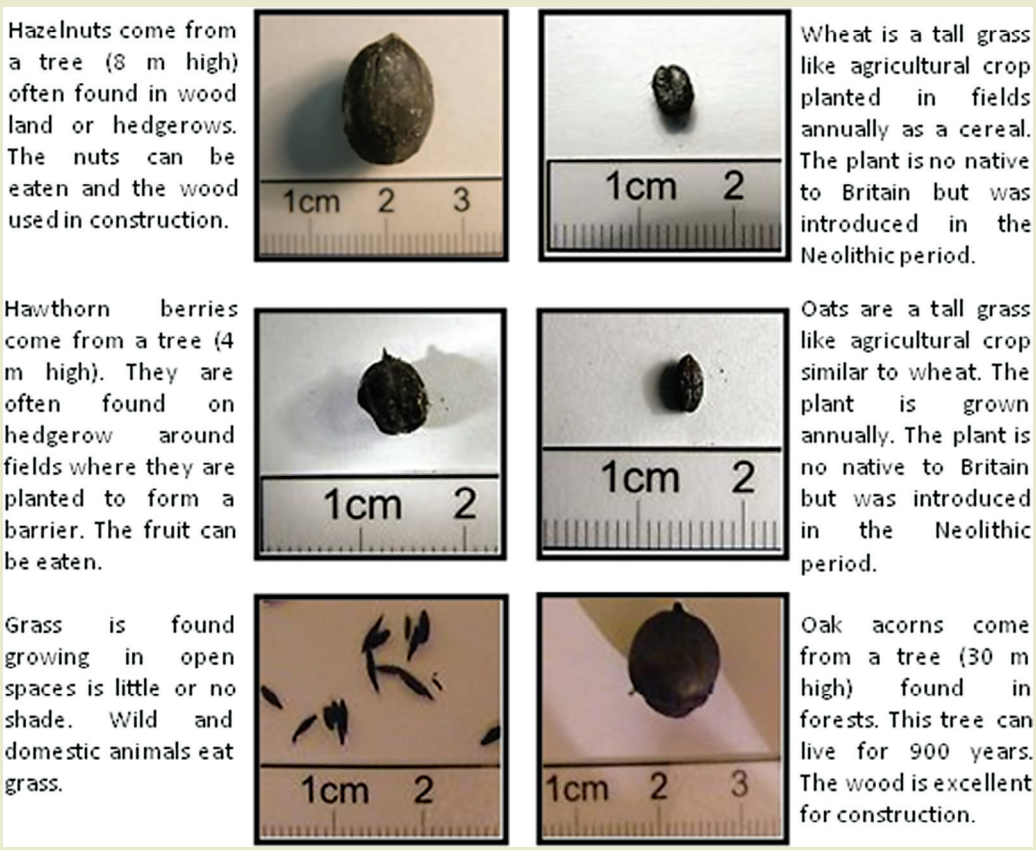

Figure 9 An example of a visual identification key

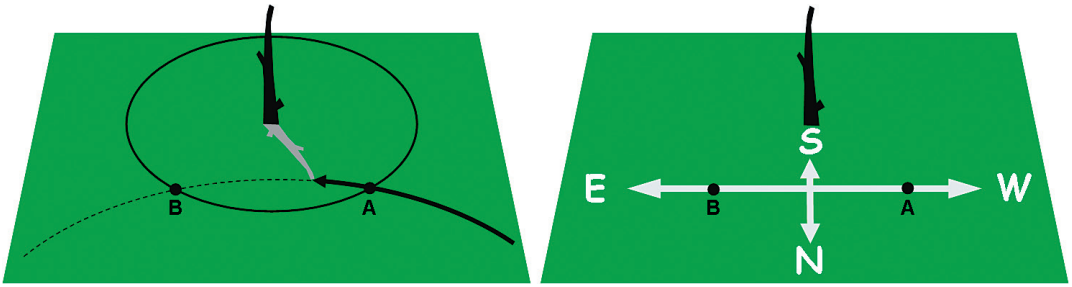

Figure 10 The Indian circle method. Draw a circle around an upright stick and then wait until the tip of the shadow crosses the circle once in the morning (A) and again in the afternoon (B). Connecting both points allows you to determine the east–west axis and thus the north–south axis.

Did it work?

The impact of the project was judged on the students' choice and content of topics presented during the final day. Small groups of two to four students presented topics of their choosing that stood out for them in this summer school. The students covered all the areas – ecology, archaeology and astronomy – that we had targeted. The content of these presentations illustrated that all predefined outcomes were achieved and important key words were included in their appropriate context, for example including the three-age system in a theatre performance. Furthermore, the students presented their results using *PowerPoint* slides, photography, theatre performance and poetry (Box 4).

The use of these different approaches reflects skills linked to individual growth and improvements in social skills that could especially be observed with the initial focus group of four G&T students.

A summer school legacy

To support further the skills the students developed in the summer school, follow-up work was undertaken for more than a year. This work included the setting up of a web-based environment (wiki), the development of continuing professional development (CPD) activities and a visit to Weston Park Museum, Sheffield.

The wiki pages developed by the students (see *Websites*) allowed them to reflect on their work and use both literacy and information technology (IT) skills to communicate their findings. Their

BOX 4 An archaeo-astronomy poem written by students on the summer school

Archaeo-astronomy is what we learnt this week
Before we came to summer school about this subject we were bleak.

To start with the guys from CELS sent us out to seek
Some things about Stonehenge, so we thought we'd have a peak.

Next we did some experiments to find out how to roll
A heavy box of coco-pops using a large pole.

Then we did a big mock dig which meant going underground
And after all the layer and layers this is what we found.

We found some roman artefact, coins, swords, and bones.
There were also some old ancient tools – which were of course made of stone.

On Wednesday we went to two heritage sites both different in their way.
Measured ditches, stones, learnt about hills and bones – so were sleepy at the end of the day.

It's Thursday, we're at University, looking through a big telescope.
Got to prepare those presentations tomorrow – I don't know how we'll cope.

Friday has come at last but not least, we're sad that we're leaving – Oh No!
But after all our hard work and effort we hope you enjoyed the show.

webpage has continued to be a vital tool for keeping in contact with the students and monitoring their progress, given that the specialist scientists of the summer school are not based at the school. It also allowed the establishment of international links that enabled students to discuss their questions with foreign scientists and improved their confidence.

A spin-off from the summer school was the intensive use of *Stellarium* in learning and teaching. The initial focus group of four G&T students developed on their own a CPD activity and resources, both printed and IT based, to introduce teachers to *Stellarium*. The CPD activity was presented by them at the Association for Science Education (ASE) annual conference in January 2010 in Nottingham. Their work demonstrates again how the summer school has increased their self-confidence and allowed them to follow up on some aspects mentioned.

In March 2010, a smaller group of summer school participants explored the Weston Park Museum in Sheffield. This visit allowed the students to see some of the artefacts discovered at the sites they had visited the previous year. The students demonstrated a considerable amount of knowledge that they had retained from the summer school. During the visit the students could place the sites into their local history and learn more about antiquarians, archaeological excavation methods and curating a museum. Again, the wiki page was an essential tool to support the work of the teachers beforehand, without the need for a specialist scientist having to visit the school.

The archaeo-astronomy summer school has thus created a flourishing legacy supporting both teachers and students. The summer school also provided tangible proof of how easy it can be to incorporate an interdisciplinary topic such as archaeo-astronomy into the curriculum of a secondary school on many different levels. We have also provided and developed many resources that can be used to develop workshops and organise field trips to use the outdoor classroom to its full potential. The examples of Arbor Low and Nine Ladies are only two possible locations and schools in other areas will have a wide range of ancient sites and landscapes waiting to be explored.

We feel that such work should be fully supported by schools, head teachers and parents since it has not only furthered the teaching and learning experience of the participating students, but also allowed the involved teaching staff to overcome many barriers associated with the use of the outdoor classroom (Rickinson *et al*., 2004). Its success has enabled us to develop a more general project supporting the outdoor classroom.

References

Barnatt, J. and Smith, K. (2004) *The Peak District: Landscapes through Time*. Macclesfield: Windgate Press.

Braund, M. and Reiss, M. (2005) Learning science outside the classroom: bringing it all together. *Science Teacher Education*, **42**, 7.

Burl, A. (2005) *A Guide to the Stone Circles of Britain, Ireland and Brittany*. Rev. edn. London: Yale University Press.

Kibble, B. (2010) *Sunshine, Shadows and Stone Circles*. Sandbach: Milgate House.

McGuire, S. and Smith, K. (2007) *Stanton Moor Conservation Plan 2008*. English Heritage.

McGuire, S. and Smith, K. (2008) *Arbor Low and Gib Hill Conservation Plan 2008*. English Heritage.

Rickinson, M., Dillon, J., Teamey, K., Morris, M., Young Choi, M., Danders, D. and Benefield, P. (2004) *A Review of Research on Outdoor Learning*. Shrewsbury: Field Studies Council. Available at: www.field-studies-council.org/reports/nfer/index.aspx.

Schmidt-Kaler, T. and Schlosser, W. (1984) Stone-age burials as a hint to prehistoric astronomy. *Journal of The Royal Astronomical Society of Canada*, **78**(5), 178.

Ward, D. (2005) Eco-warriors sense victory in battle to protect Nine Ladies. *The Guardian*, 14 February 2005. Available at: www.guardian.co.uk/environment/2005/feb/14/environment.society.

Websites

Meden School Archaeoastronomy wiki: medenschool.pbworks.com.

Stellarium free planetarium software: www.stellarium.org.

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