

# Authentic alternatives to practical work

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How authentic learning activities can be used as alternatives to practical work to improve pupil engagement in the science classroom

Authenticity is a buzzword that has gained momentum in science education over the last decade or so. Authentic activities, which are designed to reflect 'the ordinary practices of the culture' (Brown, Collins and Duguid, 1989), are commonly conceived as involving the exploration of problems through open-enquiry practical work (Roth, 1995; Wellington, 1998a). Evidence to suggest that so-called authentic activities in the science classroom are invaluable in engaging young people with science, increasing motivation and making science seem relevant to their everyday lives is convincing (Roth, 1995). However, for classroom teachers, the common problems still remain: how to incorporate authentic experiences into an already overcrowded curriculum; the pressure to focus on exam preparation and technique in order to produce adequate exam results; how to incorporate authentic learning experiences into class periods of one hour or less, and how to do so on very limited resources. This article explores the view that a significant degree of authenticity can be achieved through non-practical activities that are authentic because they encourage and develop the thinking and reasoning skills, social interactions and scientific attitudes that more accurately reflect the work of 'real scientists' than do many practical tasks.

## ABSTRACT

Given the negative perceptions of school science amongst many young people, science teachers must develop a range of strategies to engage pupils with science. Authentic learning experiences, often involving complex practical work, are designed to engage and motivate pupils, but are often too demanding in terms of time and resources to be incorporated into everyday practice. In this article, strategies for incorporating authentic learning experiences based on discussion rather than practical work are described. Evaluation indicated that this approach helped pupils engage with the lesson and enhanced enjoyment.

## Background

The fact that science is seen as sterile and unexciting by many pupils has been well-documented in the literature (Osborne, Driver and Simon, 1998). The current top-down curriculum is designed for the minority, focusing on providing pupils with the prerequisite knowledge for them to take their science studies on to the next stage. However, for most, their experiences of compulsory science education are enough to turn them off science, and this next stage never comes.

The science curriculum as it stands focuses very heavily on factual content, with an essentially exam-driven curriculum. Teachers are encouraged to train their pupils for public examinations by drilling into them exam technique, with thorough preparation from past exam papers, mark schemes and so on. Whilst such thorough preparation can produce some very good exam results and pleasing Ofsted reports, it does not encourage pupils to be creative or free-thinking. The didactic teaching approaches often adopted mean that interesting digressions or points of topical relevance cannot be explored in full, because of the need to 'get through the syllabus' (Osborne and Collins, 2000). This approach to science education, far from preparing pupils for the next stage of their science education, is at least partly responsible for turning off from science the very creative, divergent thinkers that should be our future scientists. Our current system of science education and assessment favours the syllabus-bound, diligent pupils who are happy to learn the facts, often by rote, and answer questions almost parrot-fashion. Whilst such pupils may well gain the highest grades at GCSE and often also at advanced level, are they really the sort of people who will thrive in the research laboratory where the safety of the syllabus has gone and innovation is the key to success?

## Role of authentic learning experiences

One answer to the problem of the somewhat turgid nature of compulsory science education in many schools today is the introduction of authentic learning experiences in science.

Many practitioners have interpreted authentic learning experiences as experiences that set out to mimic or repeat the work of 'real' scientists in the science classroom. It is my view that this aim is neither feasible nor desirable. Firstly, during compulsory science education pupils of all abilities are unlikely to have the scientific knowledge or understanding to be able to appreciate much of the work of real scientists, even if they were to be given such an opportunity. Secondly, and of paramount importance, such activities would simply not be possible, given the time and resources available in most schools. Many classroom teachers have little or no experience of 'real science', and so would be uncomfortable using such experiences in the classroom, and many such experiences would require liaison with practising scientists, which, although possible through organisations such as SetPoint, is often difficult to arrange and usually only an occasional experience.

## Alternatives to practical work

Given the limitations outlined above, a slightly different interpretation of 'authentic' can be useful. For instance, an activity need not aim to simulate 'real science' in order to be authentic. Instead, the authenticity can come from the context of the activity or the processes pupils are involved in. 'Authentic' in this sense does not require the mimicking of the work of real scientists through practical investigations, but instead may encourage pupils to learn and practise the ways of thinking, discussing and reasoning that display more features of the way the scientists and the scientific community operate than do many practical tasks. Such authentic activities relieve the pressure on time and resources generated by many practical investigations, and should allow the pupils a degree of freedom and creativity in their work that involves them in the learning process for what they understand to be authentic purposes. That is, they learn for reasons other than to satisfy the requirements of the syllabus. Given the limitations of practical work discussed in full in the literature (Wellington, 1998b), the aim of this article is to describe examples of authentic activities that can be used as alternatives to practical work in the

science classroom on a day-to-day basis, at little or no additional cost, in a way that enables all science teachers, regardless of their background in science, to build them into their repertoire of teaching and learning activities.

One of the major factors in pupils' negative perceptions of school science is the lack of opportunities for discussion work (Osborne and Collins, 2000). In comparison to other school subjects, such as English or history, science provides little or no opportunity for pupils to express their own views, or exercise any creativity over their approach to the subject matter. This means that for many pupils there is little opportunity to engage with the subject, and so science is seen as remote and unconnected to the everyday worlds of the pupils.

Given that much of the work of the scientific community is based on discussion and collaboration, discussion work in the science classroom is a surprisingly under-exploited activity. Discussion activities can be deemed authentic if the pupils are required to think and act like scientists, and like true scientific activities there is no protocol to follow, and more than one way of arriving at a suitable answer.

The following discussion-based activities were designed to teach the topic 'disease' at GCSE level. The lesson was trialled with two groups of 14–15 year-old pupils, one middle-ability group and another high-ability group, who had elected to take the triple science course.

## Warm-up activity: discussion statements

Over the last two decades, an extensive body of literature on children's thinking and ideas in science has emerged. This has allowed us to explore common pupil misconceptions in science, and use them as a tool for discussion in the classroom. Classroom dialogue amongst pupils has long been acknowledged as a useful way for them to explore their own misconceptions. When such dialogue is appropriately structured, the pupils can gain a deeper understanding of scientific concepts as they construct their own meaning from discussion with their peers.

In this activity, some common pupil misconceptions were used as starting points for structured pupil discussion in small groups. The purpose of this activity was to introduce the pupils to the idea that scientific 'theories' simply represent the current consensus amongst scientists, based on discussion of the available evidence. In the previous lesson, I had been asked about the cause of 'mad cow

disease', and this prompted a discussion about the various lines of evidence and opinions of different scientists about the causes of such diseases. The class seemed fascinated by the fact that the scientists did not necessarily 'know', and that scientific 'proof' is open to debate. This prompted me to consider a discussion-based starter activity, based on common misconceptions, to give the pupils experiences of openly discussing with peers their ideas and opinions on scientific phenomena, and having to justify these with evidence or scientific reasons.

The table of statements used is shown in Box 1, and is based on an activity described in Osborne, 1997. The pupils were first asked to read through the statements and indicate their responses, and any reasons or evidence that led them to their conclusions. They were then asked to discuss their responses in pairs until they could come up with conclusions with which both partners were happy.

Given that this was designed as a quick starter activity, I had chosen statements for which I knew many pupils were already aware of the correct answers, and so would be able to guide others and give reasons for their choices. However,

some statements still provoked a good degree of discussion, and gave the opportunity for pupils to ask questions. On several occasions, pupils knew the correct answer, but did not really know why it was correct. This activity gave the opportunity for detailed discussion about ideas such as specificity of immune responses. The lack of understanding of important concepts revealed by the activity may well have gone unnoticed, as rote-learned responses to exam questions on this topic could gain full marks, even when the pupil lacked a full appreciation of the scientific concepts involved.

From a motivational perspective, pupil involvement in this activity was excellent, with pupils in both classes remaining fully engaged throughout, and some debate emerging between groups. This activity also appeared to inspire some of the quieter pupils in the groups with the confidence to contribute to the final class discussion of the statements. Perhaps, giving pupils the opportunity to clarify understanding in peer groups and 'try out' explanations with friends, made them feel safer in contributing to whole-class discussion.

#### BOX 1 Statements for the warm-up activity

<i>Scenario</i>	<i>Agree</i>	<i>Disagree</i>	<i>Evidence/reasons</i>
Simon's cat has the 'flu and is sneezing a lot. Simon's sister says he will catch the 'flu if he holds the cat, but his mother says he will be fine. Do you agree with Simon's sister?			
Karen's Grandma has a terrible cold and has been to see the doctor. She is cross because the doctor did not prescribe her anything. The lady in the waiting room told Karen's Grandma that budget cuts mean they are not writing as many prescriptions this winter. Do you agree with the lady in the waiting room?			
You are much less likely to catch the mumps if you have already had the measles.			
Mark has a cold and his glands are swollen. This is because the germs are multiplying inside his glands and making them swell.			

## Main activity: the work of an epidemiologist

This activity required the pupils to take on the role of an epidemiologist working for the Public Health Laboratory Services, investigating a fictitious outbreak of a diarrhoeal disease. The initial brief for the activity is shown in Box 2. Pupils were asked to work in teams of three to encourage discussion.

Initially, the pupils were given worksheet A, a table of information about the patients from an initial outbreak of an unidentified diarrhoeal disease (see Box 3). The groups were asked to discuss this information in order to complete a grid on worksheet C to give evidence for and against different modes of transmission (Box 3). Groups were then given worksheet B, an information sheet summarising important information on different diarrhoeal diseases (Box 3), in order to discuss which disease they think is the most likely cause of the outbreak.

At this point, groups are allowed to submit their most likely choice to the teacher, who acts as the 'laboratory official' to give confirmation of the cause

### BOX 2 Initial brief for the epidemiologist

You are working as a coordinator of epidemiology for the Public Health Laboratory Services (PHLS). A cluster of cases of a severe diarrhoeal disease has arisen. The disease first manifests itself with a high temperature and nausea, progressing quickly over 24 hours to severe diarrhoea leading to acute dehydration and death in some cases. There have been 14 victims so far, with four fatalities. All patients so far live in a small rural town in East Dorset.

Your job is to determine the cause of the outbreak and how it is spread.

You have been provided with some basic information. However, you will need to ask lots more questions in order to proceed with your investigation.

Your first task is to try to work out how the disease is spread and which diarrhoeal disease it is, using the information on worksheets A and B. You may use the grid on worksheet C to record the decisions you make and the reasoning and evidence behind them. Once you have made a decision as to which disease(s) is/are most likely, you may ask your teacher to confirm this from laboratory samples.

of infection. The cause is confirmed as a water-borne infection, *Cryptosporidium*, and it is now up to the pupils to begin investigating the likely source of infection and how it has been spread.

At this point, pupils were expected to discuss and decide on further information they would need to obtain, including questions they would need to ask the patients, in order to proceed with their investigation. The level of prompting required by different groups varied considerably, with some working completely independently, and others needing more assistance. With varying levels of prompting, all groups began to look for a common link in the lifestyle and behaviour of the patients, which may have exposed them to the infection. Once questions about occupation and lifestyle begun to emerge, pupils were provided with a summary of relevant information on factsheet D (see Box 4). However, at this point in the activity it was noticeable that groups were either sharing ideas freely with each other, or eavesdropping to gain clues. Either way, pupils appeared totally engaged with the activity and completely focused on trying to solve the problem.

For many groups, discussion of this stage in the investigation was sufficiently challenging to occupy them for the remainder of the lesson. Some groups had solved this part of the problem, and correctly proposed that the infection had been spread via the jacuzzi at the health spa. For these groups, the study was extended (see Box 5). They were given the information that other outbreaks of the same illness had been reported by other public health laboratories around the country, and the new task was to establish the link between these outbreaks and the first. Again, the groups were expected to ask for information and data regarding the additional outbreaks and patients in order to determine how the outbreaks were related. Just one group managed to establish the link that the young females had all been exposed to contaminated water at the rock festival, and had subsequently carried the infection back to their home towns.

## Discussion

Pupil responses to the 'day in the life of an epidemiologist' activity were very positive indeed. In the plenary session, we discussed what they enjoyed most about the activity, and pupils said they found it 'fun', that it 'gave us a chance to have a go at what real scientists do' and that it was 'different to other stuff we usually do in science'.

From a teaching perspective, the activity required lengthy preparation to ensure it ran smoothly; however, it required very little in the way of

**BOX 3 Tracing the cause of the disease****Worksheet A: Information on the Corfe Mullen outbreak**

- Patient 1 first became unwell on 1 June 2004.
- Patients 2–14 all became unwell within two days of the first victim.
- No further cases have been identified within the families of the victims.
- No further cases have been identified in the office of victims 9 and 10.

Patient	Age	Male/female	Other information
1	24	Female	First victim of illness, now recovered.
2	75	Male	Deceased 2 days after illness.
3	74	Female	Deceased 3 days after illness.
} Married			
4	66	Female	Deceased 2 days after illness.
5	69	Male	Deceased 2 days after illness.
} Married			
6	58	Female	
7	45	Female	
8	35	Male	
9	36	Male	} Work together in same office
10	32	Female	
11	26	Male	
12	27	Female	
13	14	Male	
14	39	Female	

**Worksheet B: Diarrhoeal diseases**

Disease	Symptoms	Spread
<i>Salmonella</i>	Headache, chills, vomiting and diarrhoea.	Symptoms begin several days after eating contaminated food, usually eggs and meat.
<i>Clostridium</i>	Diarrhoea and intestinal cramps. Nausea and vomiting in 1/3 cases. Symptoms rarely last 24 hours, rarely fatal.	Symptoms begin after eating contaminated food, usually meat products.
<i>Cryptosporidium</i>	Severe diarrhoea. Most recover in 2 weeks. May be fatal in the very young and elderly.	Protozoan parasite often found in cattle, but may be spread to humans via contaminated water. Can be highly resistant to chlorine.

**Worksheet C: Modes of transmission**

Mode of transmission	Yes	No	Reasons/Evidence
Sexually transmitted			
Food-borne			
Water-borne			
Vector-transmitted			
Air-borne			
Droplet infection			
Direct contact			

**BOX 4 Finding the source of infection**

**Factsheet D: Information on lifestyle for patients from the first cluster**

<i>Patient</i>	<i>Age</i>	<i>Occupation</i>	<i>Hobbies</i>
1	24	Student	Swimming; aerobics; rock music.
2	75	Retired	Gardening; keep fit; vegetarian cookery.
3	74	Retired	Gardening; keep fit; vegetarian cookery.
4	66	Retired	Singing in local choir; aquaerobics.
5	69	Retired	Golf; swimming.
6	58	Cleaner	Gym.
7	45	Restaurant manager	Squash; swimming.
8	35	Personal trainer	Movies; clubbing.
9	36	Accountant	Tennis; gym.
10	32	Receptionist	Aerobics; clubbing.
11	26	Waiter	Body-building.
12	27	Waitress	Aerobics.
13	14	School pupil	Working out at the gym.
14	39	Teacher	Reading; keep fit.

**Other available information (to be elicited by pupil questions):**

- All victims are members of the Corfe Health Spa.
- Check-in records have shown that all of them used the health spa on 1 and/or 2 June 2004.
- Questioning the patients has revealed that they all used both the showers and the jacuzzi in their last visit to the Health Spa.
- The water in the jacuzzi at the Corfe Health Spa was changed on 4 June 2004, and the jacuzzi was fully cleaned. The water was unavailable for testing.
- Extensive microbiological testing of the water supplies for the showers has shown the water to be completely clean.

resources. In terms of differentiating the task to meet the needs of pupils with a wide range of abilities, the level of prompting I gave to different groups was sufficient to ensure that all made progress during the course of the lesson. In future, I would also consider

arranging the groups so there is a range of abilities within individual groups.

Throughout the activity, the pupils remained fully engaged with the task and the level of discussion was very good. Whilst not an explicit aim of the

**BOX 5 Extension activity**

Two days into your investigation, you are contacted by representatives from five other laboratories around the country. They have identified similar clusters of disease with similar timing, and are concerned that there may be a link between the outbreaks. A comparison of the profiles of the victims from all outbreaks reveals that the first victim in all cases is a young female between the ages of 15 and 27.

**Further Information (to be elicited by pupil questions):**

- All these young women were found to have an interest in rock music.
- Further questioning regarding recent travel and behaviour revealed that all had attended a rock festival on 28–30 May in rural Wiltshire, camping on site.
- All had used the same female-only portable toilet facilities to wash, clean their teeth, etc.

task, I also observed in some groups the emergence of distinct roles for individuals, with a clear leader taking responsibility for delegating tasks in several instances. Many groups became quite competitive, striving to be the first to solve the problem, and this developed a sense of urgency and importance that created an ‘authentic climate’ within the classroom. Overall, the activity appeared to matter to the pupils, they had engaged with it, and in this way it fulfilled one of the main aims of utilising authentic activities in the science classroom.

**Conclusion**

Authentic learning experiences in school science are clearly an important tool in engaging pupil interest and challenging negative conceptions of school science. As Woolnough (1998) argues, any teaching we do will only be really useful if the pupils are fully engaged and *want* to learn. Exposure to authentic science activities is not only useful in motivating pupils, but can also help them develop the skills and attributes that will be of value to them in the workplace, as future citizens, or even as future scientists.

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