Case study 5: ‘Infiltration Experiments’  
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The Geography National Curriculum Context

The Key Stage 2 National Curriculum programme of study states:

Themes: Rivers
7a "In studying rivers and their effects on the landscape pupils should be taught: that rivers have sources, channels, tributaries and mouths, that they receive water from a wide area".

Skills
2 "In investigating places and themes, pupils should be given opportunities to observe and ask questions about geographical features and issues."
3b "Pupils should be taught to: undertake fieldwork, including the use of instruments to make measurements."
3a “use appropriate geographical vocabulary”.

Key questions:

- When the rain falls in a river valley how does it get into the river?
- Why are there boggy areas in the valley?
- What effect does a slope have on what happens to the rainwater?
- How long does it take for rainwater to soak (infiltrate) into the ground?

Key Concepts:

precipitation, surface storage, soil moisture, percolation, permeability, water cycle, saturation, river basin system, hydrological cycle.

<table>
<thead>
<tr>
<th>infiltration</th>
<th>the transfer of surface water into the soil</th>
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<td>the soil becoming full of moisture so that it is unable to hold any more (e.g. peat bog)</td>
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<td>surface run-off</td>
<td>the flow of water overland</td>
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<td>water table</td>
<td>the level at which the soil or rock becomes saturated</td>
</tr>
<tr>
<td>percolation</td>
<td>the moving of water down into underlying rocks</td>
</tr>
<tr>
<td>throughflow</td>
<td>the movement of water through the soil into a river/lake</td>
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Figure 16: The main processes addressed by the infiltration activity
Activity: Walk along the river bank

The children were taken for a walk along the river bank to search for evidence of surface water. During the walk, the children stopped at various places where little rivulets of surface water were trickling into the Cherry Brook River. These originated from nearby peat bogs. The bogs were examined and a handful of dark peat was squeezed to demonstrate its water-retentive properties. The children were encouraged to invent their own words for the feature they were observing, e.g. "boggy", "soggy", "sinky", "oozy", "black and gooey", etc. Then new vocabulary was introduced e.g. "water-logged", "saturated", "peat bog", "marsh".

"Whilst we may no want to overburden children with unnecessary terminology there is no doubt that many will enjoy having command over specialist words. It would be ridiculous to deny their use to those who can cope, but insistence on the correct term is likely to exclude some children. One way to side-step this dilemma, and, at the same time, foster imaginative language, is to invite children to invent their own terms"
Lewis & Watts 1995

Infiltration experiments
The object of these experiments was to make the children aware that rain falling on the valley sides made its way into the Cherry Brook River by the processes surface run-off, infiltration and through flow.

"Children can investigate the hydrological cycle at a number of entry points. What happens, for example, when rain-water reaches the ground? Some of it runs off on the surface (as overland flow) or into the ground (as through flow), eventually via rivers entering the sea.............Infiltration into the soil, and the rate at which it happens, can be investigated with a baked bean tin and a stop watch."
Wiegand 1993 p. 110

We did not use baked bean tins but rather three pieces of drain pipe, 20 cm in length. These were calibrated on the inside, starting with the top at 0 cm and ascending in 2 cm intervals towards the bottom at 20 cm. This meant the children could calculate how much water had infiltrated by recording the drop in water level in the tube. The bottom of each tube had been bevelled to give a sharper edge. This made it easier for the children to press, twist or tap the tubes into the ground.

Three contrasting locations were chosen near to the Cherry Brook. These were the river bank, a boggy area, and a steeply sloping side of the valley. The children tapped the top of each tube with a tent mallet so that it was embedded in the ground, (see photo ). They ensured that the ground was pressed firmly around the bottom of the tube to prevent leakage. The tubes were then filled with simulated rain, (water from a watering can), and
the time recorded, (see photo ). On one of the fieldwork days, the children's infiltration experiment was squashed by a stray pig which appeared on the scene and decided to have a mud bath in the peat bog so it was back to the drawing board!

**Recording and explaining findings: evidence for assessment**

An hour later, the children re-inspected the tubes and graphically recorded the water levels on their worksheets, (see figure 17). These sheets not only encouraged description and measurement but also explanation by asking the two questions:

- "Is the amount of infiltration the same or different in each place?"
- "Why do you think this is?"

The children's explanations provide useful evidence for assessment. Two children collaboratively wrote:

> "1) Because the river bank was made from gravel and the water sinks through. 2) The boggy area had enough water already and couldn't take much more as it was waterlogged. 3) The steep slope took in the most water which could flow down hill so more water could soak through."

(Ashleigh & Nicola)

These children are implying that the type of soil is a variable affecting infiltration on the bank because it was "made from gravel." We can also infer that they seem to have grasped the concept of saturation, although they do not use this actual terminology, by their use of the phrases "waterlogged" and "the boggy area had enough water already". The word "waterlogged" has been assimilated by the children from oral discussions with the teacher in the field. Finally, we can infer that they have perceived slope to be another variable affecting infiltration by their phrase, "which could flow down hill so more water could flow through." The children don't use the correct term, "infiltration" but demonstrate their understanding of this process with the words, "Soak through."

> "Because the boggy area had water underneath so the water did not soak in. The slope was a slope so the water drained away and went downhill. on the bank it wasn't a slope or a boggy area it was inbetween".

(Karlie, Natalie & Melanie)

The writing of these three children indicates an embryonic grasp of the concept of a 'water table' by the phrase "the boggy area had water underneath". This idea had not been fed to them by the teachers.

> "Where it is marshy and boggy the ground is fully saturated and the top of the water table is at the surface, every interstice being
filled with water. The surface of the water in a river is approximately the top of the water table.”

(Bowles 1992 p.30).

The children's phrase, “the slope was a slope so the water drained away and went downhill”, suggests that they see slope as an important factor affecting infiltration. The words "soak" and "drain" are used in place of infiltration but convey the same sense of the process involved.

"Because the bog was all ready filled with water so the level didn't go down it was waterlogged. Also the steep slope infiltrated all of the water because it was on a steep slope. The river bank only infiltrated 2 cm because it was almost flat."

(Kyleigh & Kelly)

Again, the new vocabulary "waterlogged" appears. The two girls seem to have expressed the idea of saturation not only in the use of “waterlogged” but also in the phrase, "all ready filled up with water". "Steep slope" is given as the reason for rapid infiltration and they extrapolate from this that the bank was slower because it was not sloping but in fact "flat". These children also use the correct term "infiltration" but see it as something that the bank does to the water rather than the other way round.

Extension activities

Infiltration in the school grounds:
Back at school the children can carry out a similar activity in their school grounds.

"This activity can be carried out in different parts of the school grounds. Each site will need to be numbered and located on a plan so that a permeability map can be plotted. Such a map may be useful when planning the location of a school pond or when planting out areas of vegetation"

Hare, Attenborough & Day 1996 p. 28.

Testing soils
Children can test different samples of soil for infiltration properties. The soil can be placed in small buckets with lots of holes drilled in the bottom. These can be rained on with watering cans, (see photo ). If the amount of "rain" is measured first, in arbitrary or standardised units, and measured and timed as it comes out of the bottom of the bucket, it is possible for the children to:

• time the rate of percolation. This can be communicated as cumulative and rate graphs, (see figures 21 & 22)
• measure the amount of water that percolates through the soil and calculate the amount of water retained by the soil. These calculations lend themselves to pie charts and graphs and help the children to compare the water retentive properties and permeability of soils, (see figures 23, 24);

• use what they have learned about the permeability and retentiveness to modify a soil's properties to suit different plant types e.g. a bog plant or a cactus, (see figure 25 and photo ).

I have published a case study of just such a project in the Unit: ‘What happens to rainwater when it reaches the ground?’ to be found in Water Excel Project, Teacher’s Guide (NCET 1993). This includes an EXCEL spreadsheet and graphics software package to help children interrogate and communicate their results.

Simulating a water table
Water table is a very abstract concept. Young children may literally visualise a table with four legs under the ground! Using a clear plastic fish tank and some shingle, children can begin to grasp the idea of a water table and how this can affect river-beds and wells, (see figure 26 ). The children can see the underground water level through the sides of the tank and watch it rise and fall as human consumption competes with rainfall.

They can try sinking a well and devising technologies for raising the water from below ground. I often do this by putting a flock of toy sheep on the surface and telling the children that in this dry region the animals will die unless they, (the farmer), can bring water up from underground.

If the water table is raised within a few centimetres of the surface of the shingle, the children can dig out a river channel with spoons and watch it fill with water. When water is drawn off from the water table for “human use”, they can see the river level begin to fall and eventually leave a dried out river-bed. The principle is very similar to that which children experience on a beach when digging holes and channels in the sand.

If siphoning water from the tank is too difficult a process, you can always drill a hole in the side and insert a piece of polythene tubing, making sure it is well glued or sealed in to prevent leaks.
Kyleigh Williams & Kelly Beale

INFILTRATION AT CHERRY BROOK ON DARTMOOR

When rainwater soaks into the soil we call this infiltration.

We are going to find out how quickly the water infiltrates the soil alongside the Cherry Brook River?

We are going to test the infiltration in three places:

<table>
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<tr>
<th>1. the river bank</th>
<th>2. a boggy area</th>
<th>3. a steep slope</th>
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<td><img src="image1" alt="Diagram" /></td>
<td><img src="image2" alt="Diagram" /></td>
<td><img src="image3" alt="Diagram" /></td>
</tr>
</tbody>
</table>

Draw the level that the water has dropped to on the tube above.

How many centimetres of water infiltrated?...

How long did this take?...

First we picked 3 different surfaces:
1. River ban
2. Boggy area
3. Steep slope.

Then we filled each container with the same amount of water. They came back in 1 hr 15 mins to take the results.

Is the amount of infiltration the same or different in each place?...

Why do you think this is?

Because the bank was already filled with water so the level didn't go down. It was waterlogged. Also, the steep slope was not infiltrated at all as the water because it was on a steep slope. The river bank only infiltrated 2cm because it was almost flat.
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Is the amount of infiltration the same or different in each place? Different...

Why do you think this is?

Because the river bank was made from gravel and the water sinks through. The boggy area had enough water already and couldn't take much more so it ran off. The steep slope took in the most water which could slowly seep through so more water could seep through.
**Task 1: Raising Water**
- Sink a well.
- Find a way to reinforce collapsing sides.
- Devise a way of bringing up the water (e.g., hand pump, windlass, etc.).
- Observe what happens in the well when the factory draws off water from the water table faster than it is replaced by rain. (The well will dry up)

**Health & Safety:**
*Don't let children suck water up the tube to get the syphon going.*

**Task 2: Create a River Channel**
- Raise the water table to within a few centimetres of the surface of the shingle.
- Dig out a river channel using a spoon.
- Watch the bottom of the channel fill up with water to make a river.
- Watch what happens if the factory draws off water from the water table faster than it is replaced by the rain. (The river-bed will dry up)
Children are using mallets to embed the infiltration tube in a peat bog.

Children simulate rainfall by filling the infiltration tube from a watering can.
A group of children filling an infiltration tube with water on the river bank.

A group of children observing the amount of water that has infiltrated into the peat bog after 1 hr 15 mins.
Children observing the amount of water that has infiltrated into the river bank.

Children observing the amount of water that has infiltrated into the steep valley slope.
A child recording her infiltration findings on the worksheet in words and on diagrams.

The stray pig that rolled all over the infiltration tube in the peat bog!
**Figure 11:** Extension activity – a way of investigating how quickly water soaks away in the school grounds on different soil areas. This exercise is described in Hare, R. Attenborough, C. and Day, T. (1996) Geography in the School Grounds. Exmouth: Southgate.

**Question:**
As well as looking at what drains out of the bottom of the bucket of soil children can explore what happens on the surface, for example, how long it takes the rainwater to soak away into the soil. Do you know what this process is called?

**Answer:**
This process is called infiltration (e.g. the transfer of surface water into the soil). Children can investigate this by filling an infiltration tube with water and timing how long it takes it to soak into the ground. Although this experiment could be conducted using different buckets of soil, there is an opportunity here for some excellent fieldwork. This diagram illustrates how the investigation could be set up in the school grounds.

"This activity can be carried out in different parts of the school grounds. Each site will need to be numbered and located on a plan so that a permeability map can be plotted. Such a map may be useful when planning the location of a school pond or when planting out areas of vegetation"

Hare, Attenborough & Day (1996:28)

Look for different types of ground to investigate, e.g. flowerbed, sand pit, grass, gravel path, bark chippings, flat versus sloping, etc.

"Children can investigate the hydrological cycle at a number of entry points. What happens, for example, when rain-water reaches the ground? Some of it runs off on the surface (as overland flow) or into the ground (as through flow), eventually via rivers entering the sea.............Infiltration into the soil, and the rate at which it happens, can be investigated with a baked bean tin and a stop watch."

Wiegand (1993:110)

Infiltration and drainage are also interrelated with the following series of processes

<table>
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Plate 32: Hammering the infiltration tube into the ground
Question:
What sort of soil are the children hammering their infiltration tube into?

Answer:
This is a small patch of peat bog on Dartmoor next to the Cherrybrook River. The children were taken for a walk along the river bank to search for evidence of surface water. During the walk, the children stopped at various places where little rivulets of surface water were trickling into the river. These originated from nearby peat bogs. This bog was examined by stomping in it and squeezing a handful of peat to experience its water-retentive properties. It behaved like a saturated sponge and water dribbled between the children’s fingers. The children were encouraged to invent their own words for the feature they were observing, e.g. "boggy", "soggy", "sinky", "oozy", "black and gooey", etc. Then new vocabulary was introduced e.g. "water-logged", "saturated", "peat bog", and “marsh”.

"Whilst we may no want to overburden children with unnecessary terminology, there is no doubt that many will enjoy having command over specialist words. It would be ridiculous to deny their use to those who can cope, but insistence on the correct term is likely to exclude some children. One way to side-step this dilemma, and, at the same time, foster imaginative language, is to invite children to invent their own terms"  (Lewis & Watts 1995:33)

Plate 33: Filling the infiltration tube with water

Question:
What do you notice about the infiltration tube?

Answer:
It is a piece of drainpipe which has been calibrated in centimetres on both the outside and the *inside*. This allows the children to quantify the rate/speed of infiltration, e.g. how many centimetres of water infiltrates per minute? The rate of infiltration in the peat bog was very slow because it was already waterlogged, so the children had to return to the tube at intervals during the afternoon to make observations and recordings.
Question:
What do you notice about the infiltration tube on the right in this photograph?

Answer:
Ideally, the infiltration tube should be transparent as illustrated in this photograph. This allows the children to see the water level through the side of the tube and in relation to the calibrations. Notice the ping-pong ball helps to give an additional visual cue of the infiltration rate as the level of the water lowers.
Question:
What type of ground are the children testing for infiltration here?

Answer:
This is a grassy bank of the river. The children not only recorded the rate of infiltration but were also able to observe the water eventually seeping out of the undercut bank. This illustrated the part of the water cycle that links infiltration in a river valley with percolation of water through the soil and drainage into the river.
Question:  
What type of ground are the children testing for infiltration here?

Answer:  
The children are testing a shingle bank deposited on the inside of a river bend. The water level in the tube drops very quickly because of the gaps and cavities between the particles of coarse grit and shingle. This is in contrast to the peat bog where the water level drops so slowly, that the children had to revisit the tube at intervals to see any change.
Plate 37: Observing the water infiltrating

Question:
What type of ground are the children testing for infiltration here?

Answer:
This is a steep grassy slope on the side of the river valley, so children are investigating effect of the variable of slope by seeing if there is any difference between infiltration on the level grassy bank and the steeply sloping grassy bank. The children are beginning to develop the concept that rivers receive water from a wide area, in this case the sides of the river valley.
Question:
What has happened here in the peat bog?

Answer:
This group of children have noticed that only 2 centimetres of water have infiltrated after an hour in the peat bog.

"Where it is marshy and boggy the ground is fully saturated and the top of the water table is at the surface, every interstice being filled with water. The surface of the water in a river is approximately the top of the water table." (Bowles 1992 p.30).

Question:
How would you get the children to record their investigations?

Answer:
One possible approach is to ask children to record graphically by registering the levels of the water and times on the tubes already pre-drawn by the teacher on the worksheet. Asking the children to draw the tubes would be too time-consuming and detract from the geography / science / numeracy learning focus of the lesson. The children worked on their recordings in pairs. Following illustrations will show these worksheets and the children’s recordings in detail.
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Is the amount of infiltration the same or different in each place? different...

Why do you think this is?

Because the river bank comprises more gravel and the water sinks through. In the boggy area there is enough water already, much more. The steep slope took the most water, which could flow down hill so more water could soak through.

Figure 12: Children's recording sheet for their infiltration investigations
Question:
Can you make an assessment from these children's worksheet of what learning has taken place?

Answer:
- The two children are able to read the calibrations on the diagrams of the infiltration tubes.
- They can graphically record the levels of water in the tubes correctly.
- They can use a stop watch to time the infiltration and record the time period elapsed using the correct notation.
- The children are able to describe the differences between the three infiltration tubes.
- The children are able to move beyond description to offer some possible explanation for the differences in infiltration rates. They think that infiltration is slow in the peat bog because the peat “had enough water already and couldn't take much more” They have both understood the concept of “waterlogged”, and used the correct terminology. They also understand that a steep slope makes the water “flow down hill”, which is why infiltration was faster. They suggest that water sinks through gravel more easily but don't understand why, e.g. the gaps / holes / cavities between the gravel allowing water to pass more quickly through. This would suggest that a follow-up science investigation using transparent containers into the effects of size of particle on water infiltration would help children to understand this relationship between the variables of infiltration, particle size and spaces between them.
When rainwater soaks into the soil we call this infiltration.

We are going to find out how quickly the water infiltrates the soil alongside the Cherry Brook River?

We are going to test the infiltration in three places:

1. the river bank
2. a boggy area
3. a steep slope

Draw the level that the water has dropped to on the tube above.

How many centimetres of water infiltrated?

How long did this take?

Is the amount of infiltration the same or different in each place?

Why do you think this is?

Because the box was already filled with water so the level didn’t go down.

Also the steep slope infiltrated all of the water because it was on 2cm because it was almost flat.

Figure 13: Children’s recording sheet for their infiltration investigations
Question:
Can you make an assessment from these children's worksheet of what learning has taken place?

Answer:
These two children have a very similar level of understanding to the previous two. However, they make comparisons between the flat river bank and the steep slope to thereby illustrating that they understand that gradient is a variable affecting infiltration.

Both sets of children are beginning to work at level 5 because they are moving beyond the purely descriptive of Level 4 towards explaining geographical processes of Level 5. They are also presenting their findings both graphically and in writing.

“Geography must go beyond identifying and describing the location and components of a place to seeking explanations for what is observed.” Smeaton (1998:17)


Level 4
Pupils show their knowledge, skills and understanding in studies of a range of places and environments at more than one scale and in different parts of the world. They begin to recognise and describe geographical patterns and to appreciate the importance of wider geographical location in understanding places. They recognise and describe physical and human processes. They begin to understand how these can change the features of places, and how these changes affect the lives and activities of people living there. They understand how people can both improve and damage the environment. They explain their own views and the views that other people hold about an environmental change. Drawing on their knowledge and understanding, they suggest suitable geographical questions, and use a range of geographical skills from the key stage 2 or 3 programme of study to help them investigate places and environments. They use primary and secondary sources of evidence in their investigations and communicate their findings using appropriate vocabulary.

Level 5
Pupils show their knowledge, skills and understanding in studies of a range of places and environments at more than one scale and in different parts of the world. They describe and begin to explain geographical patterns and physical and human processes. They describe how these processes can lead to similarities and differences in the environments of different places and in the lives of people who live there. They recognise some of the links and
relationships that make places dependent on each other. They suggest explanations for the ways in which human activities cause changes to the environment and the different views people hold about them. They recognise how people try to manage environments sustainably. They explain their own views and begin to suggest relevant geographical questions and issues. Drawing on their knowledge and understanding, they select and use appropriate skills and ways of presenting information from the key stage 2 or 3 programme of study to help them investigate places and environments. They select information and sources of evidence, suggest plausible conclusions to their investigations and present their findings both graphically and in writing.

Figure 14: A strategy for investigating water tables

Finally, here is a diagram of a strategy designed by Steve Pratchett (1997) for investigating water tables that was used with a class of 11 year-old children. What happens under the ground is invisible so Primary children have difficulties in visualising abstract processes such as the formation of a water table. They may well take the term literally and imagine that there is some sort of table under them ground. Investigating water tables in this Piagetian, concrete operational way allows children to see:

- how a water table is formed;
- how it can rise and fall;
- how it can be near the surface or far below;
• how if it falls through drought or human water extraction;
• how a fall in the water table can result in a riverbed drying out.

This investigation into water tables links well to the enquiry focus of the previous children’s work on ‘What happens to rainwater when it reaches the ground?’

"Where it is marshy and boggy the ground is fully saturated and the top of the water table is at the surface, every interstice being filled with water. The surface of the water in a river is approximately the top of the water table." (Bowles 1992 p.30).


• In addition there is a wonderful design technology link where children have to problem solve and design and make different methods of reaching and extracting water from the water table.

Reference list


SCAA (May 1997) Geography at Key Stage 2. Hayes; School Curriculum & Assessment Authority.

SCAA (1997) Expectations in Geography at Key Stages 1 and 2. Hayes: SCAA.


Wiegand (1993) **Children and Primary Geography**, London: Cassell