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ABSTRACT

This booklet summarizes the findings of the survey of science attainment carried out in 1993 by a team of researchers at Jordanhill Campus, Strathclyde University. The assessment tasks were used with a sample of pupils, selected to be representative of all pupils in Scotland, at three stages--primary 4, primary 7, and secondary 2. The report presents examples of the actual tasks used with pupils and their responses, covering the topics of planning/collecting evidence, recording and presenting, interpreting and evaluating, and knowledge and understanding. Other topics include use of language in science, range of pupil performance, comparisons between boys and girls, and science in the school. (Includes further readings and a list of AAP publications.) (JRH)

5–14
links

SCIENCE

Feedback 2

Information for teachers – from the Assessment of Achievement Programme

AAP

WHAT IS *FEEDBACK*?

Feedback is an information resource for teachers, based around the findings of the Assessment of Achievement Programme (AAP), a major research programme funded by the Scottish Office Education Department. The first series of *Feedback* looked at pupils' performance in mathematics, English language and science.

In a new series, *Feedback 2* returns to the topic of science, to look at the findings of the latest survey.

Feedback 2 can be used for:

- ☐ Personal reading: for reflecting on achievement in your classroom, for assessing class work and preparing assessment tasks.
- ☐ Staff meetings and group discussions: reviewing teaching plans in relation to 5–14 attainment targets.
- ☐ Staff development: considering effective teaching strategies in science; and helping student teachers as part of their professional training.

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Please note: you are free to photocopy or adapt *Feedback* for use in your institution.

INTRODUCTION

The Assessment of Achievement Programme

The third Assessment of Achievement Programme (AAP) survey of pupils' attainment in science was carried out in 1993 by researchers at the University of Strathclyde, Jordanhill Campus. As in other AAP surveys, the assessment tasks were used with a sample of pupils, selected to be representative of all pupils in Scotland, at three stages — primary 4, primary 7 and secondary 2.

The assessment framework used seven categories covering knowledge and understanding and a number of skills important for successful scientific enquiry. These were assessed in written and practical tasks.

In order to focus on pupils' performance in science, the amount of reading and writing was kept to a minimum in the main part of the survey. However, it is recognised that the ability to report, both orally and in writing, is an important skill in science, and so, in 1993, the AAP science team in conjunction with the AAP English language team took part in a feasibility study to determine performance in this area (see page 17).

AAP and the 5–14 curriculum

The national guidelines for *Environmental Studies 5–14* were developed by the Scottish Office to provide a comprehensive framework for science across the primary and early secondary years. Unfortunately the guidelines were published after the framework and tasks for the 1993 AAP survey had been produced and therefore could not be taken into account in the assessment tasks. Future AAP surveys will, however, have a more consistent context of learning and teaching within which to assess performance.

Environmental Studies 5–14 is essentially a learning and teaching document to guide teachers in the curricular experiences of pupils across the age range. The AAP science tasks were developed from what was primarily an assessment framework. However, although the groupings and labels may differ, there is a high degree of overlap in terms of concepts, skills and processes (see the back cover for how the categories and sub-categories of the AAP map onto the attainment outcomes and strands for the 5–14 guidelines).

This booklet

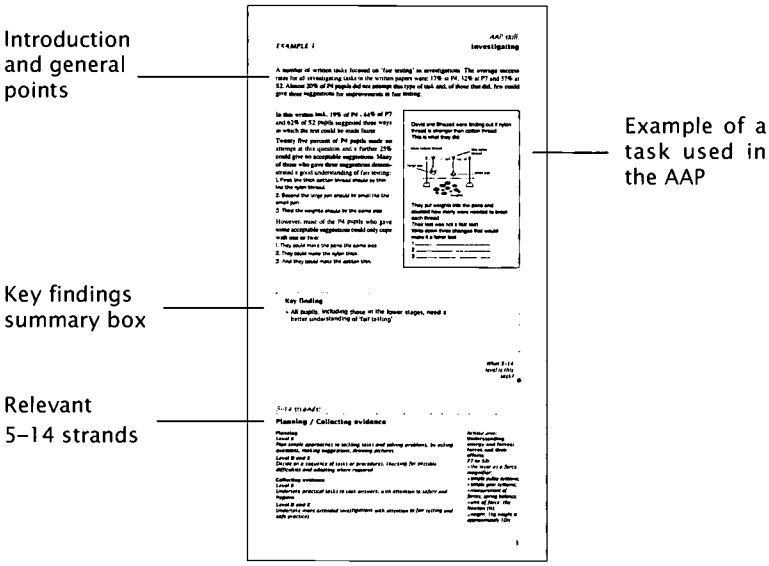
This booklet:

- outlines the main findings of the 1993 AAP science survey, using exemplars from categories within the AAP framework;
- lists the 5–14 strands and levels which could be relevant to the examples presented;
- draws together learning and teaching issues which come from the AAP findings.

Readers are invited to relate the task to the relevant attainment outcomes and targets within each strand of the *Environmental Studies 5–14* document. To assist you, three of the five levels — B, D and E — are listed on each page below the examples. While these levels correspond most closely to the stages, P4, P7 and S2 assessed by AAP, in some instances the 5–14 level depends on the degree of help a child requires. For example, in an assessment situation such as the AAP

survey there is no help is available, whereas in the classroom pupils can get help from other children and the teacher. It should also be recognised that, because the AAP framework was not derived from the 5–14 guidelines, some of the tasks shown may not fit neatly into these three levels but may lie somewhere between. Readers are advised to refer to the actual 5–14 document while reflecting on the tasks given here.

Most of the pages follow this pattern:



Learning and teaching issues which arise from the AAP findings are summarised on the back flap. These can be used as a focus for individuals or groups of teachers to reflect on their classroom practice.

Good news is no news?

Inevitably, to illustrate teaching issues of practical value to teachers, many of the examples chosen are those in which performance was poor or where the pattern of errors is of interest. In the majority of tasks the performance of pupils was satisfactory or good. For a more comprehensive picture of the performance, readers should consult the fuller report of the findings published by HMSO (see page 21).

A number of written tasks focused on 'fair testing' in investigations. The average success rates for all investigating tasks in the written papers were: 17% at P4, 32% at P7 and 57% at S2. Almost 20% of P4 pupils did not attempt this type of task and, of those that did, few could give three suggestions for improvements in fair testing.

In this written task, 19% of P4 , 44% of P7 and 62% of S2 pupils suggested three ways in which the test could be made fairer.

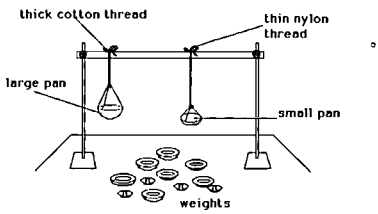
Twenty-five percent of P4 pupils made no attempt at this question and a further 25% could give no acceptable suggestions. Many of those who gave three suggestions demonstrated a good understanding of fair testing:

1. First the thick cotton thread should be thin like the nylon thread.
2. Second the large pan should be small like the small pan.
3. Third the weights should be the same size.

However, most of the P4 pupils who gave some acceptable suggestions could only cope with one or two:

1. They could make the pans the same size.
2. They could make the nylon thick.
3. And they could make the cotton thin.

David and Shazad were finding out if nylon thread is stronger than cotton thread.
This is what they did:



They put weights into the pans and counted how many were needed to break each thread.
Their test was not a **fair test**.
Write down three changes that would make it a fairer test.

1.....
2.....
3.....

Key finding

- All pupils, including those in the lower stages, need a better understanding of 'fair testing'.

What 5–14 level is this task?

5–14 strands:

Planning / Collecting evidence

Planning
Level B
Plan simple approaches to tackling tasks and solving problems, by asking questions, making suggestions, drawing pictures.

Level D and E
Decide on a sequence of tasks or procedures, checking for possible difficulties and adapting where required.

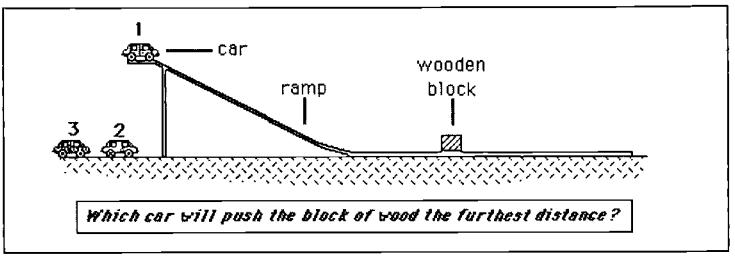
Collecting evidence
Level B
Undertake practical tasks to seek answers, with attention to safety and hygiene.

Level D and E
Undertake more extended investigations with attention to fair testing and safe practices.

Related area:
Understanding energy and forces; forces and their effects
P7 to S2:
- *the lever as a force magnifier;*
- *simple pulley systems;*
- *simple gear systems;*
- *measurement of forces, spring balance;*
- *unit of force, the Newton (N);*
- *weight; 1kg weight is approximately 10N.*

As well as the written tasks focusing on 'fair testing', a sample of pupils at each stage undertook one of two extended practical tasks involving all the stages of investigating. These were carried out on a one-to-one basis with trained assessors observing and recording on a checklist the method used by a pupil and making an assessment of the skills displayed.

One of the two tasks involved toy cars of different weights rolling down a ramp and pushing a block of wood. The table shows the success rates of pupils on the different aspects of investigations (note: the investigation at S2 was harder than at P4 and P7).



Although the figures for 'handled variables' suggest that most P4 pupils undertook 'fair tests', this was more by luck than design: during discussions with the assessor at the end, they seemed unaware of the need to take deliberate steps to ensure fair tests. The proportion of pupils who recorded any results was disappointing.

In another task the content, purpose and the variables to be controlled was less familiar to most pupils and they performed less well.

	% of pupils correct		
	P4	P7	S2
Understood problem	96	99	90
Displayed laboratory skills	60	84	69
Handled variables	69	84	62
Measured dependent variable	61	82	74
Investigative strategy	82	91	94
Recorded results	41	73	77
Concluded	91	95	92
Predicted	–	–	90
Suggested relevant modifications	18	23	36

Key findings

- All pupils needed more practice in carrying out complete investigations as well as the consituents parts.
- Pupils often failed to record their results carefully.
- Pupils' familarity with the context and materials of the investigation affected their performance.

What 5–14 level is this task?

5–14 strands:

Planning / Collecting evidence

Planning
Level B
Plan simple approaches to tackling tasks and solving problems, by asking questions, making suggestions, drawing pictures.

Level D and E
Decide on a sequence of tasks or procedures, checking for possible difficulties and adapting where required.

Collecting evidence
Level B
Undertake practical tasks to seek answers, with attention to safety and hygiene.

Level D and E
Undertake more extended investigations with attention to fair testing and safe practices.

Related area:
Understanding energy and forces; forces and their effects
P1–P3:
- *the effects of pushing, pulling floating, leading to the idea of a force,*
- *moving and stopping effects.*

P4–P6:
- *motion down a slope under gravity.*

P7–S2:
- *measurement of forces.*

For the 1993 survey it was argued that basic measuring skills were more properly assessed by the AAP mathematics project, leaving the science team to focus on the use of measuring skills within scientific contexts. In the extended investigations, pupils were left to decide on which method of measuring they would use.

In the practical investigation example (illustrated opposite), 61% of P4, 82% of P7 and 74% of S2 pupils obtained valid, reliable measurement using quantitative measures; 27%, 13% and 22% respectively relied on judgement by eye alone.

In the second investigation far fewer pupils used reliable methods with 20%, 33% and 46% of P4, P7 and S2 pupils respectively using quantitative measures.

Key findings

- Pupils' familiarity with the content of the task affected performance in practical measuring.
- A substantial number of pupils at all stages, even at S2, were still unaware of the need for accurate measuring in investigations.

5–14 strand:

Collecting evidence

Level B
Estimate and measure length, weight, time, using easily handled standard units.

Level D
Estimate and measure accurately distance, time, weight, area, volume, temperature, in small and large standard units, selecting appropriate measuring units and devices.

Level E
Estimate, measure and draw accurately, to scale where appropriate, in small and large standard units, selecting appropriate units and measuring devices.

In written observing tasks, P4 and P7 pupils were assessed on how well they could recognise similarities and differences between things. Most pupils selected the correct answer, but many were unable to explain their choice. On average over three tasks, 22% of P4 and 44% of P7 pupils gave fully correct answers. In practical tasks pupils had to recognise changes; average success rates were 62% at the P4 stage, 75% at P7 and 78% at S2.

In this example of a written task, 67% of P4 pupils selected group B, but only 19% explained this correctly:

P4

Because all of them are walking on two legs.

I chose group B because they all stand on their hind legs.

P7

Because they all stand on their hind legs.

Because their top feet have been shortened to be arms.

Because they walk on their hind legs.

Many responses were insufficiently detailed:

P4

Because they look the same.

Because they are all the same size.

Because they were scary.

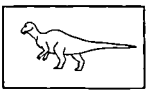
P7

Because they are a group.

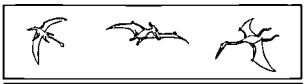
It looks more like group B.

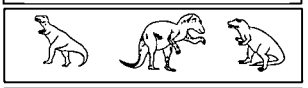
Because it looks like all the others.

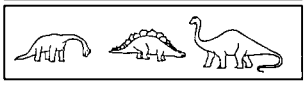
Look at this drawing of an animal which lived long ago.



These animals can be sorted into groups.
Which one of these groups does this animal belong to?
Put a tick (√) in the small box beside the group you choose.

☐ A 

☐ B 

☐ C 

Why did you think it belongs to this group?

.....

.....

Key findings

- Although overall observing skills were good, pupils found it difficult to explain reasons for their choices, particularly in the written papers.
- Pupils at the lower end of the ability ranges tended to do better in the practical tasks than in the written papers.

What 5–14 level is this task?

5–14 strand:

Collecting evidence

Level B
Observe living things, objects and phenomena, noticing obvious features and group by a single attribute.

Level D
Observe living things, objects and phenomena, organising them according to a hierarchy of classification.

Level E
Make detailed and accurate observations of living things, objects and phenomena, showing understanding of the concept of 'scientific' classification systems.

Related area:
Understanding living things and the processes of life; variety and characteristic features
P1–P3:
Sorting living things into broad groups according to easily observable characteristics.

In written papers and practical circuits S2 pupils were assessed on their ability to follow instructions, carry out standard techniques and use standard symbols and conventions.

In the example given here, 9% of S2 pupils could give only one unsafe practice, 36% gave two and 53% gave three.

In another task on safety in the laboratory, 68% of S2 pupils correctly identified all five dangers represented by symbols on laboratory bottles.

In labelling tasks, 40% of S2 pupils confused a flask with a beaker when required to label apparatus used for filtering. However, 97% were successful in labelling the basic apparatus used for a water bath.

In a similar labelling task, 91% of S2 pupils labelled four pieces of electrical equipment from the five illustrated: bulb, switch, battery, fuse, ammeter. The main failing was in labelling a switch as a transistor or resistor, and similarly, labelling a fuse as a resistor.

Only 12% of S2 pupils could draw an acceptable circuit diagram.

Look at this picture of a pupil doing an experiment using a bunsen.

Write down three things you can see in the picture that are **not safe.**

1.....

2.....

3.....

Key findings

- Many S2 pupils were unaware of safe laboratory practice.
- S2 pupils had a good grasp of most basic symbols and conventions but were less successful in combining that information to produce, for example, diagrams of apparatus or electrical circuits.
- A large number of S2 pupils were confused over the naming of some standard pieces of laboratory equipment.

What 5–14 level is this task?

5–14 strands:

Planning / Collecting evidence

Planning
Level B
Given set safety rules, check plans for safety and hygiene.

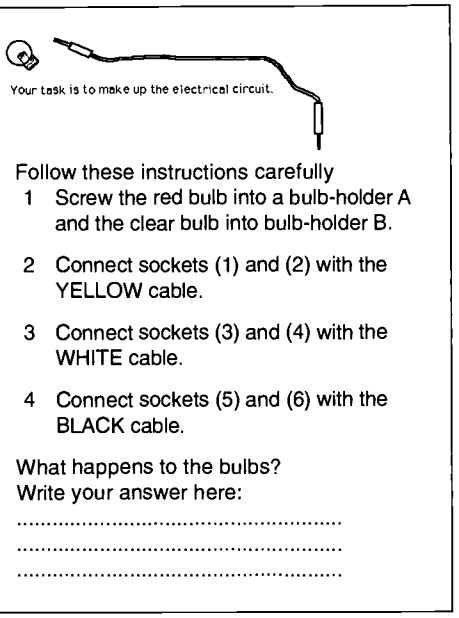
Level D and E
Suggest suitable safety/hygiene procedures.

Collecting evidence
Level B
Undertake practical tasks to seek answers, with attention to safety and hygiene.

Level D and E
Undertake more extended investigations with attention to fair testing and safe practices.

Pupils at all stages were assessed in practical tasks which involved using simple procedures; average success rates were: 48% in P4, 64% in P7 and 83% at S2.

In this task, a correctly constructed circuit would lead to the red bulb lighting up and the clear bulb not.



The success rates on this task were quite high with 72% of P4, 89% of P7 and 96% of S2 pupils correctly mentioning at least the red bulb:

The red bulb went on when I put the black cable in.

The red bulb lights up.

The red bulb lights.

Or better still, both bulbs:

The red bulb comes on but the clear bulb stays off.

The red bulb lights but the white doesn't.

The red bulb glows and the white one stays off.

However over 20% of pupils at all stages made no mention that the clear bulb did not light.

A number of pupils were not explicit enough:

One goes on.

Only one of the bulbs lit up.

And a few displayed some misconceptions in their answer:

The red bulb goes on, the clear bulb is transferring it's power to the red bulb.

Key findings

- All pupils tackled the tasks willingly and achieved satisfactory levels of success. However, in a range of tasks pupils tended to neglect details in both carrying out the task and in reporting it. This was more marked at the P4 stage than at P7 and S2.

What 5–14 level is this task?

5–14 strand:

Collecting evidence

Level B
Observe events and identify main aspects/happenings.

Use simple apparatus and techniques safely to collect information.

Level D
Observe events, noticing sequences and changes.

Select and use appropriate apparatus and techniques to collect information.

Level E
Relate observable activities or phenomena to major scientific processes.

Select and use appropriate apparatus and techniques to collect information.

Related areas:
Understanding energy and forces; properties and uses of energy
P4 to P6:
- *construction of battery operated circuits to operate,* eg. bells, buzzers, lamps, warning lights.

Pupils were assessed on their ability to extract information from tables and graphs; average success rates on the tasks were: 60% at P4, 66% at P7 and 71% at S2.

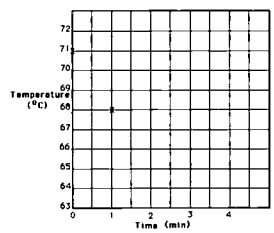
In this written task in which pupils had to construct a graph from information in a table, 59% of P7 and 83% of S2 pupils correctly plotted the points and joined the points either in a curve or a series of short lines.

Eighty-two percent of P7 pupils plotted the points correctly, but 27% did not join them up. In comparison 93% of S2 pupils correctly plotted the points, with 88% joining the points in a either a curve or a series of short lines. Only 9% of S2 pupils failed to join the points.

The temperature of a cup of tea was taken every minute as it cooled down.

Time (min)	0	1	2	3	4
Temp (°C)	71	68	66	65	64

Use the information to complete the line graph.
The first two points have been put in for you. Put in the rest and join them up.



Key findings

- Overall, all pupils performed better on extracting information from tables and charts than in constructing them.
- P7 pupils could use and construct bar graphs and tables better than they could line graphs.
- S2 pupils performed relatively well on all the information formats, showing much improvement over P7 on line graphs.

What 5–14 level is this task?

5–14 strand:

Recording and presenting

Level B
Record collected evidence in a variety of ways, including diagrams, charts, picture sequences, simple tables and databases (given headings/fields) and short written accounts.

Level D
Record evidence in a variety of appropriate ways, including making labelled and annotated sketches; constructing spreadsheet tables, databases (up to 3 fields), pie charts, line and bar graphs (providing own headings and axes); making annotated sequences of photographs/ illustrations; writing appropriately illustrated and organised reports.

Level E
Record evidence in a variety of appropriate ways, including constructing graphs, tables, databases (defining own axes, headings and fields); drawing diagrams using conventional symbols; writing notes, summaries (using own headings) and well-organised, appropriately illustrated reports.

Related areas:
Understanding energy and forces; properties and uses of energy
P4–P6:
use of thermometers to measure 'hotness' leading to distinction between heat and temperature.

The average success rates for P4 and P7 pupils in practical information handling tasks was 48% and 64% respectively. This compares with similar figures of 51% and 69% respectively in the written papers for this type of task.

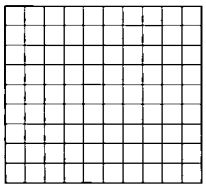
In this practical task, 33% of P4 and 58% of P7 pupils completed the table and chart correctly. Although 42% of P4 pupils and 77% of P7 pupils labelled the category axis appropriately, only 8% of P4 pupils and 42% of P7 pupils numbered the value axis.

Look at the sea shells on the table in front of you.
Your task is to sort them into four groups: cockles, winkles, limpets and whelks.
There are two parts to this task.

1 Complete this table to show how many of each kind of shell there are.

cockles	winkles (dark grey)	limpets	whelks (white)

2 Use the numbers in the table to draw a barchart here.



Key findings

- P4 pupils were better at extracting information than completing or constructing information formats.
- Lower achieving pupils performed better in the practical tasks than in the written tasks.
- In using keys, pupils had less difficulty in handling man-made objects, which are more uniform, than natural materials.

What 5–14 level is this task?

5–14 strand:

Recording and presenting

Level B
Record collected evidence in a variety of ways, including diagrams, charts, picture sequences, simple tables and databases (given headings/fields) and short written accounts.

Level D
Record evidence in a variety of appropriate ways, including making labelled and annotated sketches; constructing spreadsheet tables, databases (up to 3 fields), pie charts, line and bar graphs (providing own headings and axes); making annotated sequences of photographs/ illustrations; writing appropriately illustrated and organised reports.

Level E
Record evidence in a variety of appropriate ways, including constructing graphs, tables, databases (defining own axes, headings and fields); drawing diagrams using conventional symbols; writing notes, summaries (using own headings) and well-organised, appropriately illustrated reports.

Related area:
Understanding living things and the processes of life; variety and characteristic features
P1–P3:
sorting living things into broad groups according to easily observable characteristics.

In a third type of information handling task pupils were assessed on how well they could interpret information presented in tables or bar charts. Only 83% of P4 pupils attempted this type of task compared with 95% for both P7 and S2; average success rates were 30% at P4, 50% at P7 and 61% at S2.

In the written example given here, 20% of P4, 46% of P7 and 68% of S2 pupils clearly stated or implied the correct relationship:

The longer the bridge the fewer the amount of 2p coins it could support.

The longer the bridge the less coins it can take.

Many pupils were unable to generalise the relationship:

The length of the bridge goes up in twos and the number of 2p coins goes down in ones.

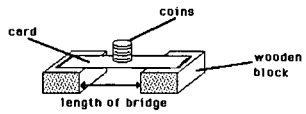
And many missed the point completely:

I notice that length was 70cm and the number of coins was 15 2p coins.

They are all odd numbers.

Forty seven per cent of P4 and 40% of P7 pupils did not state any relationship.

Lucy made a model bridge out of two blocks of wood and a piece of card.



She measured the length and counted the number of 2p coins which the bridge could support. She did this several times. Here are her results:

length (cm)	Number of 2p coins
10	5
12	4
14	3
16	2
18	1

What do you notice about the length of the bridge and the number of 2p coins which it could support?

.....

.....

Key findings

- Although there was a clear improvement across the stages, all pupils found this type of task difficult and a large number of pupils at S2 were still unable to offer satisfactory interpretations for tables and graphs.
- At all stages pupils did better on the 'mechanical' aspects of handling information than on identifying a pattern, trend or relationship.

What 5–14 level is this task?

5–14 strand:

Interpreting and evaluating

Level B
From recorded information and observations, identify simple direct relationships, including cause and effect; draw conclusions.

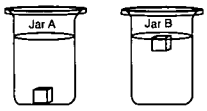
Level D
From recorded evidence, observations and published information, given information about more complex relationships answer questions about content and meaning, identify and evaluate possible explanations, draw conclusions and justify them with reference to evidence, make predictions using knowledge and information gained in several different contexts, with guidance from the teacher, recognise reliable evidence.

Level E
From recorded evidence, observations and published information, given information about more complex relationships answer questions about content and meaning, form generalisations, draw conclusions and justify them with reference to evidence, make and test hypotheses, begin to develop and apply their own criteria for making judgements about what evidence is relevant and reliable.

Short tasks, written and practical, assessed pupils' skills at inferring: these focused on the ability to distinguish between what can be observed and what has to be inferred based on a limited amount of evidence.

In this practical task, over 70% of pupils at all stages managed to select one correct statement. However, many pupils had difficulty in selecting two: only 18% of P4, 32% of P7 and 44% of S2 could do this.

In a similar practical task, success was achieved by 45% of P4, 56% of P7 and 60% of S2 pupils.



Look carefully at the two jars on the table in front of you.
Five other people looked at these jars.
Tick the boxes beside the two people who are describing what they can actually see.

Janet says	'I see a toy floating in Jar A.'	☐
Billy says	'I see a toy floating in Jar B.'	☐
Derek says	'I see a toy in jar A which is made from a different plastic from the toy in Jar B.'	☐
Joanne says	'I see jars containing colourless liquids and coloured toys.'	☐
David says	'I see a toy in jar A which is heavier than the toy in the other jar.'	☐

Key findings

- Many pupils, particularly in the older group, ignored 'what you can actually see' and selected the 'most likely' explanation.
- Results from more extended practical inference tasks suggest that handling materials and obtaining evidence directly helps pupils to distinguish between observations and inferences.

What 5–14 level is this task?

5–14 strand:

Interpreting and evaluating

Level B
Draw conclusions.

Level C
Distinguish between fact supported by evidence and opinion and speculation.

Level D
Draw conclusions and justify them with reference to evidence.

Make predictions using knowledge and information gained in several different contexts.

With guidance from the teacher, recognise reliable evidence.

Level E
Draw conclusions and justify them with reference to evidence.

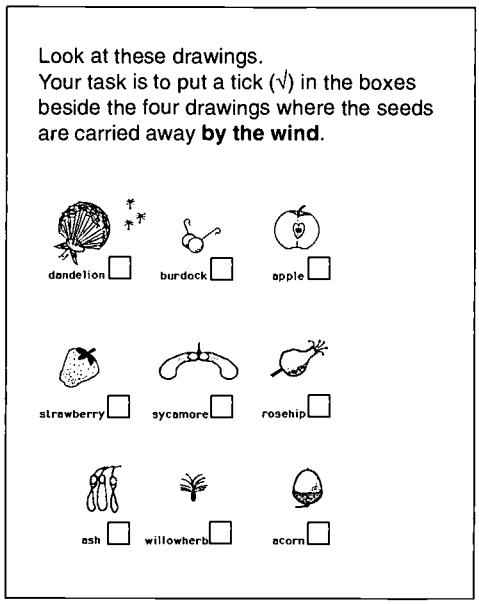
Make and test hypotheses.

Begin to develop and apply their own criteria for making judgements about what evidence is relevant and reliable.

Related area:
Understanding earth and space; materials from earth
P4–P6:
▪uses of water, methods of water conservation;
▪further properties of common materials, relationship between a material's properties and its use,
▪natural and manufactured materials and simple examples of recycling,
▪how materials can be changed: by heat; by mixing chemicals; and by a combination of both.
P7–S2:
▪the existence of materials as solids, liquids, gases; properties of solids, liquids, gases including expansion, density, pressure.

Pupils at all stages were very ready to attempt the written tasks assessing knowledge: 98% of P4, 99% of P7 and 95% of S2 attempted tasks involving labelling, matching, sorting and sequencing. However, this was not always matched by the success rates, with many pupils displaying a lack of secure knowledge in a number of areas.

In this example, 30% of P4, 42% of P7 and 52% of S2 pupils marked the four correct seeds. The most commonly selected wrong answers across all stages were burdock, rosehip and acorn. In addition, 25% of P4 pupils also selected the apple, perhaps confusing windfall apples with wind dispersed seeds.



Key findings

- Generally speaking, pupils, particularly those in P4, and to a lesser extent P7, performed better on biology tasks than physical science tasks. The difference was less marked in S2.
- Attempt rates at P4 dropped noticeably on tasks requiring extended written responses.

What 5–14 level is this task?

5–14 strand:

Knowledge and understanding

Level B
Show secure knowledge and understanding of those key features of Living Things and the Processes of Life, Energy and Forces, Earth and Space *set out for stages P1 to P3.*

Be making steady progress towards the development of understanding of the key features of these three attainment outcomes set out for stages P4 to P6.

Level D
Show secure knowledge and understanding of those key features of Living Things and the Processes of Life, Energy and Forces, Earth and Space *set out for stages P1 to P6.*

Be making steady progress towards the development of understanding of the key features of these three attainment outcomes set out for stages P7 to S2.

Level E
Show secure knowledge and understanding of those key features of Living Things and the Processes of Life, Energy and Forces, Earth and Space *set out for stages P7 to S2.*

Attainment outcome 1:
Understanding living things and the processes of life
P1 to P3:
Simple life cycles of plants and animals to illustrate stages of development.
P4 to P6:
Dispersal of fruits and seeds by animals (externally/internally), by wind and by self.
P7 to S2:
The process of reproduction in flowering plants with reference to cross- (wind and insect) and self-pollination.

In another type of written task assessing knowledge, pupils were required to explain certain phenomena that were illustrated.

In this task, 46% of P4, 77% of P7 and 89% of S2 pupils were successful. Almost 75% of all S2 pupils mentioned oxygen with the other correct responses mentioning air. In contrast, only one quarter of P7 and half again of P4 pupils mentioned oxygen:

Because there was not enough oxygen. (P4)

The flame went out because it needs oxygen and when the jar goes over it there is no oxygen left. (P7)

Rather more pupils were aware of the role of air in burning:

Because the candle used up all the air in the jar. (P4)

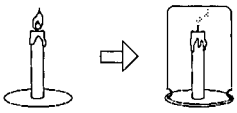
The air that was in the jar ran out and flames need air to burn. (P7)

A number of pupils, particularly in P4, showed no understanding at all:

The flame went out because the wax was melting. (P4)

Because there is air trapped inside the jar which blows out the candle. (P7)

Nita lit a candle and let it burn for a short while. Then she placed a jar upside down over the candle and the flame burned for a few seconds then went out.



Why do you think the flame went out?
Write your answer here.

.....

.....

.....

What 5–14 level is this task?

Key findings

- Performance at S2 was disappointing on some tasks, in particular those relating to the particle nature of matter and the effect of temperature on expansion and contraction of matter. Although many S2 pupils knew specific bits of knowledge, few could use this knowledge to explain related phenomena satisfactorily.

5–14 strand:

Knowledge and understanding

Level B

Show secure knowledge and understanding of those key features of Living Things and the Processes of Life, Energy and Forces, Earth and Space *set out for stages P1 to P3.*

Be making steady progress towards the development of understanding of the key features of these three attainment outcomes set out for stages P4 to P6.

Level D

Show secure knowledge and understanding of those key features of Living Things and the Processes of Life, Energy and Forces, Earth and Space *set out for stages P1 to P6.*

Be making steady progress towards the development of understanding of the key features of these three attainment outcomes set out for stages P7 to S2.

Level E

Show secure knowledge and understanding of those key features of Living Things and the Processes of Life, Energy and Forces, Earth and Space *set out for stages P7 to S2.*

Attainment outcome 3:
Understanding earth and space
P4 to P6:
The earth's atmosphere and some effects of having air around the planet.
P7 to S2:
The gases of the atmosphere — properties and uses.

In another example of a knowledge assessment, 31% of P4 and 68% of P7 pupils were successful.

P4 pupils who were marked correct showed some understanding by referring to air being trapped in the parachute:

The parachute catches the air and slows the toy down.

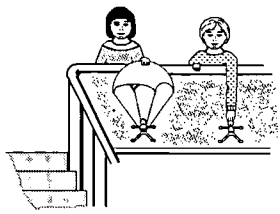
I think Jans toy parachute makes her figure fall slower because the air opens the parachute and makes it fall down.

Many made the mistake of confusing air with wind:

Because the wind gets caught in the parachute as it comes down.

One fifth gave a true statement but not an explanation, often a reiteration of the question:

Because a parachute makes you come down slow.



Sandra and Jan have identical toy figures. Jan makes a parachute for her figure. They stand at the top of the stairs and drop the figures. Sandra's toy falls quickly to the ground but Jan's toy is much slower. Why do you think the parachute makes Jan's toy fall more slowly?
Write your answer here:
.....
.....
.....

And one quarter showed no understanding of what was involved:

The parachute is heaviest.

Because Sandra's parachute is more heavier than Jan's toy.

In a similar type of task concerning friction and how far a toy car would travel on different surfaces, success rates were much higher, with 74% of P4 and 92% of P7 pupils correct.

Key findings

- Success rates ranged considerably from topic to topic: pupils seemed to understand some concepts well, but had great difficulty with others.

What 5–14 level is this task?

5–14 strand:

Knowledge and understanding

Level B
Show secure knowledge and understanding of those key features of Living Things and the Processes of Life, Energy and Forces, Earth and Space *set out for stages P1 to P3.*

Be making steady progress towards the development of understanding of the key features of these three attainment outcomes set out for stages P4 to P6.

Level D
Show secure knowledge and understanding of those key features of Living Things and the Processes of Life, Energy and Forces, Earth and Space *set out for stages P1 to P6.*

Be making steady progress towards the development of understanding of the key features of these three attainment outcomes set out for stages P7 to S2.

Level E
Show secure knowledge and understanding of those key features of Living Things and the Processes of Life, Energy and Forces, Earth and Space *set out for stages P7 to S2.*

Attainment outcome 2:
Understanding energy and forces
P1 to P3:
The effects of pushing, pulling, floating, leading to the idea of a force; moving and stopping effects; the force of friction and its effects; the turning effect of a force.
P4 to P6:
Air resistance, streamlining.

In this written knowledge task S2 pupils could achieve success by mentioning either the difference in resistance *or* current between the two circuits, *or* by stating A was a parallel circuit and B series.

Twenty–five percent of pupils were successful on this task. Most of the successful pupils made some mention of parallel or series circuits without showing any deeper understanding of why there was any difference in the brightness of the bulbs:

The bulbs shone brighter in circuit A because it is a parallel circuit so the bulbs got a higher amount of electricity.

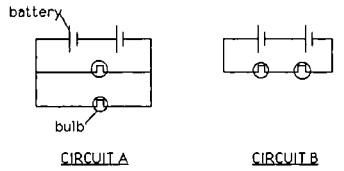
Because they were set out parallel.

Because circuit A is in parallel and circuit B is in series.

No pupils made any mention of resistance as being greater in circuit B. A number of pupils exhibited misconceptions relating to one bulb using more electricity than the other:

In circuit B the lights were much more dull especially the second one because the first light was using most of the electricity.

Pauline made two electrical circuits. She used the same number of electrical components for each circuit.



CIRCUIT A CIRCUIT B

Pauline found that both bulbs in Circuit A shone brighter than the bulbs in Circuit B. Why do you think this happened? Write your answer here.

.....

.....

.....

What 5–14 level is this task?

Key findings

- On a number of knowledge tasks, many S2 pupils were able to give superficial answers but few could demonstrate any secure understanding or give reasonable explanations for a variety of phenomena.

5–14 strand:

Knowledge and understanding

Level B
Show secure knowledge and understanding of those key features of Living Things and the Processes of Life, Energy and Forces, Earth and Space *set out for stages P1 to P3.*

Be making steady progress towards the development of understanding of the key features of these three attainment outcomes set out for stages P4 to P6.

Level D
Show secure knowledge and understanding of those key features of Living Things and the Processes of Life, Energy and Forces, Earth and Space *set out for stages P1 to P6.*

Be making steady progress towards the development of understanding of the key features of these three attainment outcomes set out for stages P7 to S2.

Level E
Show secure knowledge and understanding of those key features of Living Things and the Processes of Life, Energy and Forces, Earth and Space *set out for stages P7 to S2.*

Attainment outcome 2:
Understanding energy and forces
P4 to P6:
Electrical conductors and insulators; construction of battery operated circuits to operate e.g. bells etc.; *electrical safety.*
P7 to S2:
Basic electrical circuit components; voltage, current and resistance in simple d.c. circuits.

In 1993, the AAP science team joined forces with the AAP English language team in an attempt to compare pupils' talking and writing skills in the context of science tasks with that in English language tasks. Although essentially a feasibility study it did give rise to some interesting observations.

Talking

P4 pupils performed as well when talking about science tasks as they did about the English language tasks except in the area of content — for example, conveying relevant items of information and instruction — where they performed less well in the science survey.

P7 pupils performed better in the science tasks than in the English language tasks on most of the skills in 'communication' and 'structure'— such as, how speech is delivered, logical sequence of ideas, helping the listener to understand. This was particularly marked in the 'structure' category where the framework provided by the science task appeared to enhance performance. There was little difference in performance across the tasks on 'content'.

Similarly at S2, pupils performed better in the science tasks than in the English language survey tasks across all talking skills and, again, this was particularly marked in the 'structure' category.

Writing

In the writing tasks spelling was fairly accurate at all stages. Some pupils, particularly at S2, were able to write a report or set of instructions which suggested that they were familiar with this genre, including sequenced steps, headings, labelled diagrams. However, many pieces of writing used inappropriate language or were poorly organised, despite the structure provided by the science investigation.

5–14 strand:

Recording and presenting

Level B
Present work on an aspect of a topic in a personal folder and give a brief oral report of the work to the class.

Level D
Record evidence...making annotated sequences of photographs/ illustrations, writing appropriately illustrated and organised reports.

Select and organise relevant notes and materials into a record of work on a topic, for personal reference at a later stage.

Cooperate with others in a group to design and construct an illustrated presentation to the class about an aspect of work on a topic, using appropriate audio visual resources.

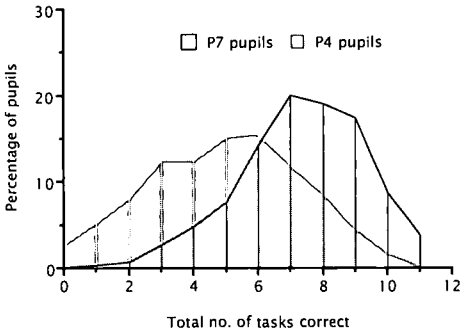
Level E
Record evidence...writing notes, summaries (using own headings) and well-organised, appropriately illustrated reports.

Select and organise relevant notes and materials into a record of work on a topic, for personal reference at a later stage.

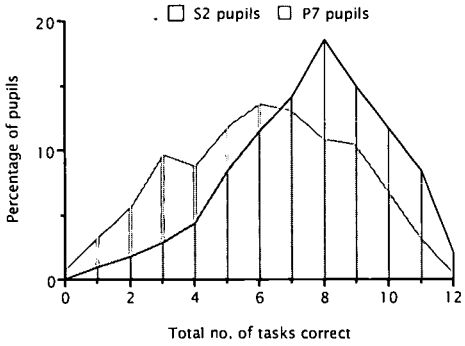
Cooperate with others in a group to design and construct an illustrated presentation to the class about an aspect of work on a topic, using appropriate audio visual resources.

In a task-by-task comparison of success rates between stages, in nearly every case there was a statistically significant improvement in performance from P4 to P7 and from P7 to S2. On the surface this suggests that the pupil population as a whole is improving significantly from stage to stage.

However, a closer look at the range of performance when pupils at different stages did the same tasks adds more to the overall picture. The graph below illustrates a typical pattern of overlap in the same 11 tasks taken by P4 and P7 pupils in one of the written papers. Although P7 pupils did better than P4 pupils overall, on average the top third of P4 pupils performed better than the bottom third of P7 pupils.



The overlap was even more pronounced between P7 and S2. This graph illustrates a typical pattern of overlap in the same 12 tasks taken by P7 and S2 pupils in one of the written papers. Here the overlap indicates that, on average over all the written papers, the top third (32%) of P7 pupils performed better than almost the bottom half (45%) of S2.



These distributions suggest that by the time children enter secondary school a considerable number of them already possess much of the skills and knowledge expected in science. However, it also suggests that, even after two years of specialist secondary science teaching, the low achievers continue to lag behind and many pupils do not get beyond a level demonstrated by most P7 children.

5–14 guidelines:

Differentiation...involves the identification of, and provision for, a range of attainment within any one class, to ensure that all pupils are engaged in activities that are suited to their different needs and capacities.' (Environmental Studies 5–14)

The 5–14 guidelines give some guidance to teachers in providing for pupils' differing needs, particularly those who have progressed beyond level E in some or all attainment outcomes and strands.

'The matching of learning activities to the stage of each pupil's development can be achieved in a number of ways:

by designing, around any given topic or theme, a set of clearly defined tasks for any given level of performance;

by structuring common tasks to allow differentiation by response;

by organising and structuring collaborative group tasks to allow pupils to contribute, each according to his or her different abilities;

by gradually withdrawing teacher support from pupils, so that they are encouraged to show increased independence in their learning and to exercise greater responsibility for the pace and structure of their work.' (Environmental Studies 5–14)

While there were no overall difference between the performance of boys and girls in the 1993 science survey, there was some evidence of gender differences across certain categories. In many categories of task, there were far more tasks where there were no differences between the sexes than tasks with differences. However, sufficient numbers of differences emerged to raise questions about how this occurs and what the implications are for teaching and learning.

Differences in performance tended to be in different categories for boys and girls, depending on the type of task — process or knowledge — and the content area of the task — biological or physical science. Knowledge tasks are primarily concerned with finding out what children know and understand about particular topic areas; process tasks cover the skills and process categories of handling information, observation, inferring and investigative skills.

Where boys performed better, particularly in S2, it tended to be in the knowledge type tasks — both 'recall' type tasks and those requiring explanations — and physical science based tasks. Where girls performed better it tended to be in process type tasks and, at P7, on biological tasks. This was more pronounced in the written papers.

5–14 guidelines:

'Pupils from all races and cultures and from all sections of society should find that the curriculum in Environmental Studies respects and builds on their social experience. Girls and boys should participate equally in all aspects of Environmental Studies'.
(Environmental Studies 5–14)

As part of the AAP survey, a questionnaire was sent to all participating schools to obtain feedback about science education within schools.

In relation to the assessment package itself 90%–95% of respondents representing all three stages, P4, P7 and S2, felt that the content of the assessment booklets matched teacher's expectations.

Policy on science

Two thirds of primary schools reported that they had a policy in science: half of them reported that science was fully integrated with environmental studies and half had both integrated and focused studies.

Time for science

Environmental Studies 5–14 suggests that 25% of time should be allocated to environmental studies in primary schools. The table below indicates that nearly half of primary schools devoted less than 5% of time to science in 1993. Given that there are three attainment outcomes for science out of a total of 10, this amount of time seems to be insufficient to meet the guidelines.

The 5–14 guidelines recommend a minimum allocation of 10% (approximately 2h 40 min) to science in secondary schools. The majority of secondary schools reported that they were spending between two and three hours a week on science, which is relatively close to this figure.

% of time on science	*% of schools at stages: P4*	*P7*
5% or less	48	41
Between 5 and 10%	30	31
Over 10%	7	12

Time on science	*% of schools at S2 stage*
2 hours or less	7
Between 2 and 3 hours	75
3 hours or more	15

Of four factors seen as obstacles to increasing the proportion of time spent on science, pressure of time (88%) and teachers' confidence and qualifications (70%) came out on top, with lack of accommodation (28%) and lack of resources (21%) not creating quite such a cause for concern.

Goals of science

The five most important goals of science teaching in the primary schools were perceived by teachers as:

- a questioning attitude to their surroundings;
- enjoyment of science based activities;
- the ability to observe carefully;
- development of problem solving skills; and
- knowledge of the natural and physical world.

Three of the five goals selected by primary schools were also selected by the secondary respondents. However, 'Understanding of science concepts' was given a far higher priority by the secondary sector. The five selected by the secondary sector were:

- understanding of basic science concepts;
- ability to carry out simple experiments carefully;
- enjoyment of science-based activities
- development of problem solving skills; and
- knowledge of the natural and physical world.

Primary–secondary school liaison

Primary-secondary school liaison tended to focus on the transfer of information and the preparation for the induction of P7 pupils into S1. Where liaison went beyond this, the main areas involved were English language and mathematics although music, physical education, technology and art were all mentioned. Few schools mentioned specific liaison in relation to science and where this occurred it tended to take the form of primaries seeking advice and/or borrowing equipment.

FURTHER READING

Further details of the methods used in the AAP surveys and the findings of the 1993 science survey are in the report entitled *Assessment of Achievement Programme. Science 1993* (ISBN 0-11-495395-7). The report was published by HMSO in December 1994 and is available from the HMSO bookshop, 71 Lothian Road, Edinburgh EH3 9AZ, tel 0131-228 4181; fax 0131-229 2734, price £7.70.

For the full information about the government's 5–14 curriculum guidelines, see *Curriculum and assessment in Scotland, National guidelines, Environmental studies 5–14*, published in March 1993. This is available from the Scottish Office Education Department.

AAP PUBLICATIONS

Fuller details of the AAP findings are published by HMSO. Recent reports include:

Mathematics 1991, 3rd survey (price £6.70)
English Language 1992, 3rd survey (price £8.00)
and the report of the latest survey on Science 1993, 3rd survey (price £7.70).

These are available from HMSO Bookshop, 71 Lothian Road, Edinburgh EH3 9AZ. Telephone 031-228 4181; fax 031-229 2734.

Other editions in the *Feedback* series for teachers include a booklet based on the 1991 Mathematics survey and a fold-out leaflet/poster on the 1992 English language survey.

The Assessment of Achievement Programme's own newsletter, *Noticeboard*, provides the latest news about the people and projects involved in the AAP. *Noticeboard* is sent free to schools throughout Scotland.

For further information about AAP publications and to obtain additional copies of *Feedback* in Science or the other subject areas in the AAP, write to the RIU Dissemination Officer, Scottish Council for Research in Education, 15 St John Street, Edinburgh EH8 8JR.

Planning / Collecting evidence

- How can you help pupils to articulate their reasons for noticing similarities and differences? What are the implications for assessment in the classroom?
- Combined efforts in group work and discussion in the classroom might result in more attention to detail. Can this be effectively used to encourage greater care and more detailed responses by individuals?
- How can you develop the skills of 'fair testing' in the context of a practical investigation so that it relates to the child's own experience?
- How can you help pupils, particularly at the lower stages, to reflect on their work in practical investigations? In investigative work this is particularly important in developing the idea of 'fair testing'.
- Pupils' familiarity with the content of an investigation can affect performance. How aware are you of the need to assess skills and processes over a range of content?
- How much do you emphasise safe practice in laboratory procedures in secondary science?

Recording and presenting

- Do you encourage your pupils to record their results methodically during practical investigations?
- How can performance in line graphs be improved? Is more practice needed here?
- Do you help pupils to identify the variable(s) to be tabulated and encourage them to provide their own labels and titles when practicable?
- Do you agree that with more practice in practical investigations and subsequent reporting of their own results, pupils will become more familiar with constructing useful information formats?

Interpreting and evaluating

- How can pupils be encouraged to report what they see and not 'jump to conclusions'?
- Can you give your pupils more practice in interpreting their own investigation results to improve performance in this area?

Knowledge and understanding

- Will the 5–14 guidelines help to improve the balance between biological and physical sciences in the primary school?
- How could you facilitate improvement in pupils' extended responses to science questions — with more group and class discussion?
- Are you aware of the need to go beyond simple question and answer routines? Further probing to uncover pupils' misconceptions will help to ensure the development of deeper understanding.

Other topics

- Do you 'compartmentalise' language and science teaching? Are you making enough use of scientific investigations as a context for developing pupils' oral and written communication skills ?
- From your experience, how much overlap in performance between stages would you expect to see? How can you organise your teaching in science to cater for such a range of abilities in the classroom?
- How do you determine the level a pupil has reached by the beginning of S1 and how can you build on the skills and knowledge that many P7 pupils already possess?
- Does assessment in your classroom reflect a balance of process/content and physical/biological activities? If not, will anyone be disadvantaged by this?

AAP science	*5–14 guidelines on environmental studies*
Content coverage	**Attainment outcomes for science**
Ourselves Plants and animals	Understanding living things and the processes of life
Energy	Understanding energy and forces
Materials Earth and space	Understanding earth and space
Categories and sub-categories	**Strands**
Using knowledge	Knowledge and understanding
Investigating Observing Measuring Using simple procedures	Planning Collecting evidence
Handling information	Recording and presenting
Inferring	Interpreting and evaluating
	Developing informed attitudes

See inside this flap for teaching and learning issues from the AAP survey

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