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Scientific Process Skills in Primary Science

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Introduction

'We teach a subject not to produce little living libraries on that subject, but rather to get a pupil to …take part in the process of knowledge getting; knowledge is a process not a product' (Bruner, 1960)

Primary science is a way of thinking and doing. Science in primary school is concerned with asking questions and finding ways of answering them through practical activities. The main reason for teaching primary science is to extend the children's innate curiosity and natural urge to explore their immediate environment. The emphasis is on developing a way of exploring and thinking in order to investigate ourselves and the environment (Sherrington, 1998; O'Doherty, 1994). It allows children to see an experimental world, where everything they encounter can be subject to scientific exploration (O'Doherty, 1994). Scientific investigations and active exploration are fundamental characteristics of primary science which assist pupils in this process (DES, 1999).

It is more a question of knowing HOW than of knowing WHAT

Science at primary level should reflect science in the real world, where children act like scientists, practicing scientific process skills, learning collaboratively, taking an active role in their own learning and carrying out investigations to answer problems and test their ideas and prior knowledge (DES, 1999). The current Irish primary school curriculum aims to develop a scientific approach to problem-solving, which emphasises understanding and constructive thinking and encourages the child to explore, develop and apply scientific ideas and concepts through designing and making activities (DES, 1999).

Figure 1: Children actively solving problems in science

Scientific Process Skills

Scientists are **curious**; they **seek explanations**. The scientist chooses from the knowledge and ideas, which have been previously established, to devise systematic studies into phenomena. There are many scientific methods – scientists **formulate hypothesis, design and carry out experiments, make observations and record results.** There is also an important place for **imagination, for inspirational thinking** and the **receptive mind**….a scientist's work can result in the formulation of a new idea or lead to the solution of a problem or the development of a new product. Scientific endeavour produces progressively more powerful, but still provisional, ways of **understanding the natural world**.

Process Skills refer to a range of abilities relating to identifying questions, making predictions, designing investigations, obtaining evidence, interpreting evidence, analysis of data and arriving at conclusions, and communicating what has been learned. Such skills are used by scientists to solve problems, i.e. they are skills necessary for effective use of the scientific method. If we are to equip children with the capacity to generate and develop their own ideas, they must develop certain skills that are central to this process.

These skills include:

- Questioning
- Observation (looking at the evidence)
- Predicting
- Investigating and experimenting
- Estimating and measuring
- Recording data
- Higher order thinking
- Analysing the information (Sorting and classifying, recognising and interpreting patterns)
- Student and teacher questioning
- Collaboration (dialogue)
- Arriving at conclusions
- Communicating

Scientific Process Skills in the Irish Primary Science Curriculum

(see Figure 1)

Basic scientific skills:

Questioning

- Children need practice in asking questions about the world around them. Every science lesson should begin with a question that needs to be answered at the end of the lesson through active exploration and carrying out investigations. Teacher questioning is very important in the teaching of science, however encouraging children to raise questions is also very important in primary science.

For example:

What would you like to know about the seeds?

What would you like to find out about these rocks?

Write down a list of things you would like to know about mini beasts?

Looking at the materials you have in front of you, lets come up with a question to be investigated in today's Science lesson?

Observing

- Careful and precise examination using as many of the five senses as possible.

	Working Scientifically	Designing & Making
Junior & Senior Infants	• Questioning • Observing • Predicting • Investigating and experimenting • Analysing ○ Sorting & Classifying • Recording and communicating	• Exploring • Planning • Making • Evaluating

1st & 2nd Classes	• Questioning
	• Observing
	• Predicting
	• Investigating and experimenting
	• Estimating and measuring
	• Analysing
	  ○ Sorting & classifying
	  ○ Recognising patterns
	  ○ Interpreting
	• Recording and communicating
		• Exploring
		• Planning
		• Making
		• Evaluating

3rd & 4th Classes	• Questioning
	• Observing
	• Predicting
	• Investigating and experimenting
	• Estimating and measuring
	• Analysing
	  ○ Sorting & classifying
	  ○ Recognising patterns
	  ○ Interpreting
	• Recording and communicating
		• Exploring
		• Planning
		• Making
		• Evaluating

5th & 6th Classes	• Questioning
	• Observing
	• Predicting
	• Investigating and experimenting
	• Estimating and measuring
	• Analysing
	  ○ Sorting & classifying
	  ○ Recognising patterns
	  ○ Interpreting
	• Recording and communicating
		• Exploring
		• Planning
		• Making
		• Evaluating

Table 1: Summary of working scientifically and designing and making skills in the Irish Primary Science Curriculum (DES, 1999)

- Use of simple instruments to extend the senses.
- Selection of observations which are relevant to the current investigation.
- Recording the observations as written descriptions, tables of measurements, graphs or drawings.

For example:

Get pupils to use all their senses to describe the colour, shape, smell and texture of different types of fruit e.g. grapes peeled and

un-peeled, a whole banana and a mashed banana, peanuts, a peeled and unpeeled orange etc.
Heat the fruit and vegetables to see how they change as they cook (colour, texture and smell).
Freeze raw and cooked fruit and vegetables to explore how their textures change as they freeze and melt.
Make a fruit salad. Ask the pupils to taste each item as it is added. Make a chart with descriptive words (bitter, sweet, sour etc.)
Explore if there any change to the taste of different fruits when a spoon of sugar is added.
Observe dry seeds, then soak overnight and observe the changes in their colour, texture and size.
Observing the effect forces can have on fruit and vegetables (pushes and pulls).

Classifying

- Recognising characteristics, similarities and differences.
- Sorting objects according to given properties.
- Explaining clearly the classification system used and why it was chosen.
- Finding the most convenient way of classifying material to achieve a particular purpose.
- Seeing the value of classifications in everyday life e.g. in dictionaries, in libraries.
- Using established ways of classifying for identification purposes e.g. sorting and identifying leaves, insects, birds, rocks etc.

For example:
Sort and group fruit and plants according to similarities and differences between for example stems, leaves, flowers, fruit, nuts etc.
Using a collection of plant and plant parts, tell the children to put all of the items that are alike into a pile. Then have them sort the remaining items. Allow the children to decide for themselves how they sort the remaining items. Ask them why they have sorted them in that way. At first they will choose obvious reasons such as colour and size. But later they will make more obvious sophisticated distinctions.
Pre-sort items into three groups using an easily perceived property, such as small, medium and large. See if the children can work out the criteria for sorting.
Play a sorting game. Have a child begin to sort a collection of objects. After he or she is half way through, ask another child to complete the sorting by identifying the properties the first child used and continuing the system.

Predicting, Followed by Investigating and Experimenting

- Pupils should always predict what they think will happen during an exploration and investigation at the beginning, during the exploratory phase of a lesson. They can then plan and design an investigation to test their prediction. At the end of the investigation refer them back to their investigation to see if their ideas have stayed the same, changed or have been slightly altered by their findings. This is the 'Eureka' moment where the child makes sense of what is being learned.

For example:
Will a large orange and a small orange have the same mass?
Will they both drop to the ground at the same time or will the heavier fruit or vegetable hit the ground first?
What will happen if we do not water the seeds we have planted?
Predict can we ever change the effects of heat on a fruit of vegetable?
Which type of paper will be most absorbent?

Figure 2: Children testing their predictions

Investigating and Experimenting

- Measurements always involve comparisons and are never exact. They are dependent on the accuracy of the instruments used and on the skill of the user. Pupils should have a good deal of practice in the use of measuring instruments, for example, rulers, balances and thermometers. They should develop an increasing awareness of the level of accuracy involved.

For example:

Predicting and comparing the mass of two different vegetable using their hands.

Predicting and comparing the mass of two different vegetable using a weighing scales.

Use a variety of different instruments to measure the diameter and length of fruit and vegetables (using string, cubes, ruler, measuring tape).

Predict and measure which cucumber is the longest (include a straight and more curved cucumber etc.)

Predict and measure which water melon is the 'fattest'.

Measure at what temperature a strawberry loses its shape.

Looking for Patterns

- This involves ordering observations and recognising patterns of shape, structure, growth and change, collecting data purposefully and organising and presenting it systematically to reveal more precise patterns.

For example:

Plant seeds and investigate do all their shoots grow upwards and roots grow downwards?

Do all plants grow towards the light?

Attempting to Explain

Asking questions and suggesting explanations are essential features of science, because science is an attempt to provide rational explanations of events and phenomena. Children naturally want to explain their observations. Two types of explanations are commonly used in science:

- Making inferences;
- Formulating hypotheses.

Making inferences: collecting clues from a situation, and then deducing a conclusion from those clues.

Formulating hypotheses: a speculative explanation or suggestion based on experience and knowledge, or inspired by imagination. When a teacher poses a question about a problem, he/she is asking for a hypothesis to be formulated.

Communication

Science provides good opportunities for the development of communication skills:

- Discussing ideas
- Formulating questions
- Planning experiments
- Descriptive writing
- Tabulation of measurements
- Drawings
- Making models
- Preparing reports/diagrams/maps.
- Drama

For example:

Drawing flow charts showing changes in plants.

Sorting cards and cartoon sequence strips.

Write a post card using descriptions of fruit, vegetables and plants.

Writing a diary of a gardener or fruit shop owner.

Writing a sales pitch for a particular fruit or vegetable.

Creative writing (song or poem about the pupil's favourite fruit etc.)

References

Bruner, J (1960) *The Process of Education*, Cambridge, Mass.: Harvard University Press.

DES (1999). *Primary school curriculum: Science*. Social, Environmental and Scientific Education. Teacher Guidelines. Dublin: The Stationery Office.

O' Doherty, C. (1994). *Primary Science Starts Here*. Limerick, Primary School Science Project.

NCC (National Curriculum Council) (1989). *Science. Non-statutory Guidance*. York:NCC.

Sherrington, R. (1998). *ASE Guide to Primary Science Education*. Stanley Thornes (Publishers) Ltd.

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