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INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Zvyšování kvality vzdělávání učitelů přírodovědných předmětů

The Nature of Science

Niel Hutton

Some thoughts about its place in the English school science curriculum, and the implications for teacher training.

Tento projekt je spolufinancován Evropským sociálním fondem a státním rozpočtem České republiky.

National Curriculum 1989

Implications for science teaching:

- science for all 5-16
- science teaching is:
  - scientific enquiry
  - life processes and living things
  - materials and their properties
  - physical processes
- GCSE Double Award endpoint for 85%

Issues and challenges

- science for all led to one-size fits all
- curriculum (PoS 2006) needs more diversity
  * the core based on scientific literacy and how science works
  * additional including academic, vocational
- core curriculum leads to single GCSE

Core Curriculum

Scientific Literacy enabling a person to:

- appreciate and understand the impact of science and technology on everyday life
- take informed personal decisions about things that involve science, such as health, diet, use of energy resources
- read and understand the essential points of media reports about matters that involve science
- reflect critically on the information included in, and (often more important) omitted from, such reports; and
- take part confidently in discussions with others about issues involving science

  (www.21stcenturyscience.org)

Core curriculum

How Science Works:

- the scientific method
- scientific issues and controversies

PoS 2006 - Ideas and evidence in science

- how scientific ideas are presented, evaluated and disseminated (for example, by publication, review by other scientists)

- how scientific controversies can arise from different ways of interpreting empirical evidence (for example, Darwin's theory of evolution)

PoS 2006 - Ideas and evidence in science

- ways in which scientific work may be affected by the contexts in which it takes place (for example, social,historical, moral and spiritual), and how these contexts may affect whether or not ideas are accepted

- to consider the power and limitations of science in addressing industrial, social, and environmental questions, including the kinds of questions science can and cannot answer, uncertainties in scientific knowledge, and the ethical issues involved.

How Science Works

What is disturbing is that, although the emphasis for teaching science is on ‘How Science Works’, none of the specifications sets out what they mean by that. I would have expected the specification or at least the supporting materials to set out from the start what is meant by ‘How Science Works’. In the history and philosophy of science, there are many works that refer to ‘the scientific method’, but what is this method and does it really exist?

Williams,J (2006), *Education in Science,* ASE

How Science Works

Indeed, Wivagg and Allchin are of the opinion that there is no ‘scientific method’, that it is only applied retrospectively to what scientists ‘do’ in order to conform to the conventions of publication of the results of scientific research.

Williams,J (2006), *Education in Science*, ASE

The Nature of Science

this module seeks to enable students to address such questions as:

- Why learn science?
- What distinguishes science from other forms of learning?
- What constitutes scientific ideas and methods?
- How do schoolchildren progress their scientific knowledge?

The Nature of Science: Learning Outcomes

- describe in general terms the methods of scientific enquiry
- critically analyse the development of scientific ideas
- evaluate how science curricula in schools seek to progress children's knowledge and understanding of key scientific ideas

The Nature of Science: Content Synopsis

- how science contributes to the state of individuals and societies
- the methods of science, eg descriptive science, modelling, theories
- uncertainties and misconceptions in science
- scientific communication
- experiences which develop school children's knowledge and understanding of science
- the treatment of controversies in school science

The Scientific Method

- there are a range and variety of methods of doing science, ie there is no single method
- in simple terms, scientists collect evidence from observations that lead to conjecture about the real world and its nature
- such conjectures - the ideas and theories of scientists - are subject to to experimental test and survive or fall
- initial ideas are always tentative - as they survive experimental interrogation, the model becomes more generally accepted
- it is these processes - the commitment to evidence, the testing of models and theories, and the significance of refutation that is the principle of the scientific method

The Scientific Method

- postulates a model based on existing experimental observations and measurements
- checks the predictions of this model against further observations or measurements
- adjusts or replaces the model as required by the new observations or measurements

Walker, M (1963) *The Nature of Scientific Thought.* Prentice-Hall

or as Sydney Brenner said

‘For 20 years I shared an office with Francis Crick and we had a rule that you could say anything that came into your head. Every now and then a half-formed idea could be taken up by the other one and really refined. I think a lot of the good things we produced came from these completely mad sessions. But at one stage or another we have convinced each other of theories which have never seen the light of day - I mean completely crazy things’

or as Richard Feynman said

‘In general we look for a new law by the following process. First we guess it. Then we compute the consequences of the guess to see what would be implied if this law that we guessed is right….If it disagrees with experiment it is wrong. In that simple statement is the key to science…..It is true that one has to check a little to make sure that it is wrong!’

Learning through scientist's lives

- scientists working in different fields of science adapt the general principle of the scientific method to suit the circumstances
- social, political, military and other non-scientific features may influence the method utilised
- the personal and emotional state of the scientist may influence this too

Galileo and the telescope

Galileo comments, ‘we are certain the first inventor of the telescope was a simple spectacle maker who, handling by chance different forms of glasses, looked, also by chance through two of them, one convex, one concave, held at different distances from the eye; saw and noted the unexpected result; and thus found the instrument.’

Meitner and fission

- Lise Meitner (1878-1968)
- born in Vienna, third of eight children of Jewish family
- first woman to obtain PhD in physics from Vienna University
- studied with Boltzmann, Planck and Hahn
- first woman to achieve rank of professor in Germany
- fled Nazi Germany in 1938
- first person to realise process of nuclear fission
- refused to work on Alamo project, *'I will have nothing to do with a bomb!'*
- Hahn alone receives Nobel prize for discovery of fission

Einstein and thinking

‘The normal adult never bothers his head about space-time problems. Everything there is to be thought about it…has already been done in early childhood. I, on the contrary, developed so slowly that I only began to wonder about space and time when I was already grown up’

Development of a scientific idea poster assessment

- ideas such as theory of evolution, periodic table of elements, plate tectonics, the Big Bang
- describe in general terms the methods of scientific enquiry involved in the development
- critically analyse the development of the scientific idea including historical development, contributing scientists, outcomes and considering ordered development, chance discoveries and fruitless lines of enquiry

Controversial Science: Examples

- alternative medicine - homeopathy
- religious beliefs - evolution vs creationism
- use of pesticides in agriculture
- fuels and the global environment
- current ideas about the birth and evolution of the Universe

Controversial Science: Resources

- SATIS - science and technology in society (readings, activities, debates, role-plays, data-analyses on a variety of scientific topics for ages 8-19) - www.ase.org.uk
- DEMOCS - free, downloadable card game dealing with controversial scientific issues - www.neweconomics.org/gen/democsdownload.aspx
- Science Upd8 - topical science from the media including prepared lessons - www.upd8.org.uk

A New Type of Science

- schoolchildren like to learn this way
- schoolteachers are unprepared
- trainee teachers have to be prepared

The last word (Einstein again!)

I. R-S. - Eddington's measures have confirmed the theory Herr Einstein.

E. - But I knew that the theory is correct

I. R-S. - What if the prediction had not been confirmed?

E. - Then I would have been sorry for the dear Lord - the theory IS correct.