‘Now this is what *should* have happened…’: a clash of classroom epistemologies?

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What is ‘real’ contemporary science?

- Different methods of science
- The pursuit of provisional theories
- Fundamental physics theory
- Typical public view of science as positivist
- We want pupils to be constructivist

Why do practical work?

In order to provide enhanced experiences for pupils in two general areas:

1. Providing for encounters with scientific methods
2. Assisting the learning of science concepts

If I hear, I forget; if I look, I understand; if I do, I remember.

(Millar, 1991).

The benefits of encouraging students to behave as scientists include:

- Familiarity of 'good practice' in science - what are acceptable conventions for experimentation (i.e. process concepts) (Millar, 1989)
- More control of their experimenting, so imparting a sense of ownership, and promoting motivation (Atkinson, 1990)
- Transfer of process skills to other areas of the school curriculum, as well as to everyday problems (Millar, 1989)
- An acceleration of general cognitive development (Shayer, 1999)

Supporting substantive theory

- As well as introducing pupils to the acceptable conventions of experimentation school science also aims to deliver a body of irrefutable ‘right answers’ (e.g. steel is better conductor of heat than wood)
- Assumes a naïve-realist epistemological stance
- Needed to avoid solipsism
- This is in opposition to how real science works

Right answer chasing

If practical lessons fail to confirm theory, which may happen due to inadequate apparatus or technique, teachers often conclude by stating,

'This is what ought to have happened…'

(Simon & Jones, 1992, p3).

Right answer chasing

The routine churning out of a known answer (cookbook practicals):

- Dull
- Tedious
- Lack of intellectual challenge

Clash of epistemologies

- Do we want pupils to be positivists or constructivists?
- Within school science the parallel encouragement of positivist and constructivist attitudes means that two conflicting epistemologies coexist in a state of uneasy peace
- Flip-flopping
- Right answer chasing drives fraudulent practice

Clash of epistemologies

- The presentation of science as a blend of two disparate epistemological positions does not help pupils to see the subject as a holistic entity
- This can be confusing for pupils, particularly the less able
- E.g. rates of chemical reaction
- Requires pupils to make a significant Gestalt shift

Cognitive implications of delivering a positivistic curriculum

- Failure to bracket expectations
- Experimenter-expectancy effect (e.g. cold fusion)
- Revert to scientifically inappropriate behaviour in order to generate a positivistic right answer
  - Fabrication of data
  - Ignoring anomalies
  - Rigging apparatus

Cognitive implications of delivering a positivistic curriculum

- 1. Rejection of the scientific conception due to holding a misconception theory
- 2 Promoting a lack of differentiation between theory and evidence
- 3 Causing a shift towards preferring theory over evidence
- 4 The creation of serial-fudgers
- 5 The continuation of positivist-related epistemological belief into tertiary education

To sum…

Promoting the positivistic chasing of a right answer has unwelcome ramifications:

- Encouraging positivist attitudes during school science practical work
- Philosophical inconsistency creating epistemological confusion with a tendency towards positivism that continues into higher education, and perhaps beyond

Improving the situation

- Content-driven curricula promotes the continued existence of naïve and debunked positivistic approaches to science (particularly inductivism) that reflect realist epistemology (Hipkins & Barker, 2005)
- Make do, but limit damage

Improving the situation

Discouraging the careless disposal of anomalous data

- Reasoned justification of rejections, for instance on grounds of truly invalid method
- Forget if data have delivered *the* right/wrong answer, but see if they have given *an* answer that can be defended (Fairbrother & Hackling, 1997)
- Gunstone (1991) recommends an increased awareness of the biasing effects of preconceptions
- Support contradictory theories (Millar, 1989)

Improving the situation

Rediscovering discovery

- We cannot wholly reject confirmatory practical work
- Open ended investigations can reduce confirmation bias (Rigano & Richie, 1995)
- Pseudo-discovery

Pseudo-discovery

- Empirically test a series of given hypotheses
- Little known right answer (teacher knows the answer, pupils do not)
- Avoids churning out textbook answer
- No potential loss of academic status encourages pluralism in the classroom, representing a retreat from naïve-realist absolutist views of theory
- A return towards a genuine spirit of enquiry for pupils

Improving the situation

Overt encouragement of an authentic view of the nature of science

- *How Science Works* strand emphasises NOS
- HSW confers aspects of contemporary constructivist scientific methods (pluralism, uncertainty, the statistical variability of data and the refutation of pure, unbiased, inductive observation)

How Science Works

"We are still finding out about things and developing our scientific knowledge. There are some questions that we cannot answer, maybe because we do not have enough reliable and valid evidence. For example, it is generally accepted that the extra carbon dioxide in the air (from burning fossil fuels) is linked to global warming, but some scientists think there is not sufficient evidence and that there are other factors involved" (QCA, 2006, p31).

How Science Works

"A body of content has been identified which underpins the knowledge and understanding of *How Science Works* at all levels" (ibid., p12)…[An aim of the course is for pupils to] acquire and apply skills, knowledge and understanding…" (p16).

Improving the situation

- External cultural factors are likely to play a significant role, as a predominant naïve-realist epistemology is reflected in the common media presentation of a positivistic interplay between scientific theory and evidence

Why not simply teach pluralism overtly?

- Pupils may need specialist scientific knowledge to fully appreciate pluralism, and avoid solipsism (good reasoning facilities required) (e.g. Osborne, Ratcliffe, Collins, Millar & Duschl, 2001)
- ‘Science is too difficult’
- Historical illustrations of interplay between theory and evidence may help

Summary

- Current curricula may present a confused view of the nature of science to pupils.
- Theories are viewed as absolute truths to be learned as an examinable canon of facts
- Practical activities may be carried out in a spirit of genuine enquiry, where pupils collect data and judge hypotheses pluralistically towards an unknown end point

Summary

- Pupils adopt a positivist epistemological position when conducting many science practical activities, chasing an irrefutable right answer
- Pupil knowledge of a right answer leads to confirmation-bias related behaviours in order to produce that answer, and may have further, cognitive repercussions

Summary

There are some ways in which to limit the problems relating to epistemological clash and positivistic experimenting.

- Discouragement of a neglectful rejection of anomalous data
- Presenting practical work as a pseudo-discovery task
- Pupil assimilation of a fully integrated, authentic post-positivist view of the nature of science

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Thank you.

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