Driver

p109; 'cause & effect' idea in physical systems

Psillos, 1988

- difficulty w/ idea that const $\mathcal{E}$ voltage needed
- idea that p.d. across load may differ as $\mathcal{E}$ = const
- volt appears to be something relating to 'capacity' w/in batteries
- coulomb very unfamiliar (p31 in pdf; table 1a)
- secondary elec. teaching brings w/in it several variables
  - eg brightness of bulb, size of battery, etc

- idea of p.d. / emf voltage
- idea that voltage is always relative; $V_{AB} = V_A - V_B$
  - p37, idea of potentials as difficult

- voltage-charge model was highlighted to discuss

(conclusions)

- might be worth introducing voltage as a primary feature

Shipstone – children

- uncertainties identified:
  - observations sans models
  - vagueness about terminology
    - ⇒ what is 'power'
  - location of resistance (pre- or post- lamp) & the effects (or lack thereof) of changing R values

- prevalence of 'the sequence model'
  = 'time-dependant model of current flow' - Riley, Bee, Mokwa, 1981
  ↳ idea that changes are carried forward w/ flow of current
  ↳ 'localised' reasoning wrt. changes in circuit

Consider parallel circuits:
- very problematic, 'sequence model' prevalent
- voltage seen as a consequence of current
↳ need to challenge model, perhaps experimentally

Shipstone - Europe
- Batteries seen as source of current - p 307
  ↳ 'local' reasoning as before

Harlen
- discussion re current, voltage, resistance
- usually order of teaching:
  - circuit blocks
  - current flow (w/ charge)
  - effects of current
  - voltage (this in re: previous work)
  - resistance
  - Kirchoff's

. structure seems to be:

$I \rightarrow Q \rightarrow V \rightarrow R$

. issues arise:
↳ often interdependant relationships, as eg voltmeters depend on large R

. p49, issues w/ colloquial usage of electrical concepts eg 'consumption of electricity'

. useful to discuss concepts all @ once

. idea of 'driver' & 'hinderer' to the circuit model,
↳ batteries etc ↳ resistors

. need to consider models in which energy is conserved vs models in which it isn't

. avoid discussion re: flow of electrons, refer instead to total 'charge'

introducing the term 'voltage'

. idea of field is complex, so not discussed in much detail.

Chalmers

. E&M relates to quantities which are 'invisible'

. onslaught of ideas may contribute to confusion

. idea of field should be more central, best recognised to be v. abstract

. treating fields & forces separately 'hides' the link between them

. circuits often treated as completely distinct from E&M
↳ current & {charge, fields} not linked

. Gauss' law introduced too early - students have no link between charge & field

. worth delaying bits of E&M which relate to magnetism (eg Faraday's law) until later in course

Ates 2005

common mental models:
→ see before

. students appear to use diff. models for diff. tasks

3 types of reasoning:

- sequential
- local
- superposition

. misconceptions perhaps due to
  i) current vs energy
  ii) lack of microscopic models to explain macroscopic phenom

. study showed learning cycles can have the outcomes
↳ Lawson, 2001

↳ hands on activities

So, 2003

↳ UK idea is that learning & doing science proceed the same way

→ science is methodological

The process of science:

→ 'investigations' should aim to apply concepts + practical skills

goldsworthy & wood-robinson, 1998 argued investigation is most difficult part of science, as it requires synthesis of concepts, application of evidence & application of various skills

To implement inquiry, teachers must:

- understand the nature of sci. inquiry
- understand the structure of their field
- become skilled in teaching inquiry

↳ need to look @ how curriculum can expand on children's sci. investigation

Gotwill, 99

↳ about links between different models (eg Δv caused by: $\begin{cases} \Delta E \\ \text{acceleration} \end{cases}$)

↳ links mechanisms & representations

Lakoff, 1987 → links through models are created via these transformations & representations

hypothesis: co-ordinated models (ie those with links between mechanisms & reps) are better → False?

Eylon & Glaniel → difficult for students to link electro $\begin{cases} \text{statics} \\ \text{dynamics} \end{cases}$

↳ link between micro/macro is difficult

- students seem to have 3 diff. perspectives:
  - micro (electrons et al)
  - aggregate (current, voltage etc)
  - topological (open, series etc)

↳ hard to interlink

↳ difficulty seems to arise from voltage, Eylon & Gilead, 1980

↳ other models may be eg choosing the best representations

usage of 'p-prim's as an idea

↳ already known, 'universal' concepts

eg 'force moves things'

Fizd & Johnson, 1986 → micro → macro provides better understanding

→ forcing students to form link between models seems to work better

↳ models should force students to form own links, but still provide support

Afra 2009)

students adapt model which doesn't conserve current

→ resistance seen as consequential or theoretical due to V=IR

focus on # of things, not their configurations

- 3 phases, qualitative, semi-quant, quant

↳ asked about idea, confronted, reasked

↳ battery seen as a source of current

voltages seen as a flow (what about p.d.)

- Failed to identify that resistance is a property of materials, eg no current → still has resistance

→ local reasoning prevalent

- sharing current quite difficult to move past

local reasoning stronger than sequential

→ overgeneralisation of Kirchoff's 2nd law w/ resistance also an issue

'elicit - confront - resolve' model effective

Bagno 2000

→ want to reduce science to a small number of principles

- students can separate general concepts & examples

Concepts & examples:

↓ 'ideas' ↓ exclusive ideas

eg quadrangle vs square

→ use bottom-up-bottom approach: specific to intro, generalise, apply to specific

Sorgadi

misconceptions interfere w/ learning & construction of ideas

- certain misconceptions more prevalent @ older ages:
  - current attenuation
  - battery as source of current
- others decrease:
  - sink, shared current

- empirical rule model sees large decrease
- battery as source of current model sees increase

Mediating: Types of models

- Sink
- Clashing current
- weakening current - its used up by components as it flows
- shared current - same everywhere but @ ends of cell
- empirical rule - bulb/battery light is distance dep.

- misconception possibly caused by physical experience

Vosniadou

- analogies may help, but if already understood cause difficulties
- unshared attributes btween analog/target cause misconceptions

good analogies have some key ideas:

- discovery
- development
- evaluation
- exposition

} multiple models used, but those during discovery phase most important

- analogies models quite important - lead to better results
- need to match intuitive knowledge
- difficult to move past misconceptions entirely
  - ↳ analogies dont seem to help

Moodly

- Moodly, 2013: understanding misconceptions did not guarantee better teaching
- Tsaie et al, 2007: people avoid the concept of potential diff favour current

signif. teachers still unsure of origins of misconceptions

- many science teaches do not teach conceptually, instead formulaicly

Pedagogical content knowledge - Shulman, 1986

↳ ways of representing ideas

- misconceptions frequently unknown!
  ↳ particularly constant current source

- important to learn about misconceptions adequately in higher education to teach it well

Liegeois03

- everyday experience w/ voltage is uncommon
- hypothesized that R not considered, current & voltage almost equal
  ↳ valid assumptions
- position of ammeter more relevant @ older ages
  ↳ lessons did not help much
- extended learning course, where students i) made sense
  ii) told right answers

worked better

(SST method)

RVC u2007

- correct answer reg current
- everyday language attributes to misconceptions
- extent of misconception related to teacher's ideas

"closed switch = no flow" misconception in language

- p.d., current, energy seen as interchangeable

lee 2001

- preconceptions v. resistant to change
  - ↳ even when told otherwise, students don't learn

ontological = hierarchal representation of linked ideas

idea proposed that students empty 'matter' ont. process rather than 'reasoning'

↓

tests supported this

eg current leaves battery & is used up by bulbs

- highest achievers focused on voltage more
- lower scoring students reasoned component by component, not as the circuit as a whole
- self generated analogies all matter based

- voltage seen as a conceptual idea more than current
  - ↳ might this explain why it's difficult - 2dlq

. considering voltages leads to better conceptual understanding of circuits

. teachers need to be aware of preconceptions

→ 'global' effect should be emphasized

Gupta 2010

. old view re: ontological discussion: author sees students as not matter-based reasoning but instead traverse

. Chi introd concept of emergent & direct processes

↓

difficult to grasp eg diffusion

. difficulties when emergent processes formulated as direct

. separate ontological classes cannot be merged - Chi

↳ need some restructuring

. Gupta claims students should be taught in their own ways

. Lakoff & Johnson claim crossing ontological boundaries is essential for cognitive development

. Gupta: ontological choices dep. on context

eg if we think ontologies: blood flow & diffusion

. scientific reasoning is intuitively 'mechanical'

- novices slow to switch ontologies, eg w/ ice cream
- evidence s.b. some learners switch on the fly
- danger of forcing divorce of thinking: leads to disconnect of physics from reality

Sotta defense

- 'fluid' models pop up lots of places in physics learning
- people maintain ontological categorisations unless their categorisation is challenged