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How does learning emerge in science classrooms?

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UCL Website – Mark Hardman - publications

cogsci²

SMART Spaces

SMART Spaces is an EEF and Wellcome funded project that has shown good promise in improving revision for students. We are now moving to the next stage of the project and you have a chance to be part of a research project looking to improve attainment in Chemistry in AQA GCSE combined science.

Revision model

Be part of a RCT to determine the effect of SMART Spaces revision materials on attainment in the GCSEs in summer 2019

Teaching model

A smaller pilot looking at the benefits of SMART Spaces to affect teaching and learning. The intervention will be administered at intervals during the teaching and we will be investigating how teacher practice changes with any changes in student knowledge.

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for more details

Outline

a) The problem with ‘concepts’.
b) What do teachers do to support learning?
c) What do pupils learn from in classrooms?
d) Discussion

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The Problem of Concepts

Curricula specify the conceptual understanding that pupils must :

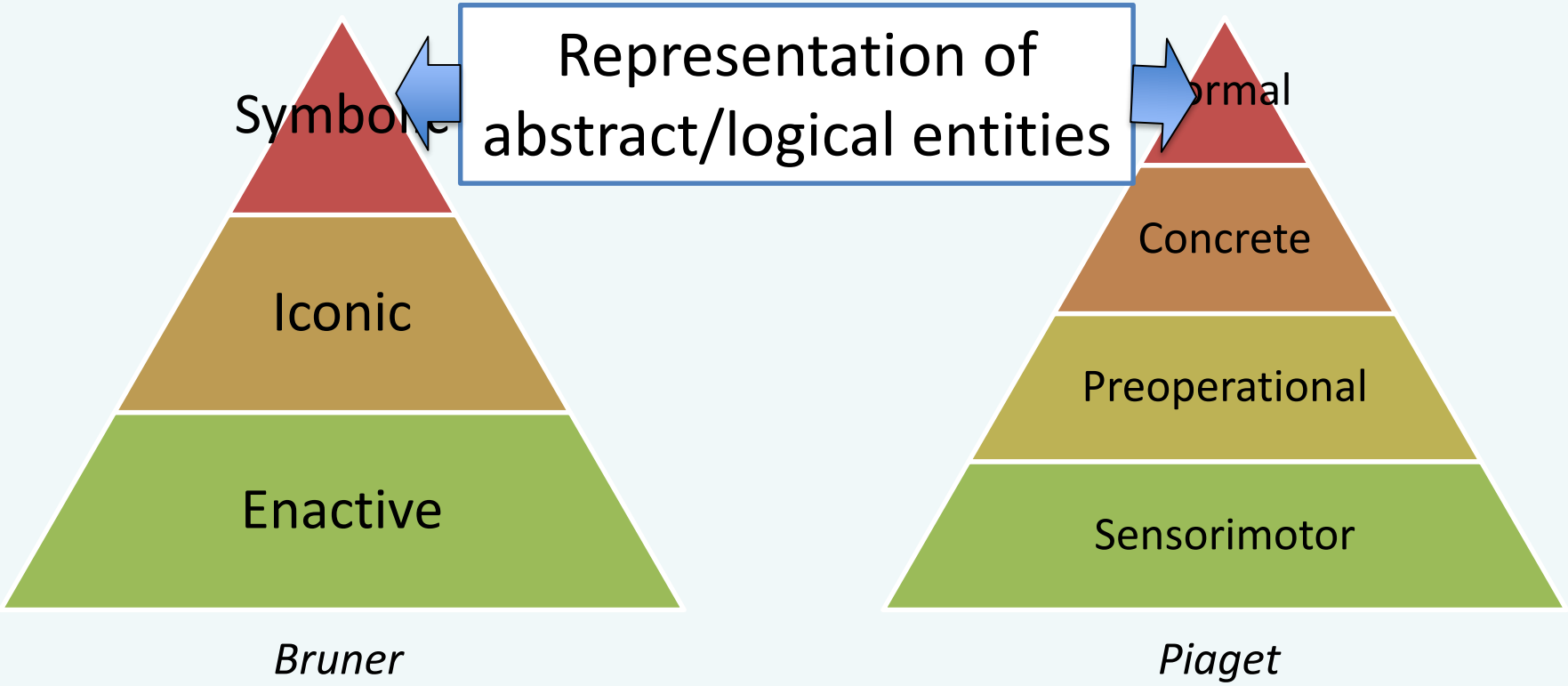
1. Defining concepts
2. Overcoming dualism
3. Guiding practice

Working out how concepts develop is really hard.

1. Defining concepts

The Classical View in Science Education → Constructivism

- Bruner, Goodnow & Austin (1956): learning of logically specified concepts
- Inhelder & Piaget (1964): growth of logic in child and how they were learned



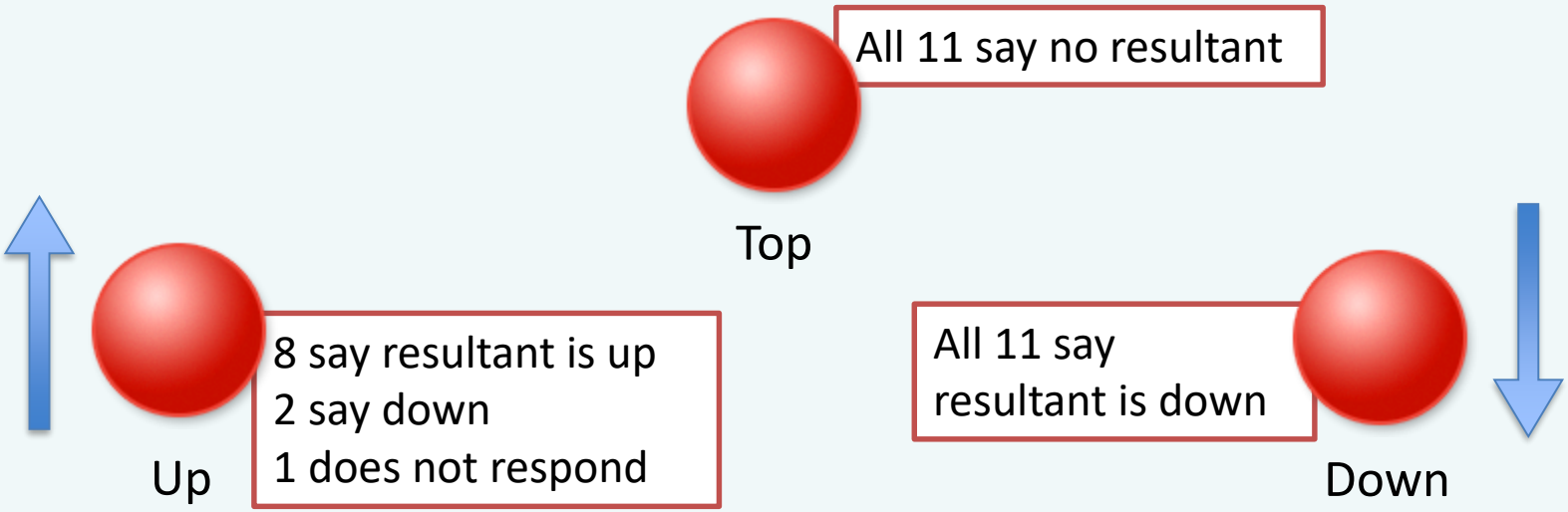
1. Defining concepts

Still no consensus around what concepts are. (Clement, 2008; Vosniadou, 2008)

An example (Graham et al., 2013)

n=11, 17 year-olds, advanced further mathematics

1. Small group discussion of what a force is → make poster
2. Discuss horizontal forces on aeroplane, what can forces do?
3. Take ideas around ball being tossed:



1. Defining concepts

The Classical View in Science Education → Conceptual Change

- Psychological literature focuses on categories; no real use in science education.
- So scientists draw on philosophy of science (DiSessa, 2006; Özdemir & Clark, 2007)

Concepts as Coherent
McCloskey (1983)

- Naïve theories e.g. impetus
- Change following conflict

Top

Concepts as fragmented
DiSessa (1983)

- Partial understandings e.g. balance
- Pieced together & revised

Sociocultural view
Graham et al. (2013), Mercer (2007)

- Pupils respond to social context
- Concepts are shared (to some extent)

2. Overcoming dualism

The issue with 'concepts'
(and how we already know this)

Concepts are ill-defined abstractions

- "The term concept is one that everybody uses and nobody explains – still less defines" (Toulmin, 1972, p.8)
- "The "conceptual" part of the conceptual change label must be treated less literally." (DiSessa, 2006, p.265)

Mental representations | P-prims | Theories | Beliefs

Mental models | Cognitive structure | Ontologies

- "numerous different representational structures, with different processes operating on them, can be formulated to explain any given research finding." (Kosslyn, 1978, p.219)

2. Overcoming dualism

The issue with 'concepts'

(and how we already know this)

Concepts vs thinking

- "a change in what a person is thinking (which is what a researcher can hope to directly infer by interpreting data elicited at any one time) from one time to another, may, or may not, reflect a substantive change in the **underlying cognitive structure** (which is only partially and less directly reflected in research data)." (Brock & Taber, 2016, p.5)

vs perception, maturation, sensorimotor operations

- "mental images have their own laws which are different both from the laws of perceptions and from those of operations." (Inhelder & Piaget, 1964, p.295)

Social or cognitive?

- "any new empirical evidence is unlikely to lead to a simple theoretical resolution in favor of an extreme situative or cognitive explanation of conceptual change." (Mercer, 2007, p.77)

3. Guiding practice

How should teachers promote conceptual change?

Concepts as Coherent e.g. McCloskey (1983)	Introduce counterevidence & present new theory
Concepts as fragmented e.g. DiSessa (1983)	Weave together fragments
Competing concepts view e.g. Potvin et al. (2015)	Instruction first
Sociocultural view e.g. Graham et al. (2013)	Discussion / group work

No consensus around practice

3. Guiding practice

Arguments against 'constructivist teaching'

Empirical Evidence

- "Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching" Kirschner, Sweller, Clark (2006)

  → Return to guided instruction and cognitive psychology research

'Pedagogic vagueness'

3 significant challenges:

Focusing on teaching ‘concepts’ is not helpful.

Outline

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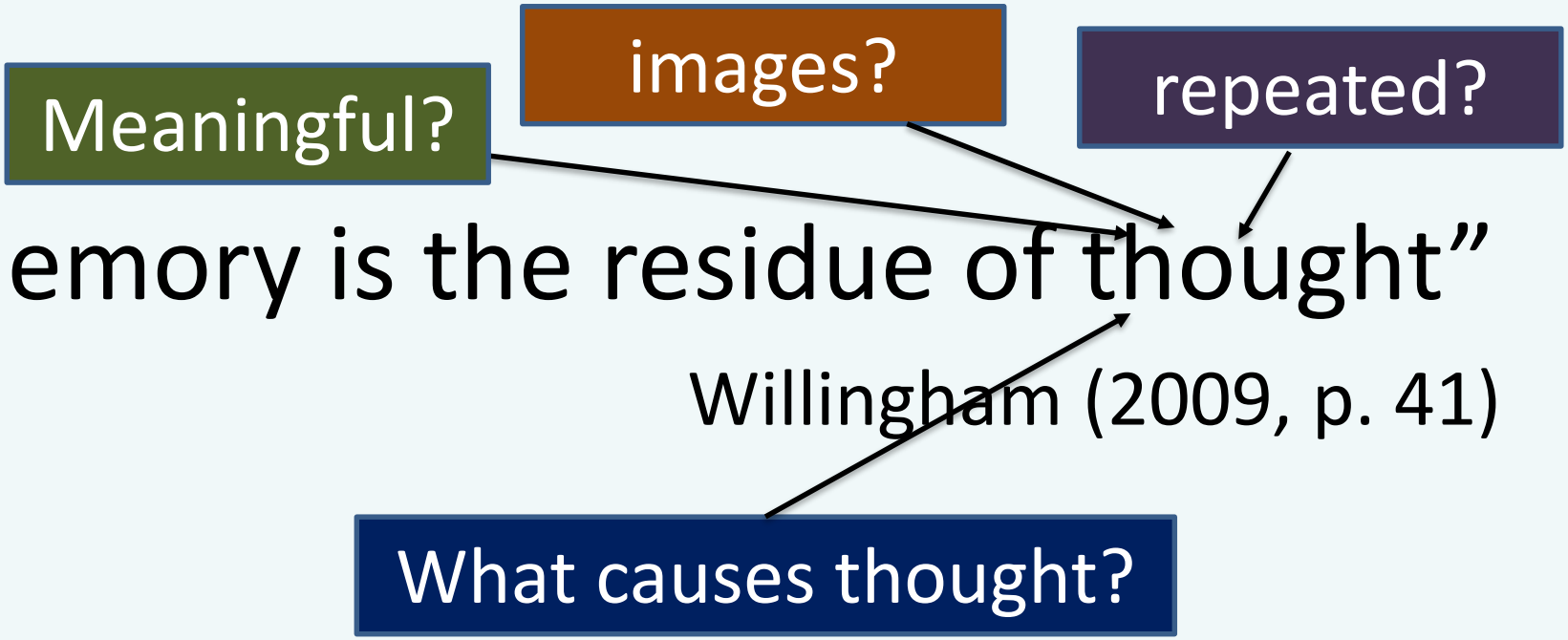
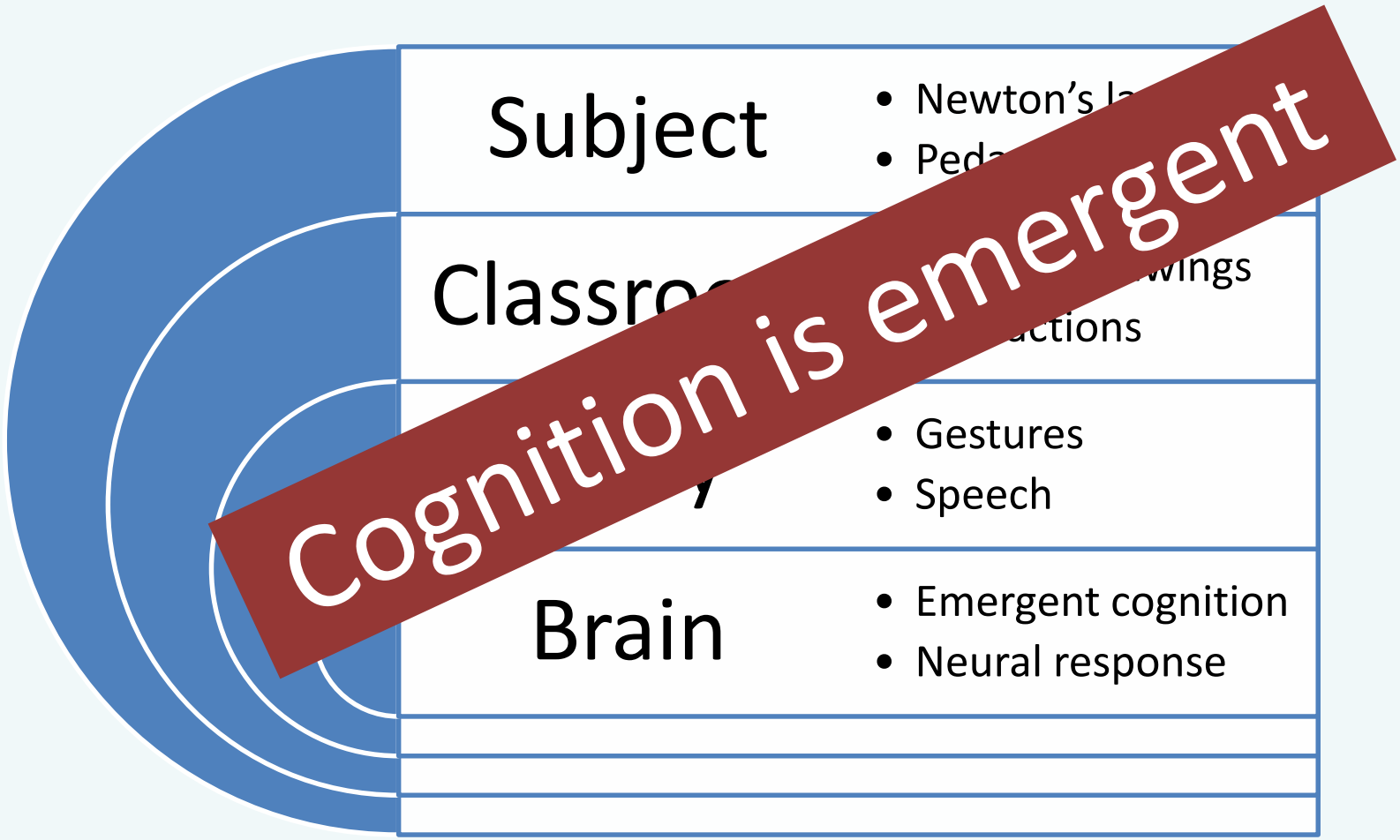
Does focus on ‘cognition’ help?

Learning is associated with memory →



Where is the cognition?

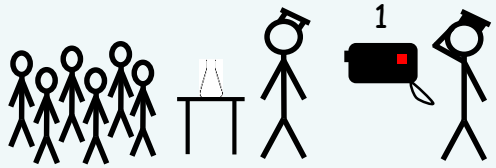
Learning as the adaptation of nested, complex systems:



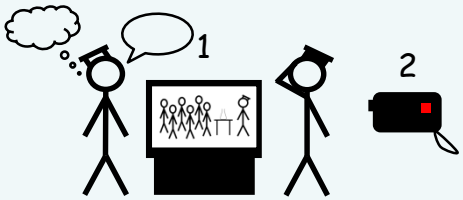
Video analysis – what do expert teachers do?

(Riordan, 2014)

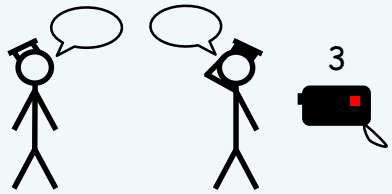
a) Expert microteaching (1 hour x 6)



b) Verbal protocols (30 min x 6)



c) Retrospective debriefing (30 min x 6)



Teachers are involved in the interpretation of their classroom practice

Important questions from the questioning route
(for the Expert Microteaching Interviews):

Please tell me what is happening to the hot tea and the cold ice cube in as much detail as you can.

Please sort these cards onto the spaces on the two mats quickly: one for living things and the other for non-living things.

Please imagine you walk into a completely dark room with that torch on and you see teddy. Please make a quick sketch showing the torch, teddy and your eye which explains how you can see the bear.

Living - please put the cards in the boxes


mushroom


dog


spider


tree


seed


person

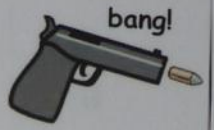

lion


plant


leaf


embryo

Non-Living - please put the cards in the boxes



gun firing

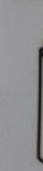

egg

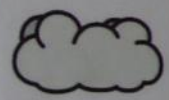

brick


gun silent


clock


bicycle


candle


cloud


milk


fire


soil


water


wind


car


bicycle


sun

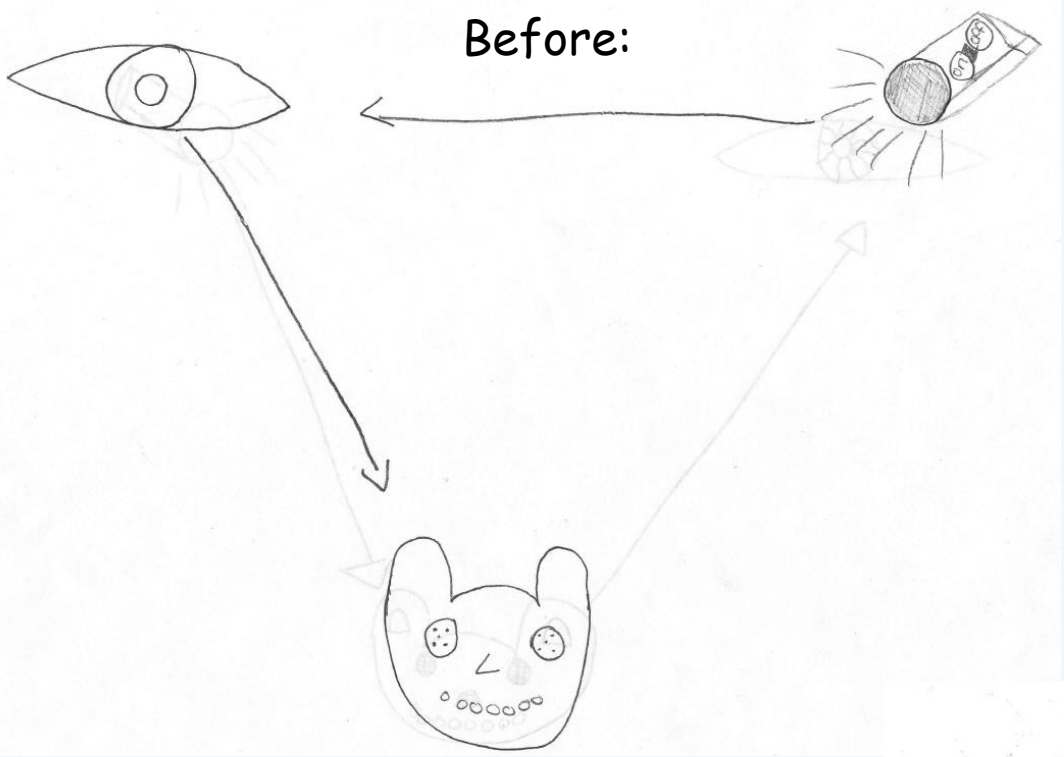

ball falling


ball on floor

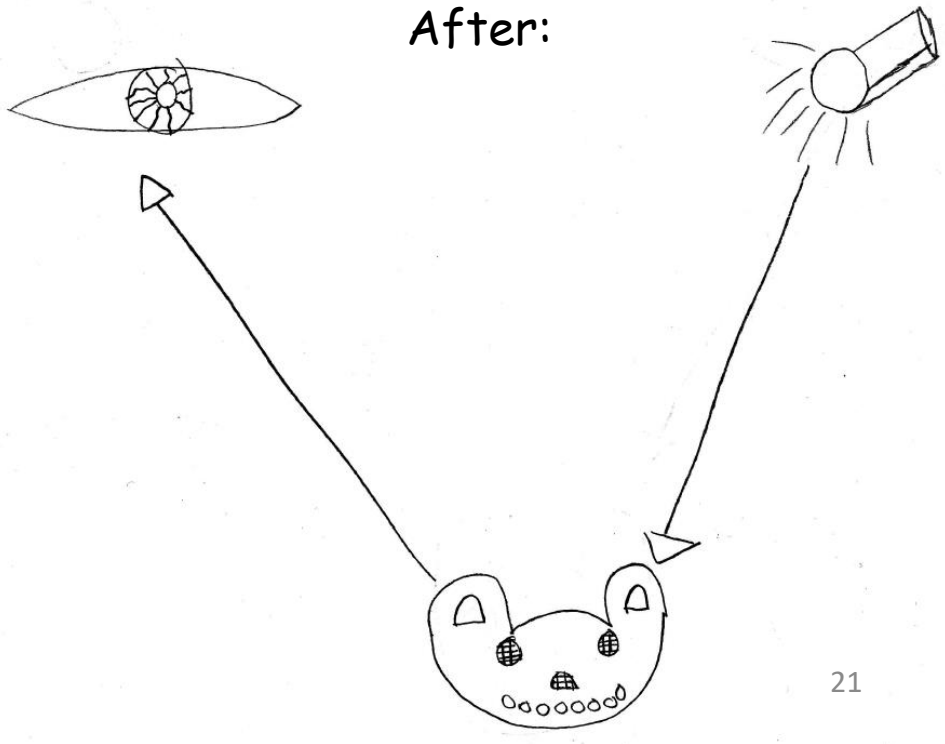

river


dead leaf

Before:

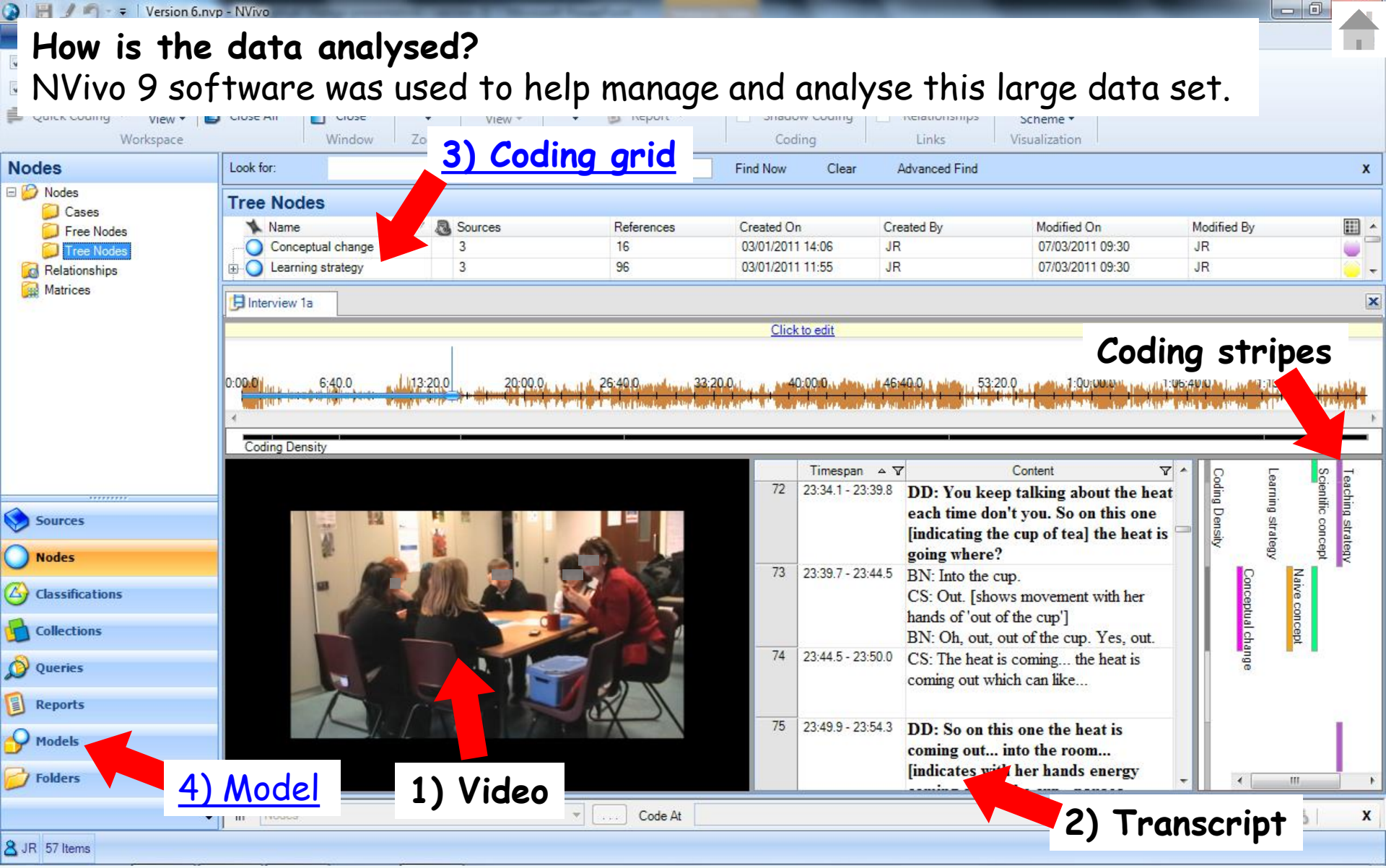


After:



How is the data analysed?

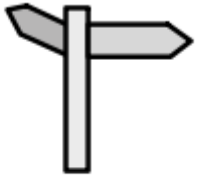
NVivo 9 software was used to help manage and analyse this large data set.



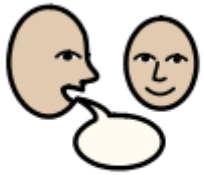
1) **Video** recorded from two different angles.
2) **Transcript** made from the videos.
3) **Coding grid** developed from the transcript.
4) Model developed using the transcript and coding grid.

~15 hours of video
18,737 references coded

What were the findings?


redirect


clarify


transfer


use a learning method

techniques


support


use a stratagem


use an activity


condition


tactics


persuade


group


use timing


strategy

What is the teacher doing?

- Supporting the development of cognition.
- Crafting that cognition: feedback, questions, actions/gesture etc.

Oh, I'm moving the torch as well.
1a:320-324

What is the teacher doing?

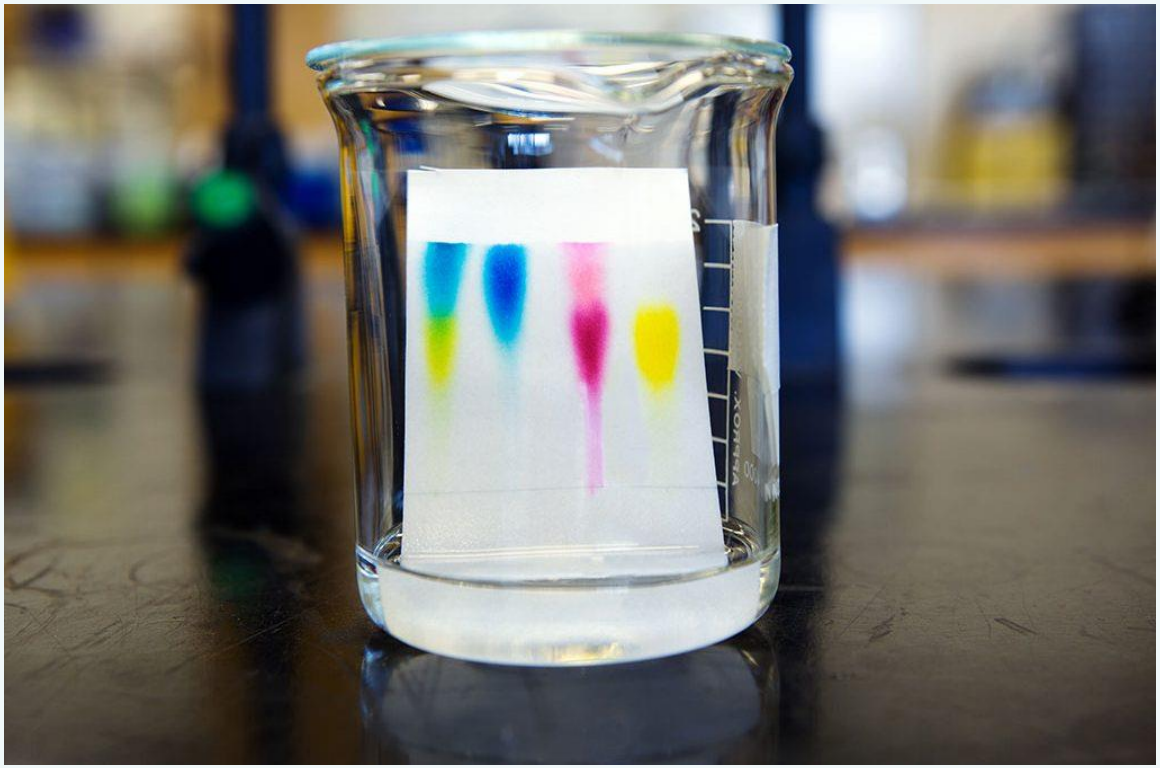
- Making some cognition ‘meaningful’.

Outline

a) The problem with ‘concepts’. ✅
b) What do teachers do to support learning? ✅
c) What do pupils learn from in classrooms?
d) Discussion

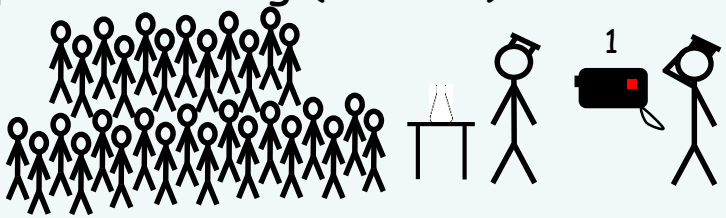
How do pupils learn chromatography?

- What activities, explanations, models etc do pupils learn from in your classroom?



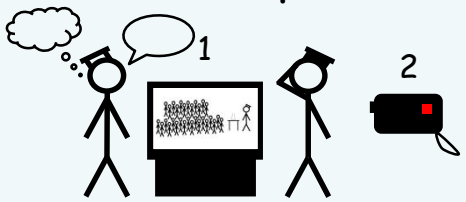
Current project (SES funded) research methods:

a) Expert teaching (1 hr x3)



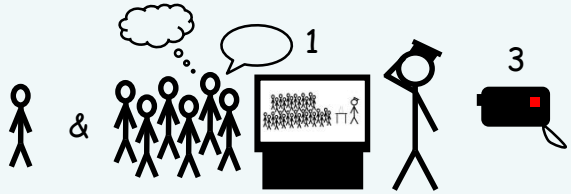
Naturalistic setting

b) Teacher verbal protocols (2 hrs x3)



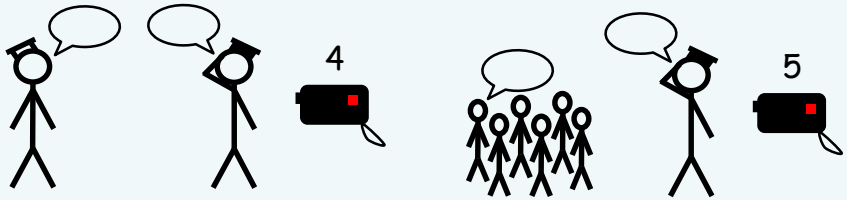
Teacher interpretation

c) Student verbal protocols (2 hrs x3)



Pupil interpretation

d) Retrospective debriefing (2 hrs x3)



Coding together

What is involved in learning science? Coding so far suggests…

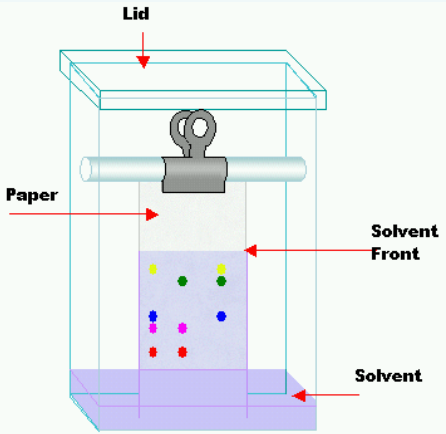
Materials & Models

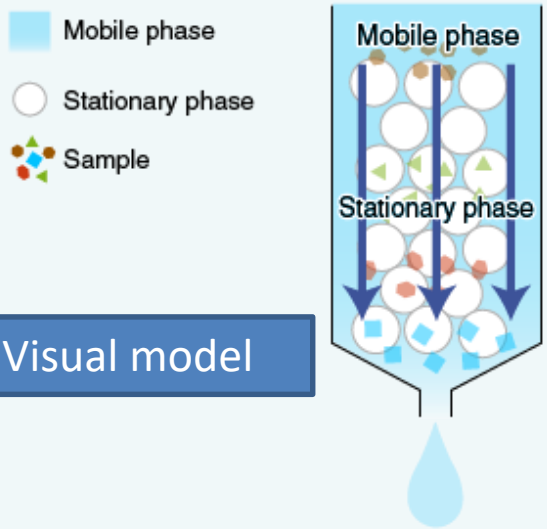
Physical model

Sr. No.	RT (min)	Peak Name	Area	Area %	Height	Height %
1	0.8	Peak 1	350	60.35	110	50.70
2	1.02	Peak 2	180	31.03	79	36.40
3	2.7	Peak 3	50	8.62	28	12.90

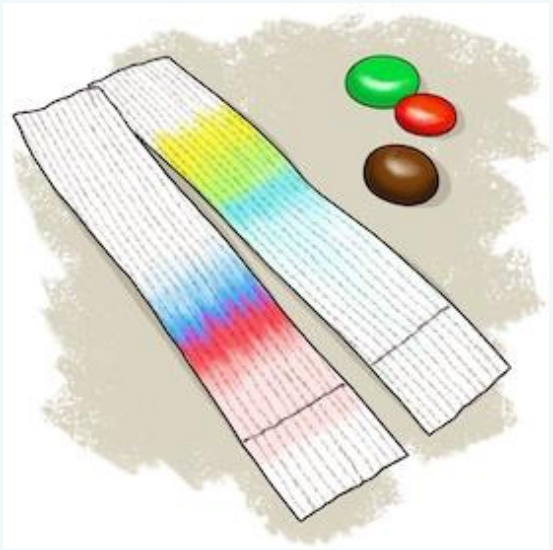
Mathematical model

Gesture





Visual model



The experiment - chromatographs

What is involved in learning science? Coding so far suggests…

Narrative & Meaning

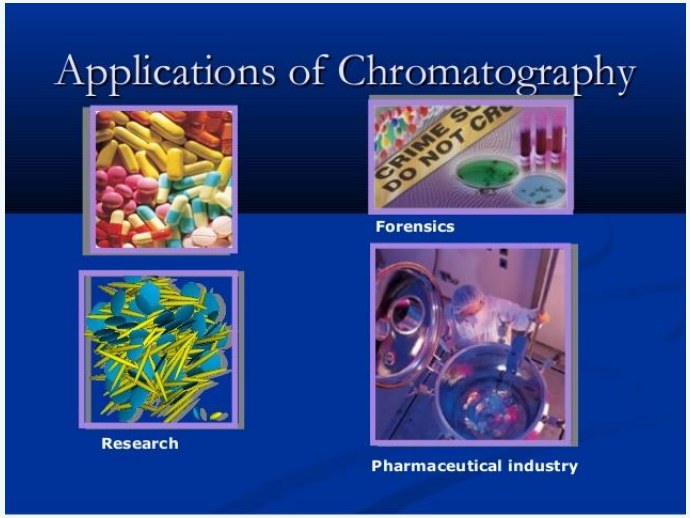
Written / verbal analogies

"the ink lets go."

Narrative: generating explanations / answering Qs

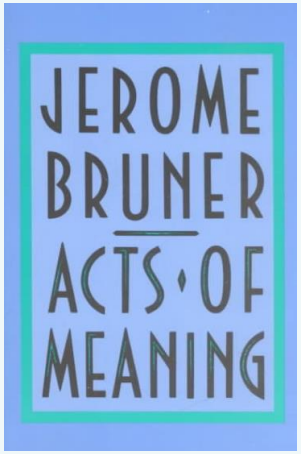
Jokes

Context - purpose



Feedback & correcting

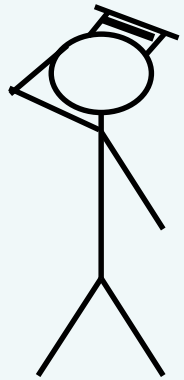
See also…



Some tentative ideas:

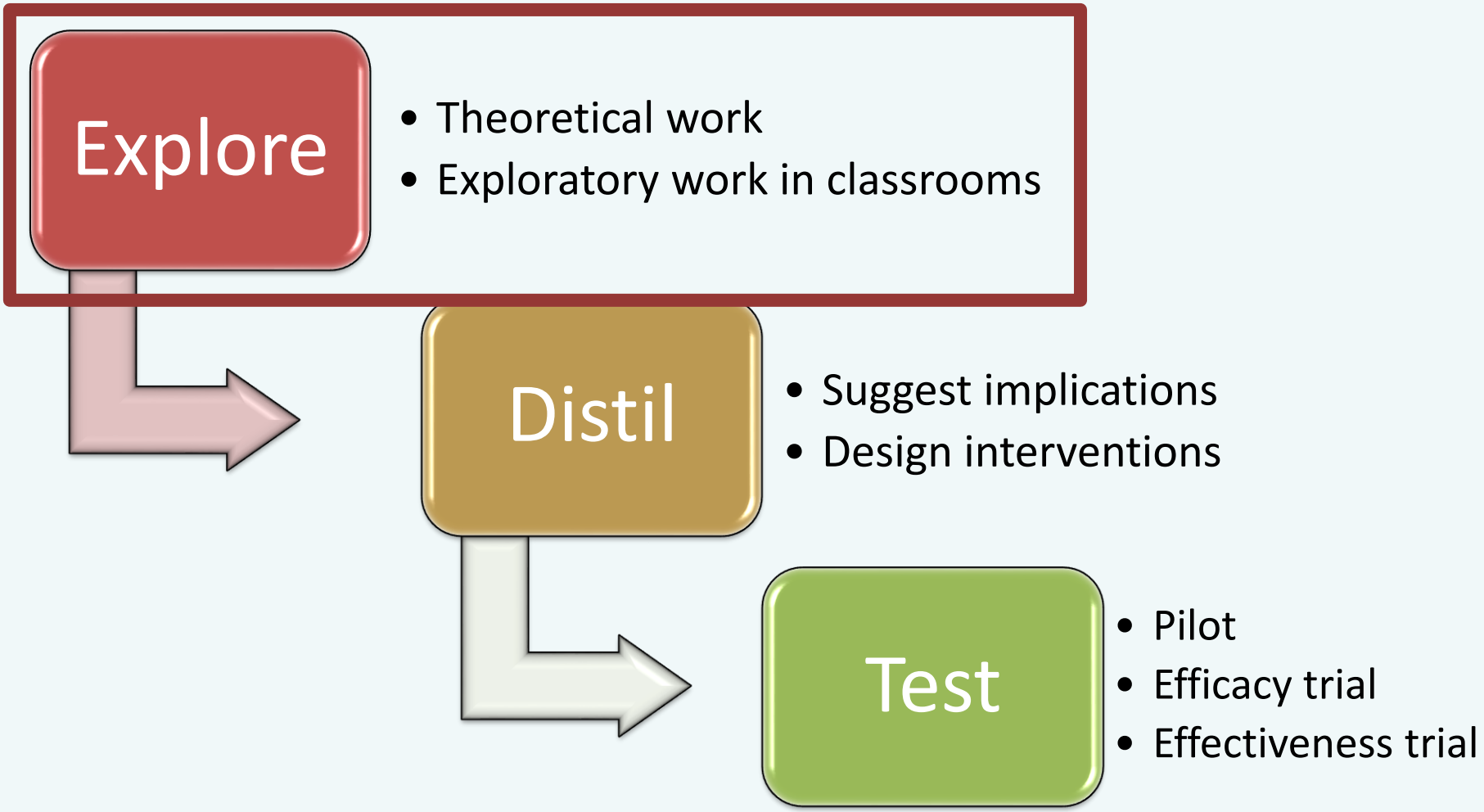
I. Pupils learn through the specific models and representations presented: this is part of cognition (episodal → semantic memory)

II. Pupils continually generate narrative:
   - 'Miscognitions' (vs direct instruction)
   - Feedback and correcting
   - Different problems



III. Meaning making is important: jokes, contexts, relationships, what is valued, emotions.

Positioning this research



Outline

a) The problem with ‘concepts’. ✅
b) What do teachers do to support learning? ✅
c) What do pupils learn from in classrooms? ✅
d) Discussion

- What do you think?
- Is this at all helpful?
- What needs work?

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