

Developing a principled and effective pedagogy

The *epiSTEMe* experience of redesigning
classroom teaching and learning in lower-
secondary-school mathematics and science

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The *epiSTEMe* project

- Part of the ESRC's targeted research initiative on Science and Mathematics Education
 - Investigating ways of addressing participation and achievement gaps in science and maths education
- A (re)design research project
 - Undertaken by a multidisciplinary university team working closely with school practitioners
 - Focusing on student engagement and learning in early secondary-school physical science and mathematics
 - Researching, developing and evaluating a pedagogical intervention suited to implementation at scale

Principled and effective pedagogy: the systemic context in England

- For more than a decade, systemic improvement effort has taken place through the National Strategies
- This has promoted a pedagogy that combines tightly structured *interactive teaching* with *target setting*
- National and international findings are that this model:
 - has **raised** *content knowledge and skills* in **mathematics** but not *broader literacy or functional capability*
 - has **not improved** either aspect of *attainment* in **science**
 - has **raised** student *valuation* of learning **each of the subjects**
 - has **substantially lowered** student *liking* of **both subjects** and *enjoyment* of learning them

Principled and effective pedagogy: the systematic research base

- Important gaps remain in the evidence base available
- Main findings on effective pedagogical components are:
 - *Domain-specific enquiry* (that poses authentic problems and takes student thinking seriously) strengthens **attainment** (in both subjects) and **attitude** (at least in **science**)
 - *Co-operative groupwork* strengthens **attainment** (in both subjects) and **attitude** (at least in **science**), as long as students are well prepared and activity well structured
 - *Enhanced context*, linked to student experiences and interests, is **beneficial** (at least for **science attainment**)
 - *Active teaching* is effective in developing **content knowledge and skills** in **mathematics** but questionable as regards higher-order reasoning and functional thinking

Core *epiSTEMe* pedagogical model

- Blends the pedagogical components found effective through systematic research synthesis
- Cycles through phases in which the key ideas of the topic are *explored*, then *codified*, then *consolidated*
- Employs domain-specific enquiry tasks to stimulate thinking that will support development of key ideas
- Makes use of *dialogic small-group and whole-class discussion*, mainly in the exploration phase
- Makes use of *active teaching*, particularly in the codification and consolidation phases
- Provides *individual checks* on understanding with *developmental feedback* during consolidation phase

Further *ePiSTEMe* pedagogical principles in design brief for topic modules

- To fill out curricular prescriptions for the topic to build strong conceptual foundations
- To show the human interest and social relevance of the topic (including, in maths, scientific application)
- To make connections with widely shared student experiences and interests relevant to the topic
- To take account of students' informal knowledge and thinking related to the topic
- To provide means of deconstructing common misconceptions related to the topic
- To develop mathematical reasoning as a support for students' scientific understanding

Challenges to systemic improvement in lower-secondary maths and science

- Narrow focus on immediate accountability requirements in many schools
- Diversity of local curricular patterns and organisational practices, often strongly embedded,
- Instability and marginality of staffing due to teacher shortages and low priority of early secondary
- Appreciable proportions of staff teaching areas for which their subject-specific preparation is weak
- Lack of professional cohesion and developmental capacity in many subject departments
- Limitations of cascade methods as against costs of teacher participation in deeper developmental activity

The *epiSTEMe* apparatus

- An Introductory Module intended:
 - To build teacher and student understanding of the value of talk in supporting subject thinking and learning
 - To develop rules and processes that support effective small-group and whole-class discussion
- Two Topic Modules (in each subject) intended:
 - To support and capitalise on use of talk and dialogue
 - To instantiate key pedagogical principles and processes
- Two professional development days intended:
 - To develop understanding of dialogic teaching and of how the Introductory Module supports its development
 - To debrief experience of teaching the Introductory Module and develop understanding of the pedagogical principles and processes underpinning Topic Modules

Design features for improvement at scale in face of typical challenges

- Introductory Module features relatively short activities that can be used flexibly over a number of lessons
- Topic Modules provide full set of classroom materials which explicitly target curricular objectives
- Sequence of activities within Topic Modules is readily adjustable to lesson length and pace, and occupies typical time period currently allocated to topics
- Equipment requirements are limited to resources known to be widely available and easily usable
- Teaching Notes support lesson planning, explain underlying rationale and key aspects of activities, and advise on handling a range of student responses
- Classroom materials provide scaffolding to support dialogic processes, particularly articulation of reasoning

The facts of earlobe life

A genetic model has been developed of how people inherit *attached* or *detached* earlobes.

In the model, this characteristic is determined by a pairing of genes, one inherited from the mother, one from the father.



Detached



Attached

The spin on earlobes

Children inherit one form of the earlobe gene (one allele) from each parent.

A parent can't pass on an allele that's not in their own pairing.

If a parent
are equally



Earlobe problems to pierce

A couple are expecting their first baby.

Both parents have a mixed pairing of **e** and **E** alleles.

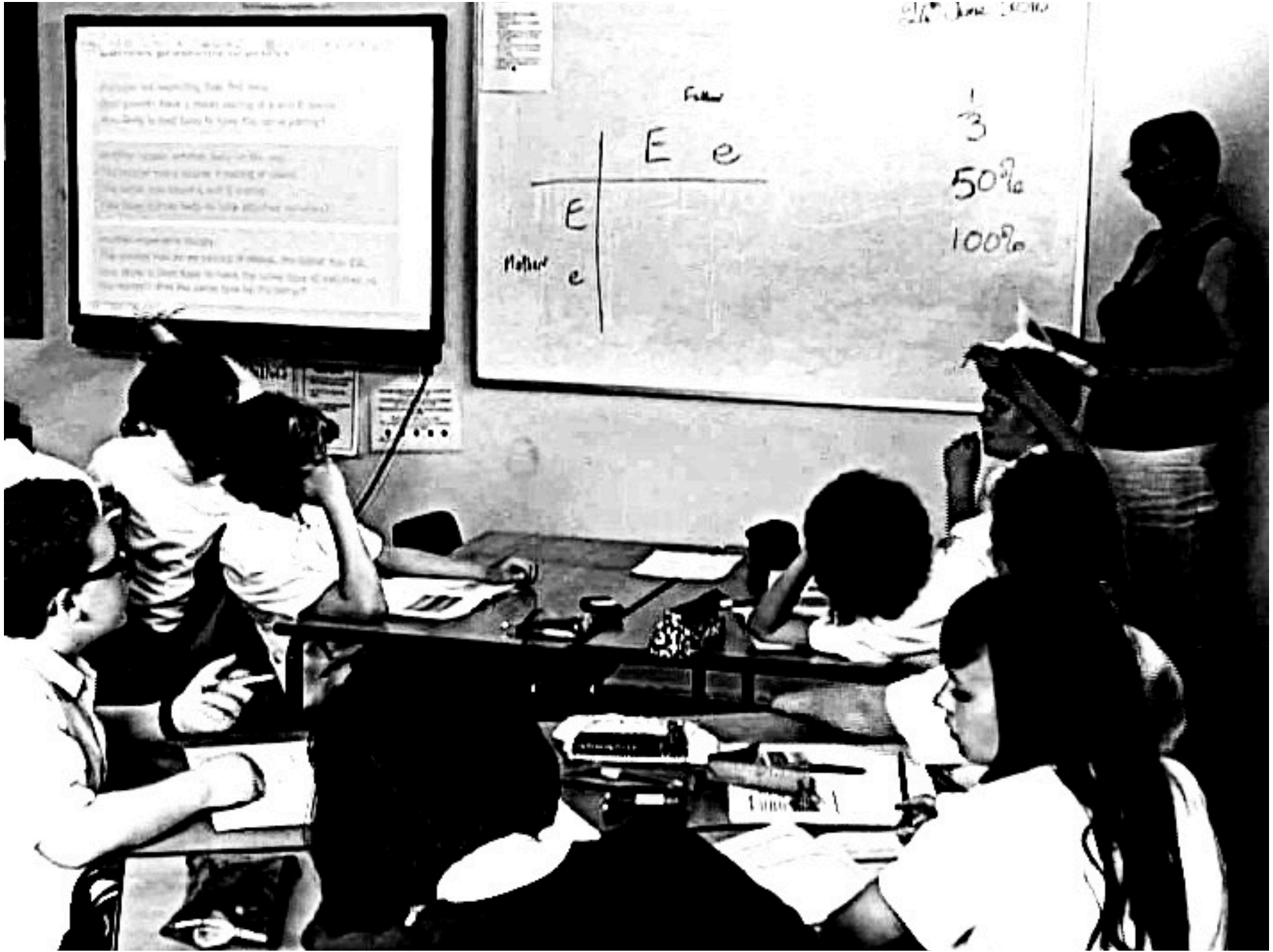
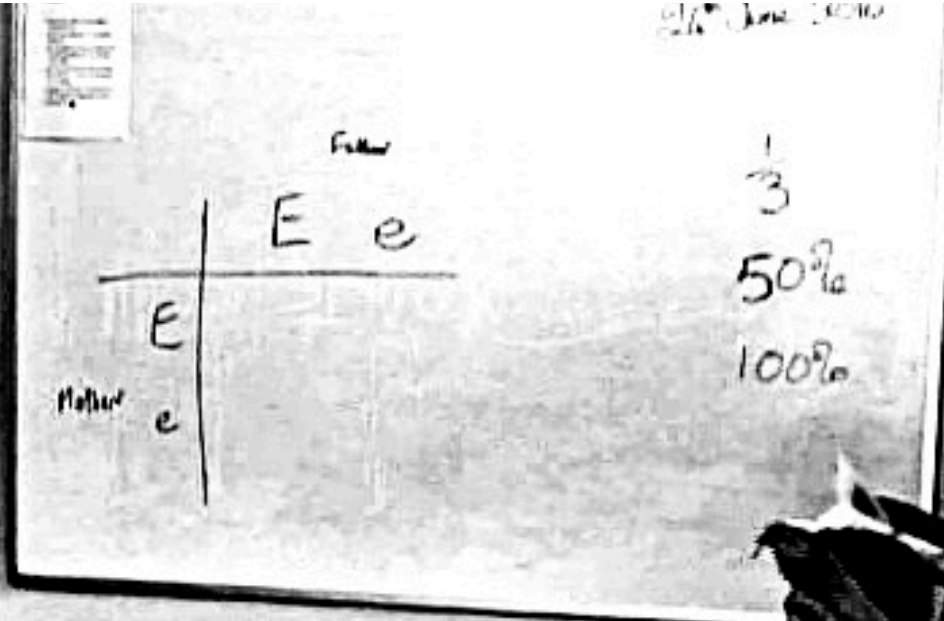
How likely is their baby to have this same pairing?

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Genetics: probability of genotypes

What is the probability that the offspring will be homozygous dominant (EE) or homozygous recessive (ee) or heterozygous (Ee)?

What is the probability that the offspring will be homozygous dominant (EE) or heterozygous (Ee) or homozygous recessive (ee)?



Teacher participation in dialogic whole-class discussion

T: Kitty.

S[Kitty]: There's three different outcomes but there's two ways of getting one outcome so that outcome has a higher probability than the other two.

T: Okay. So Hanna, does that make, does that make any difference do you think? Kitty's saying that although there are only three outcomes [pause]

T: All those people who are getting restless think of something that you can tell us that will convince people of what's going on, convince them of what you believe, because the majority of you are saying that there's a fifty per cent chance they will have the same grouping as their parents. We have some people who don't agree, and they have good reasons for not agreeing....

Teacher solicits contribution from student who has shown shift to sound idea

Teacher accepts this contribution without explicit evaluation

Teacher invites revised contribution from student who expressed confusion

Teacher revoices contribution from student expressing sound idea

Teacher asserts norm of being open to other views, and making constructive contributions aimed at persuasion

Facets of teacher participation in dialogic whole-class discussion

- *Supporting interanimation of ideas*
 - Teacher allows extended student contributions, including those advancing fallacious reasoning
 - Teacher revoices student contributions to summarise them, make them more clearly relevant, and establish connection to earlier contributions
- *Hedging epistemic authority*
 - Teacher makes contributions that are predominantly organisational and/or reflexive
 - Teacher accepts student contributions without evaluating them, and declines student invitations to do so, asserting norm of class agreement
 - Teacher scaffolds through prompts and initiations but fades to allow development by students

Facets of teacher participation in dialogic whole-class discussion (cont.)

- *Maintaining dialogic norms*
 - Teacher asserts norm of being open to other views, and making contributions aimed at persuasion
 - Teacher affirms norm of being open about holding views that diverge from emerging class consensus
- *Managing progression in reasoning*
 - Teacher solicits contributions from students who have shown understanding [without making this explicit]
 - Teacher invites revised contributions from students who have shown misunderstanding [again implicitly]
- *Prompting shifts in reasoning*
 - Teacher reacts by soliciting specific clarification
 - Teacher prompts attention to mathematical principle, use of mathematical tool, or link to earlier problem

Challenges for teachers in embracing and realising dialogic pedagogy

- Realising the dialogic element of the *epiSTEMe* pedagogy has proved challenging for many teachers
- The goal of developing thinking, not simply securing performance, requires significant shifts beyond the received ideas and reflexes of established practice:
 - Aiming to express reasoning not just produce answers
 - Giving time to multiple extended student contributions
 - Allowing extended student contributions that are fallacious
 - Interanimating the reasoning behind student responses
 - Making contributions that are reflexive not regulative
 - Steering discussion to secure progression in reasoning but not closing it down through authoritative intervention