Implementing Educational Neuroscience for educational progress: Do we need an "education first" approach?

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So how far are we from applying neuroscience in education?

- Strength of evidence (low, medium, high)

  High = multiple classroom interventions

  Medium = good lab intervention evidence

  Low = no lab intervention evidence

- Distance to application (near, moderate, distant)

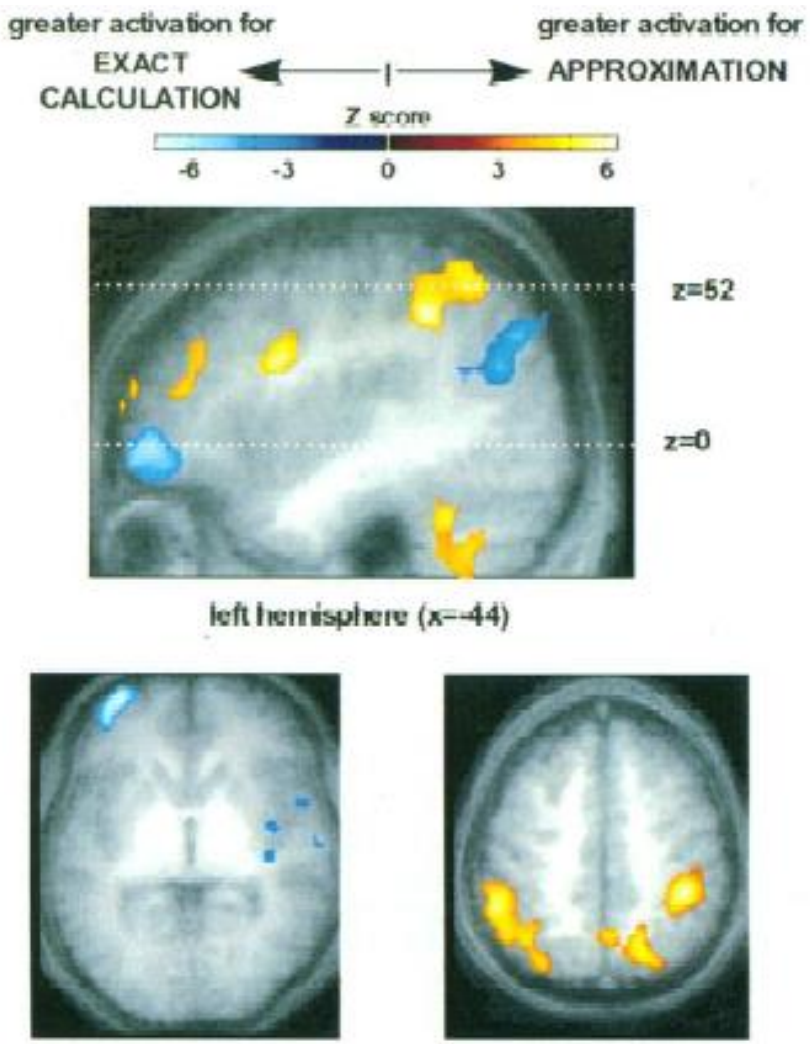
  Near – could apply this now

  Moderate – requires some specialist resources

  Distant – not clear what application would look like

Mathematics

New and Old

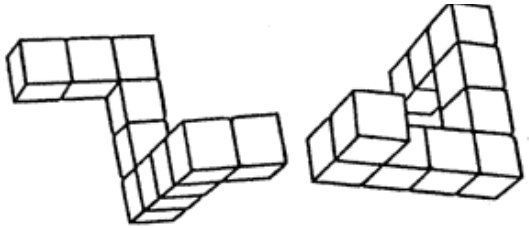


Dehaene et al. (1999)

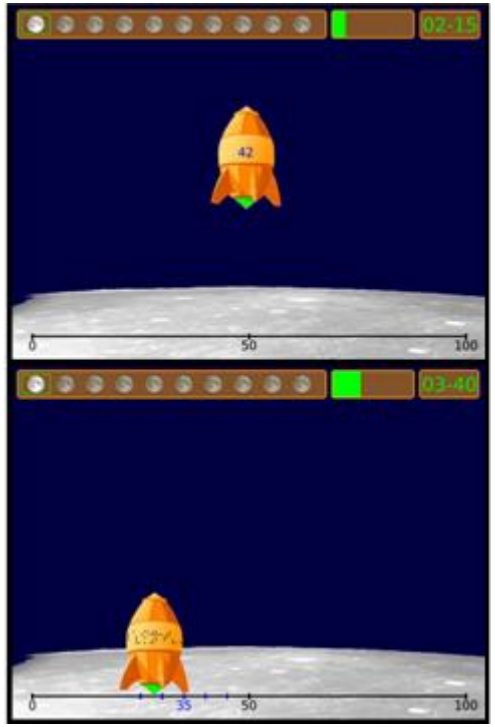
Fingers

Anxiety

Mental Rotation



Mathematics

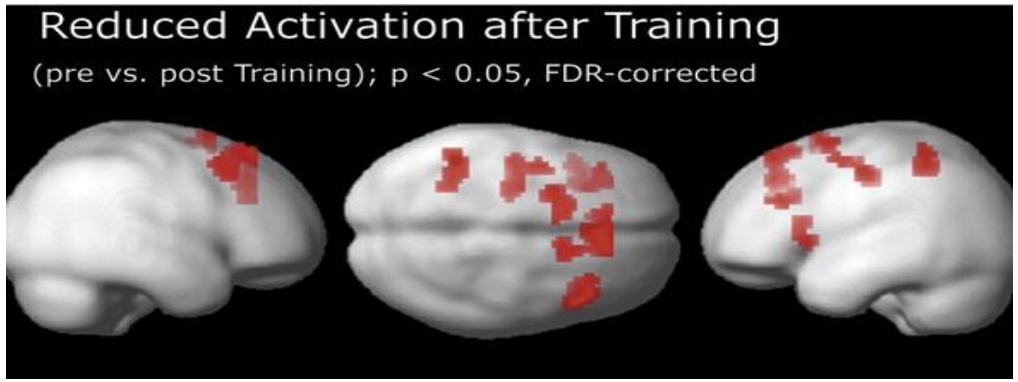


“Rescue Calcularis” (Kucian et al. 2012)

Neuroscience by design, for evaluation

Improved number line and maths for dyscalculics and controls.

Reduced frontoparietal activity:



Mathematics

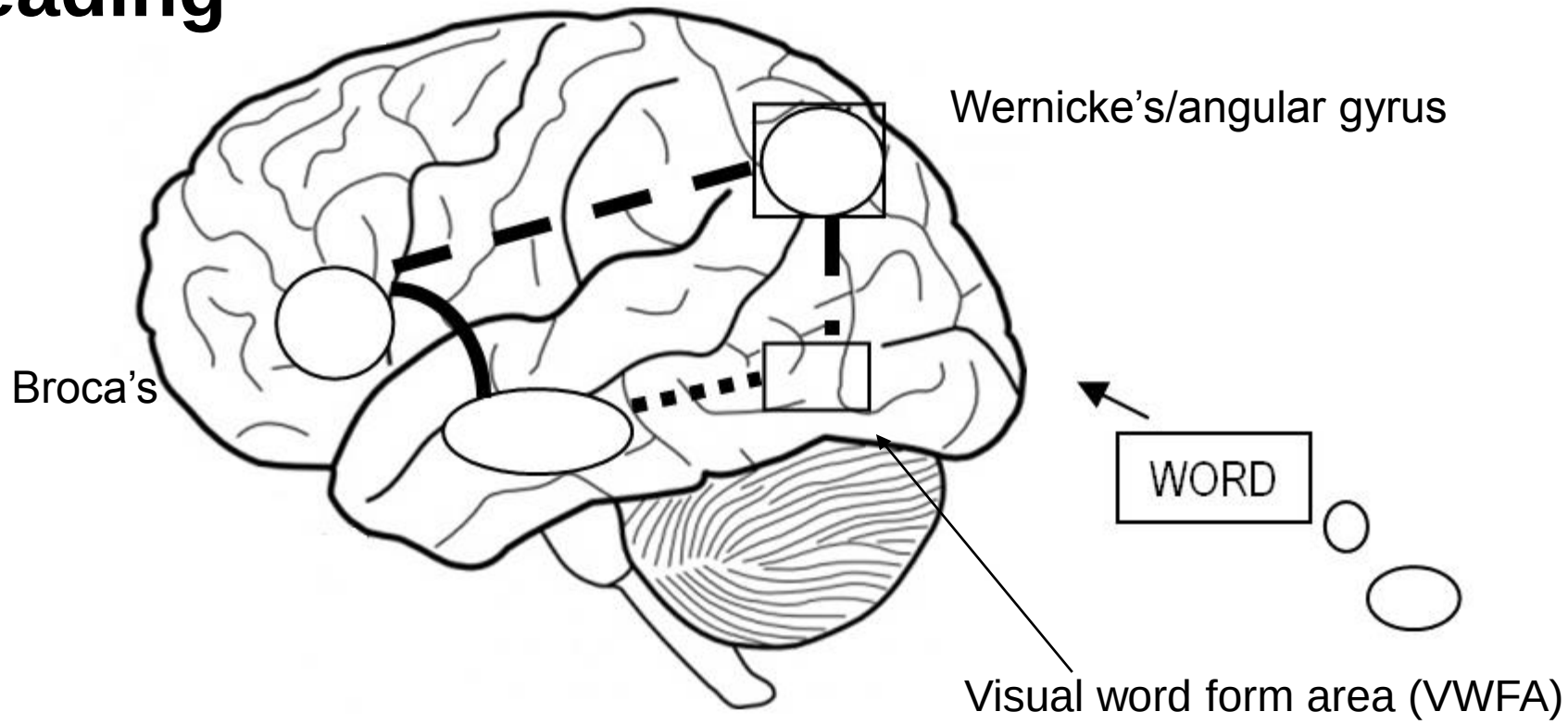
- Can training improve children's non-symbolic representation of number and its relation to symbolic representation – and does this help their mathematics?

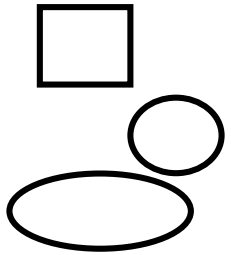
- Can video games improve STEM achievement?

- Can understanding of math anxiety improve achievement?

Mathematics	Strength	Distance
• mixed results for training non-symbolic representations, some impact of training on symbolic representation and transfer to other numeracy skills.	Medium	Moderate
• Finger gnosis training improves aspects of early number development (1 study)	Low/ medium	Near
• No attempt to show video games improving STEM achievement via enhanced mental rotation abilities	Low	Moderate/ distant
• A single study has reported that the effects of teenage maths anxiety can be reduced by writing about it	Medium	Near

Reading

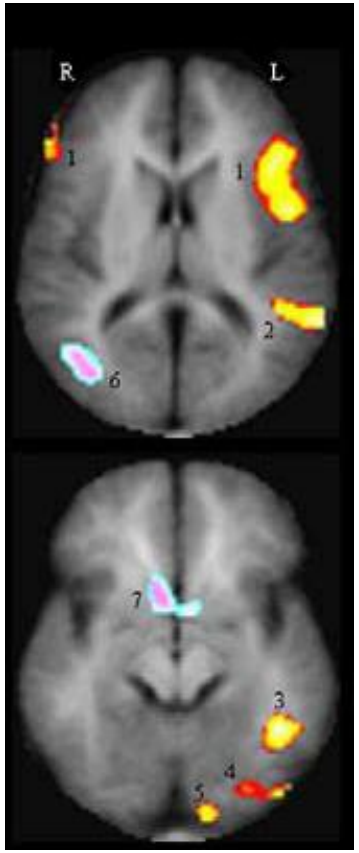


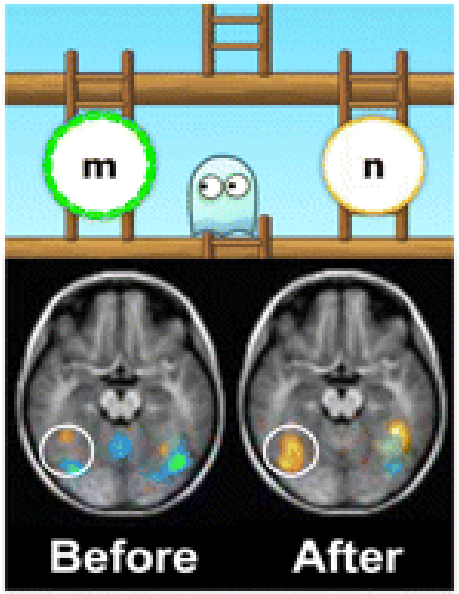


So reading systems are distributed, and contain redundancy

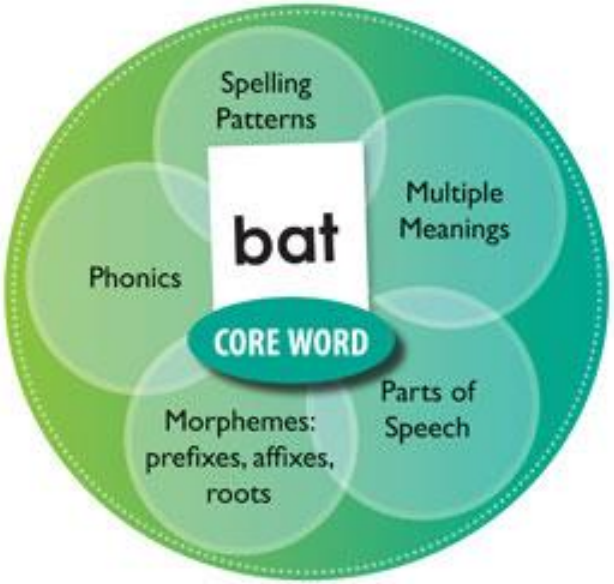
Ashby(2012)

Phonological interventions remediate reading, activation (3=VWFA)
(Shaywitz et al., 2004)





Early literacy – non-readers
Graphogame improves outcomes
increases VWFA activity Brem al.(2010)

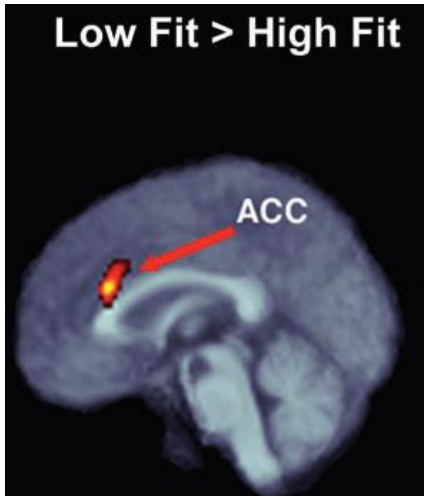


But…a multicomponent process amenable to multicomponent interventions….

Can training on the neurocognitive components of reading improve outcomes?

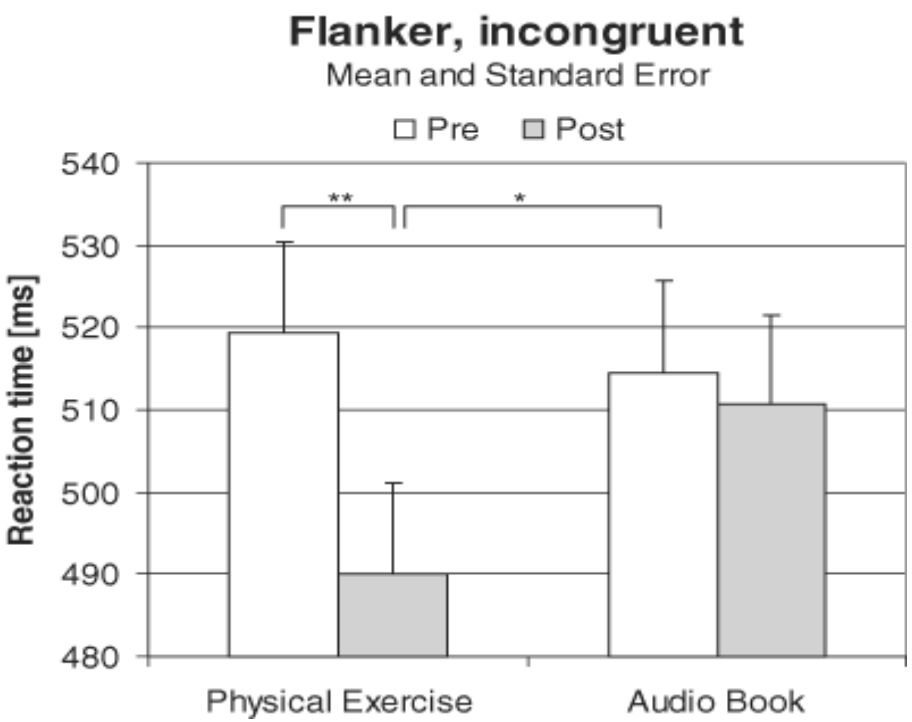
Reading	Strength	Distance
• Computer-based training focused on phonological skills has helped those experiencing difficulty to develop their reading skills.	Medium /high	Near
• Several multicomponent interventions also successful. Potential value of considering individual differences in such interventions	Medium /high	Near

Exercise



Exercise enhances executive control functions + structures

E.g. anterior cingulate cortex (ACC)
Colcombe et al. (2004)

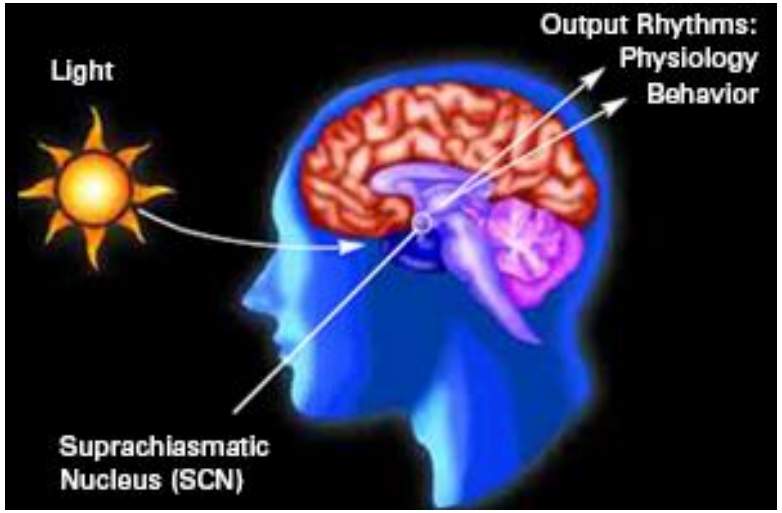


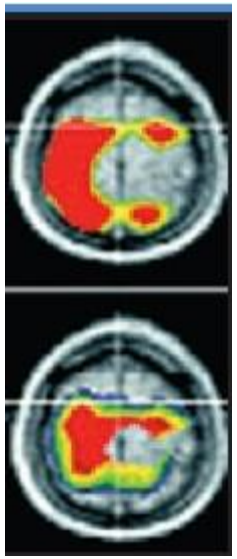
Single 30-min PE versus rest
13- to 14-year-old students
Kubesch et al. (2009)

Can exercise be used to improve academic achievement?

Exercise	Strength	Distance
• Almost entirely, exercise interventions have had either no effect or positive effects (in equal proportion) on learning, suggesting substantial likelihood of its academic value • The most important factors influencing the academic outcomes of exercise are still the subject of research	Medium	Near

Teenage Lifestyle



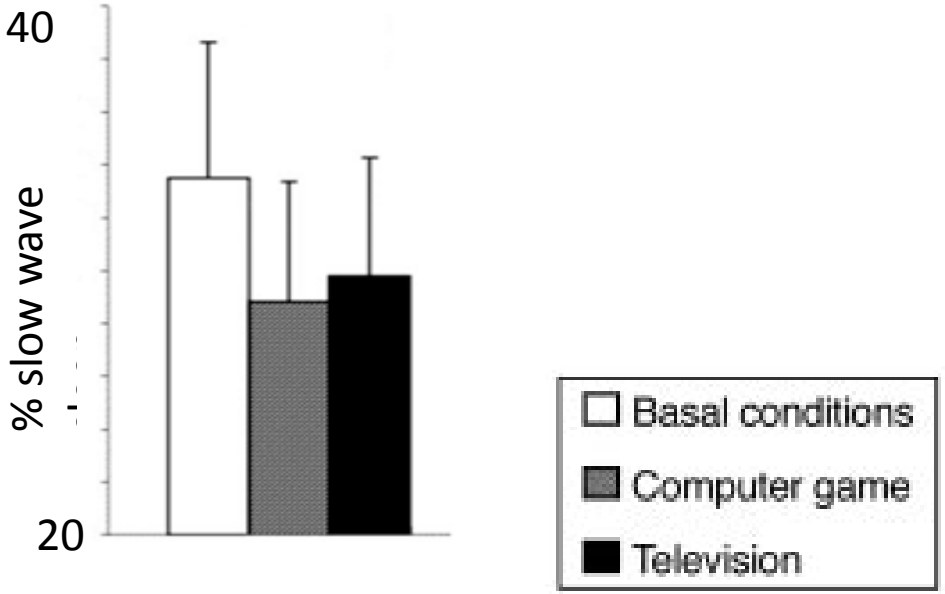


Red Bull gives you angel wings

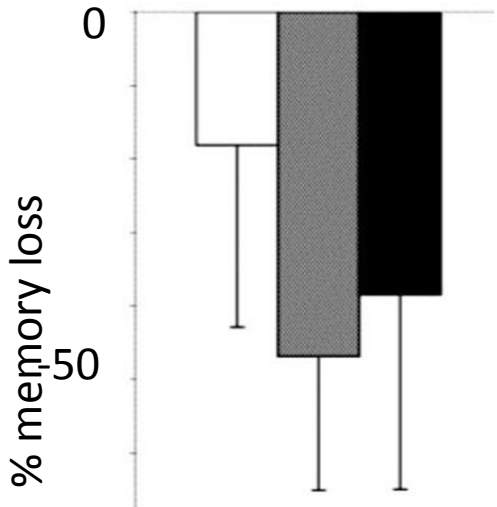
Many questions….

13-14 yr olds (N=11), 6-7pm

* playing computer games
* watching TV or
* neither (basal condition)



Later in evening asked to memorise 2 mins of facts.

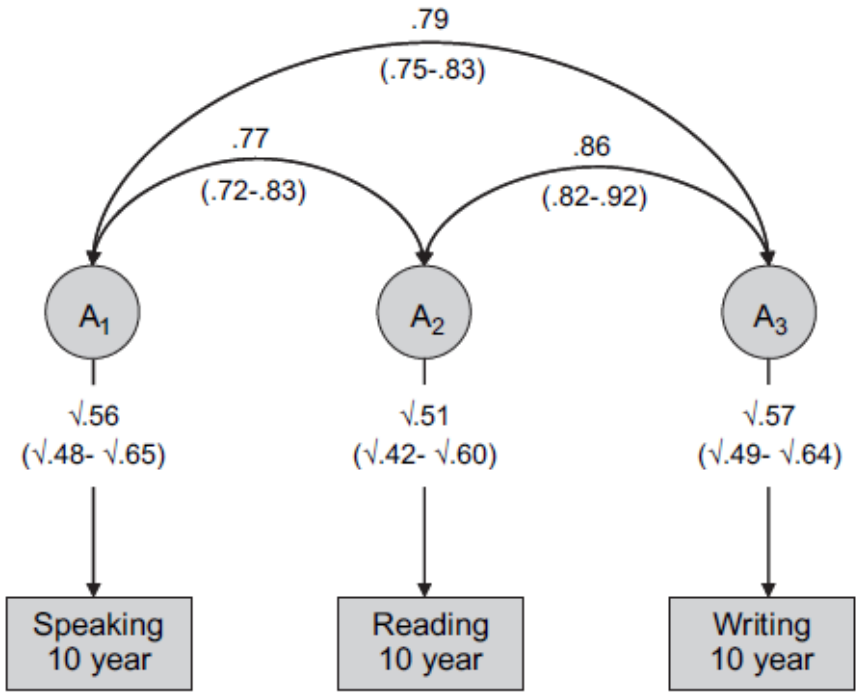


Dworak et al. (2007)

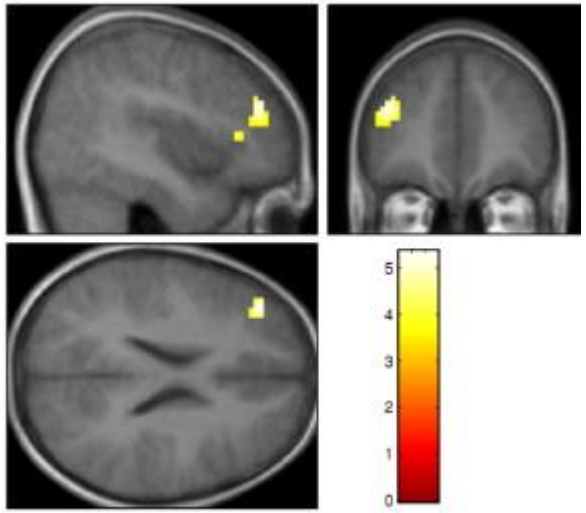
Teenage Lifestyle

Would teenagers achieve more if they were allowed to sleep later?

Teenage lifestyle	Strength	Distance
• Later starts in schools that begin the day early have been shown to improve attendance and engagement in lessons	Low	Close
• Simply providing information to teenagers about sleep, including its chronobiology, raises awareness but fails to change habits. • Great involvement of such interventions with homelife and culture has shown, tentatively, more promise	Low	Close



Plomin's generalist genes

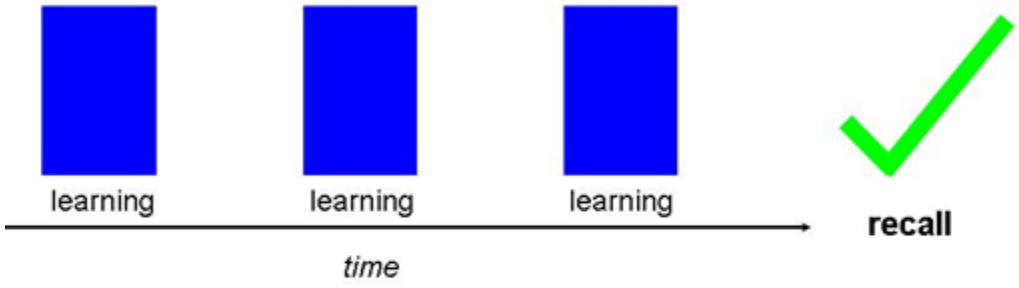


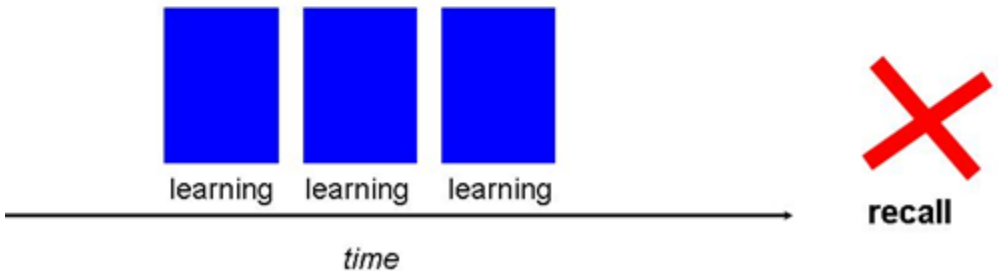
Activations greater in children w/o DRD4 7-repeat in spatial incompatability task (Gilsbach, 2012)

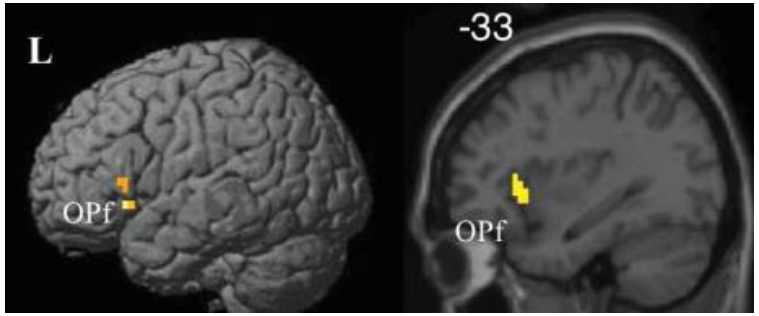
Carrier = educational 'orchid' not 'dandelion'

Genetics	Strength	Distance
• Some genetic markers already have current practical value in deepening our understanding of the effects of educational interventions	Medium	Close

Embodied cognition	Strength	Distance
• Embodied cognition helps explains the well-established enactment effect but may also provide insight into how students learn from the actions of their teachers	Low/ medium	Close/ moderate







Greater left frontal operculum (auditory-to-articulatory) mapping – suggests greater need to re-encode in spaced sessions (Callan et al, 2010)

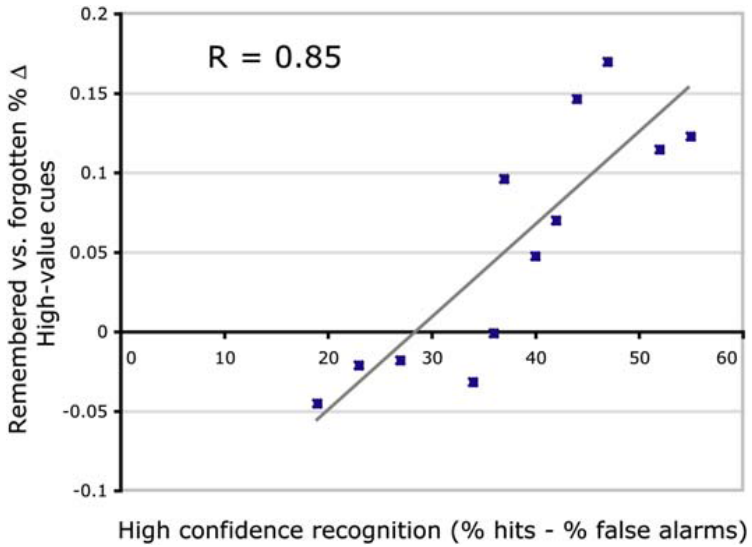
Spacing effect	Strength	Distance
• The spacing effect on memorisation is well-established, and the benefits of spacing may extend to deeper types of learning	High	Close
• Interleaving more complex and less established than spacing effect, but small number of studies reveal potential	Medium	Close

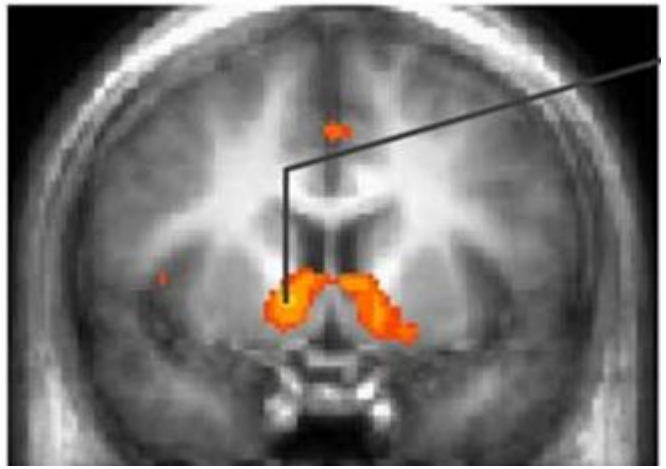
Testing	Strength	Distance
• Insight from neuroscience and psychology, particularly when combined with technology, may help improve application of the testing effect in today's classroom.	Medium	Moderate

Many candidate explanations for testing better than restudy:

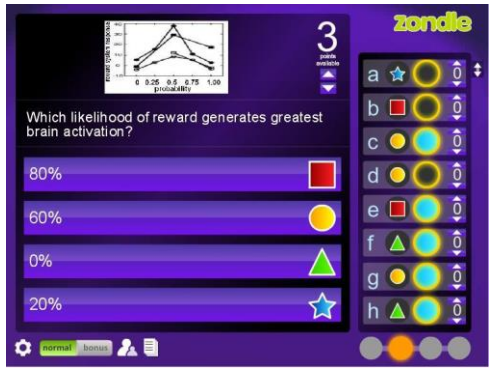
•increased attention during restudy -> enhanced encoding
•role of reward in testing (see also Learning Games)
•Different semantic processes during retrieval and restudying
•Decreased need for executive processing compared with restudy

Reward response (midbrain dopamine uptake) predicts declarative memory …





This reward response influenced by many factors, including the uncertainty of reward (peaking at 50% uncertainty)



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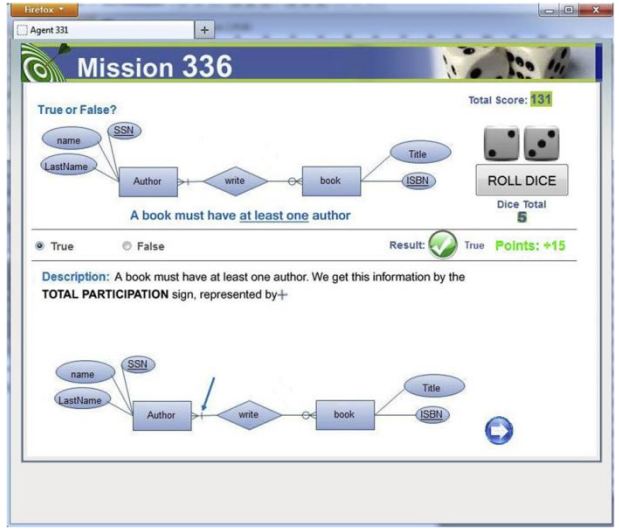
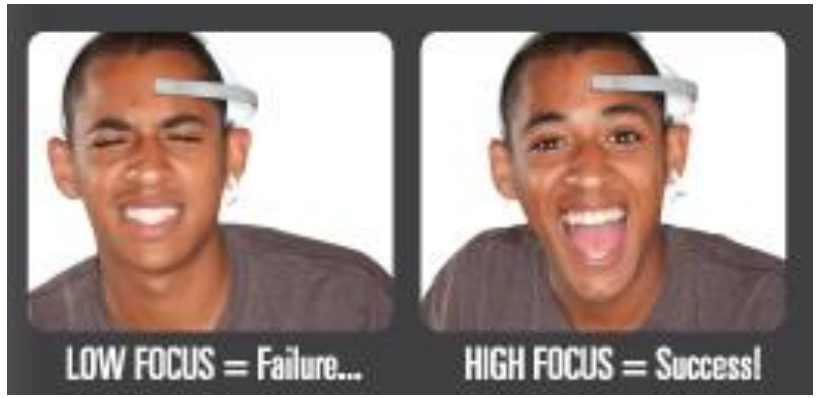
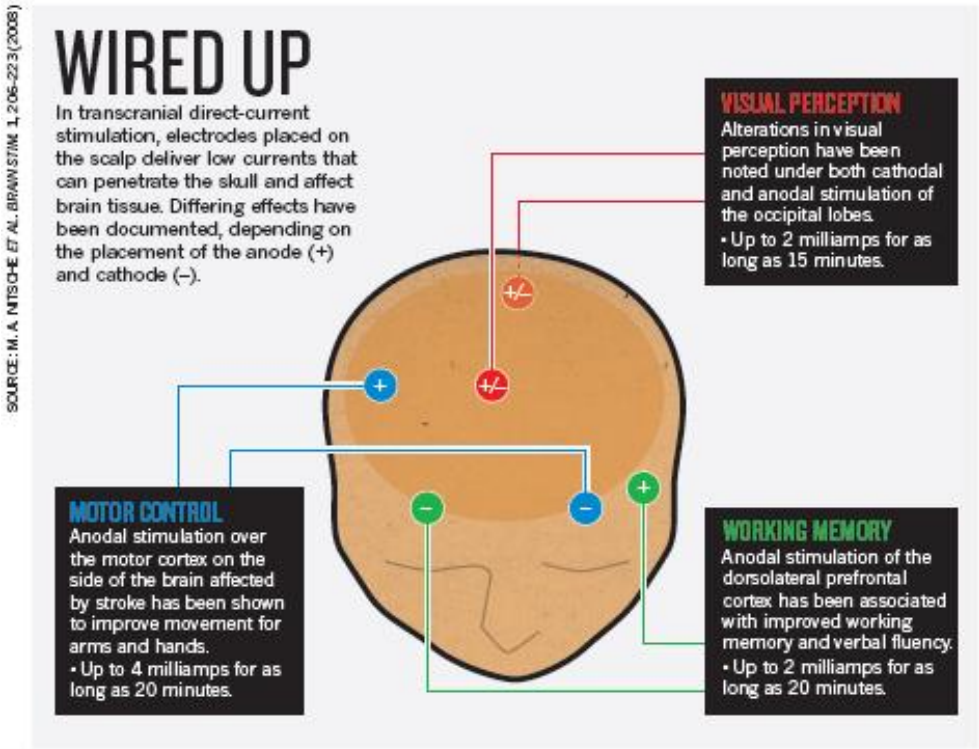


Ozcelik et al. (2013

Learning games	Strength	Distance
• Learning games are just beginning to draw on concepts about brain and mind, experimentally sound but no rigidly-controlled comparisons of classroom effectiveness	Low /medium	Moderate

Neurofeedback	Strength	Distance
• The technology to provide neurofeedback in classrooms is becoming more portable and cheaper, but its value in these contexts remains unexplored.	Low	Moderate/ distant





Transcranial direct current stimulation	Strength	Distance
• Positive effects are now being reported for learning tasks relevant to education, but remaining questions regarding risk and ethics makes tDCS classroom interventions unlikely in the near future	Medium	Distant

And also……

- Attention-deficit hyperactivity disorder (ADHD)
- Memory, stress
- How learners visualize & imitate
- Working memory training
- Adolescence (EF, risk, brain awareness)

…and much more…

Two questions…..

- Is the current model of how neuroscience should enter the classroom likely to be effective?

- Is neuroscientific research focused on the most pressing issues in education?

How should neuroscience (or any new practice) enter the classroom?

Science knowledge is established

↓

Practices/resources/interventions are designed (with help of teachers)

↓

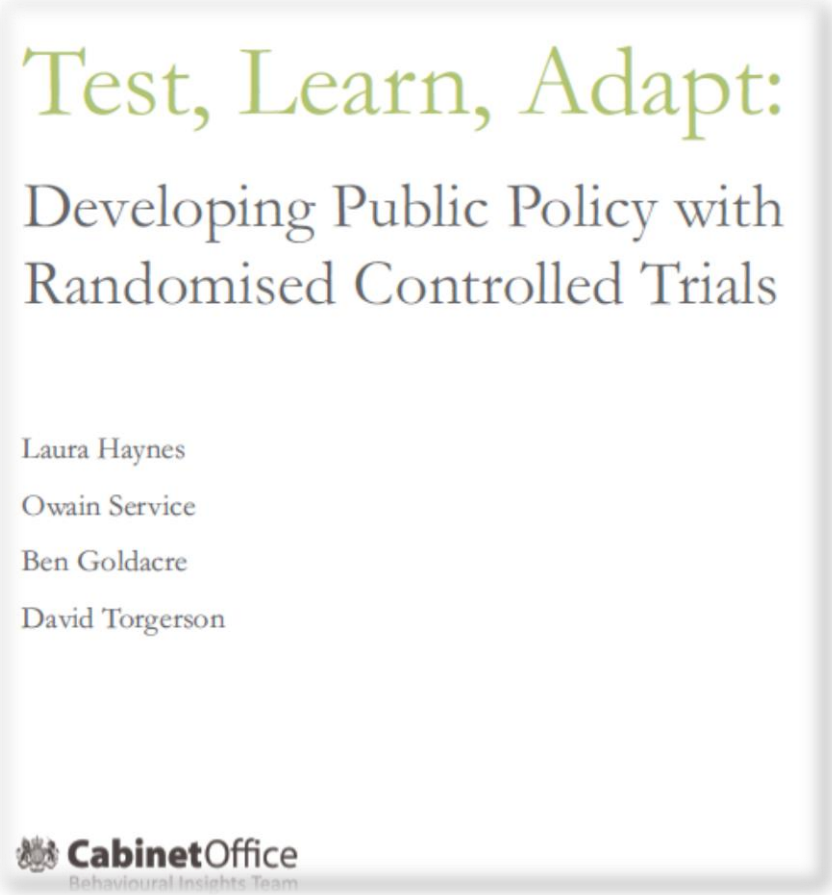
Practices/resources/interventions are evaluated against educationally meaningful criteria

↓

Practices/resources/interventions are amended in light of evaluation

↓

Practices/resources/interventions are recommended to teachers


Test, Learn, Adapt:

Developing Public Policy with Randomised Controlled Trials

Laura Haynes

Owain Service

Ben Goldacre

David Torgerson

CabinetOffice

Behavioural Insights Team

How should Science of Learning enter the classroom?

Science knowledge is established

when complete?

Practices/resources/interventions are designed

co-designed?

Practices/resources/interventions are evaluated using RCT's against educationally meaningful criteria

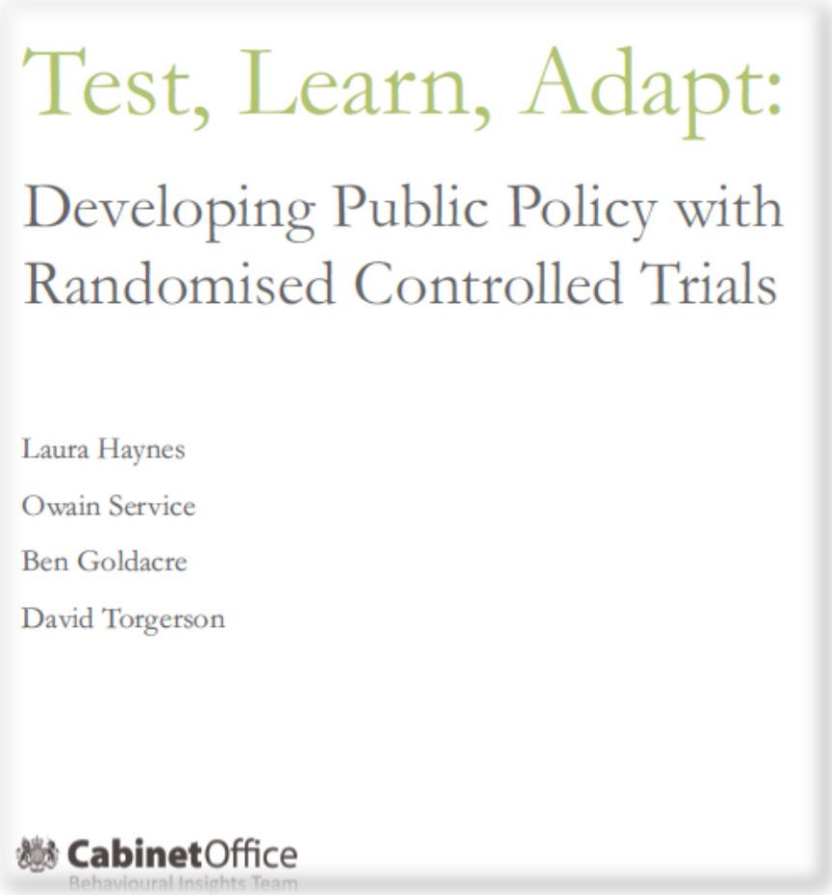
credible???

Practices/resources/interventions are amended in light of evaluation

expensive???

Practices/resources/interventions are recommended to teachers

prescriptive???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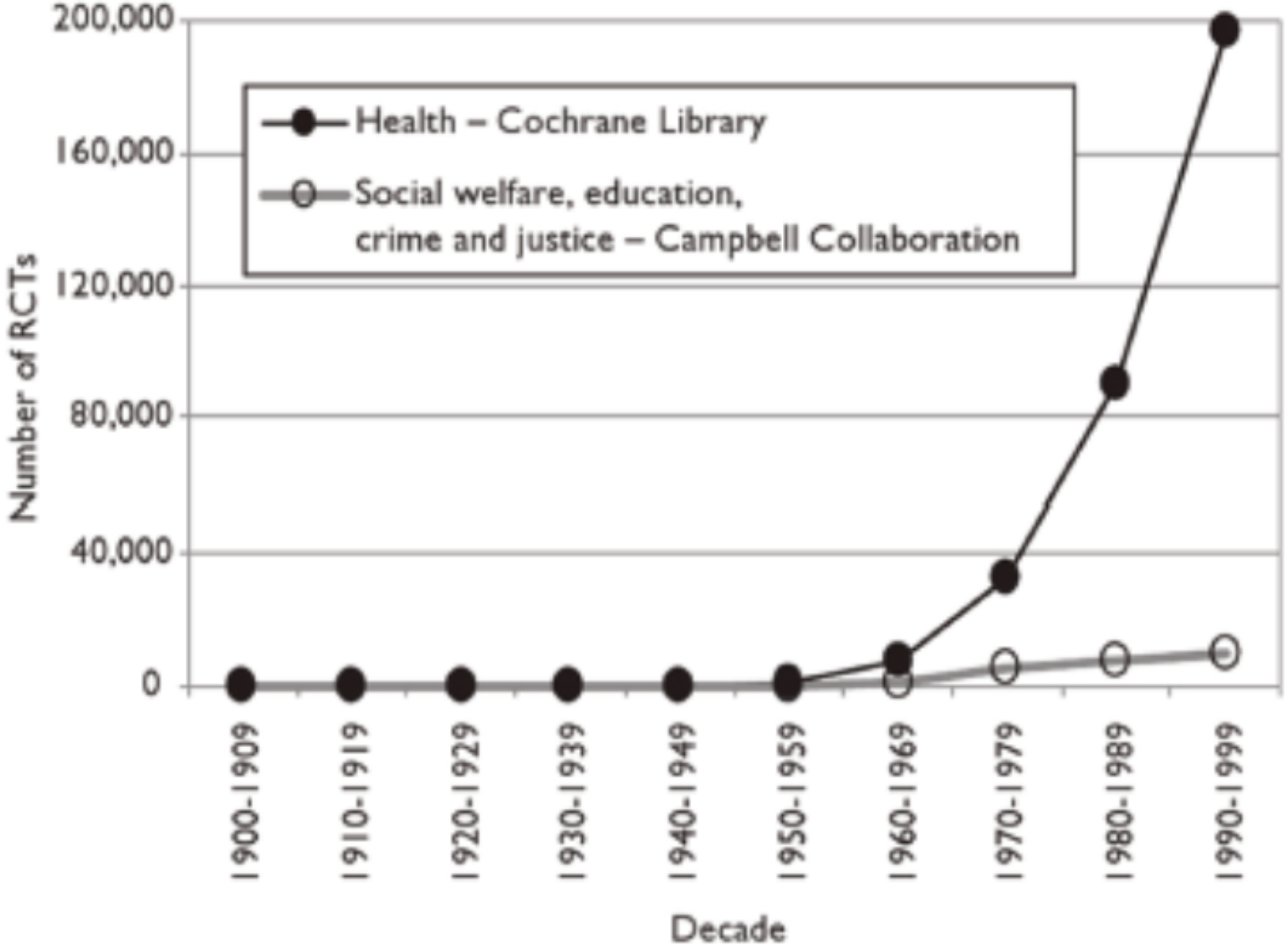
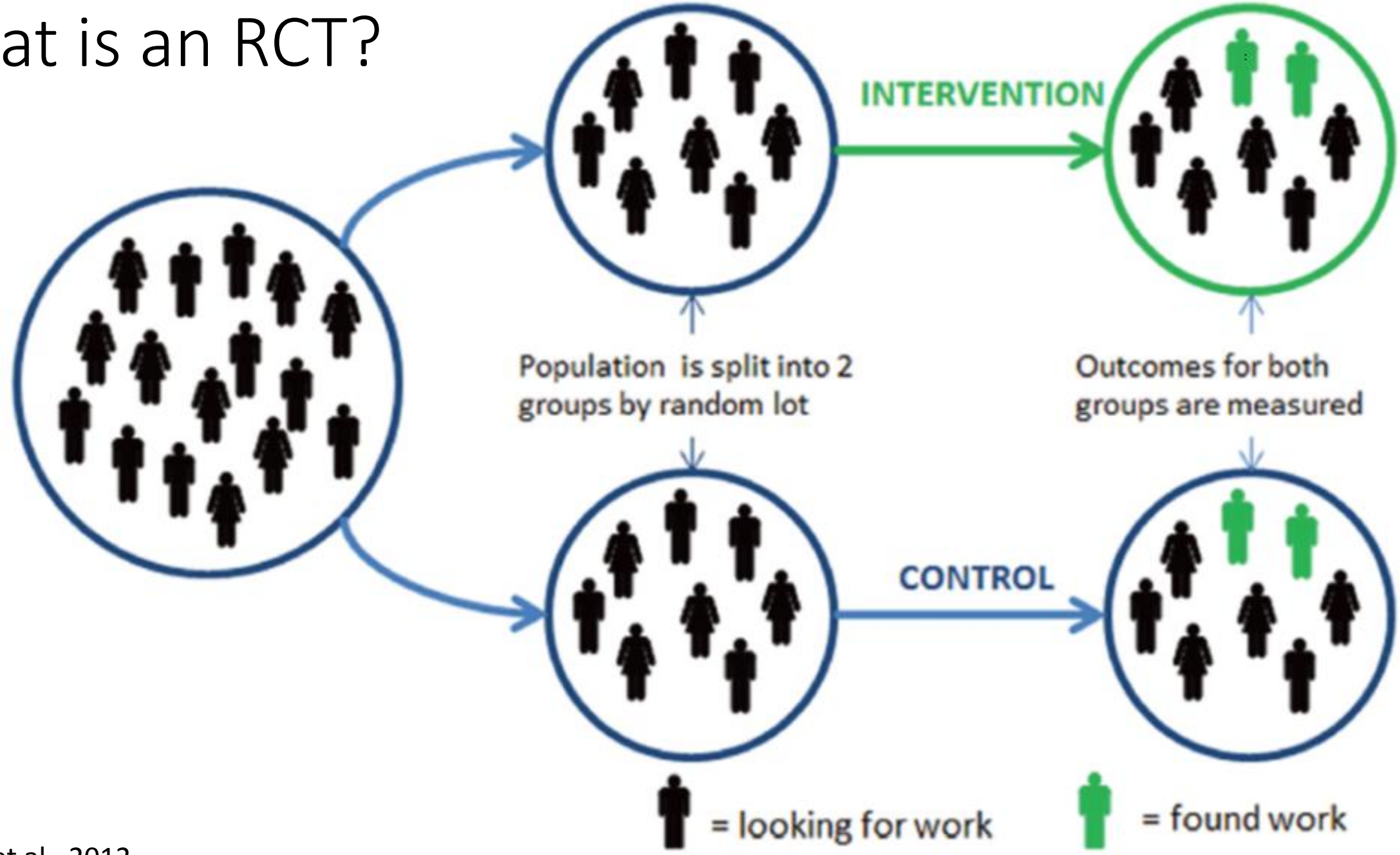
RCT's on the rise….



"to learn what is working and what is not; and to adapt our policies so that they steadily improve and evolve both in terms of quality and effectiveness……" Haynes et al., 2012

What is an RCT?



Haynes et al., 2012

Test

1. Identify two or more interventions to compare
2. Determine intended outcome and how to be measured in the trial.
3. Decide on randomisation unit (e.g. students or schools)
4. Determine how many units required for robust results.
5. Assign units (e.g. student or school) randomly to groups method.
6. Introduce the policy interventions to the assigned groups.

Learn

7. Measure the results and determine the impact of intervention.

Adapt

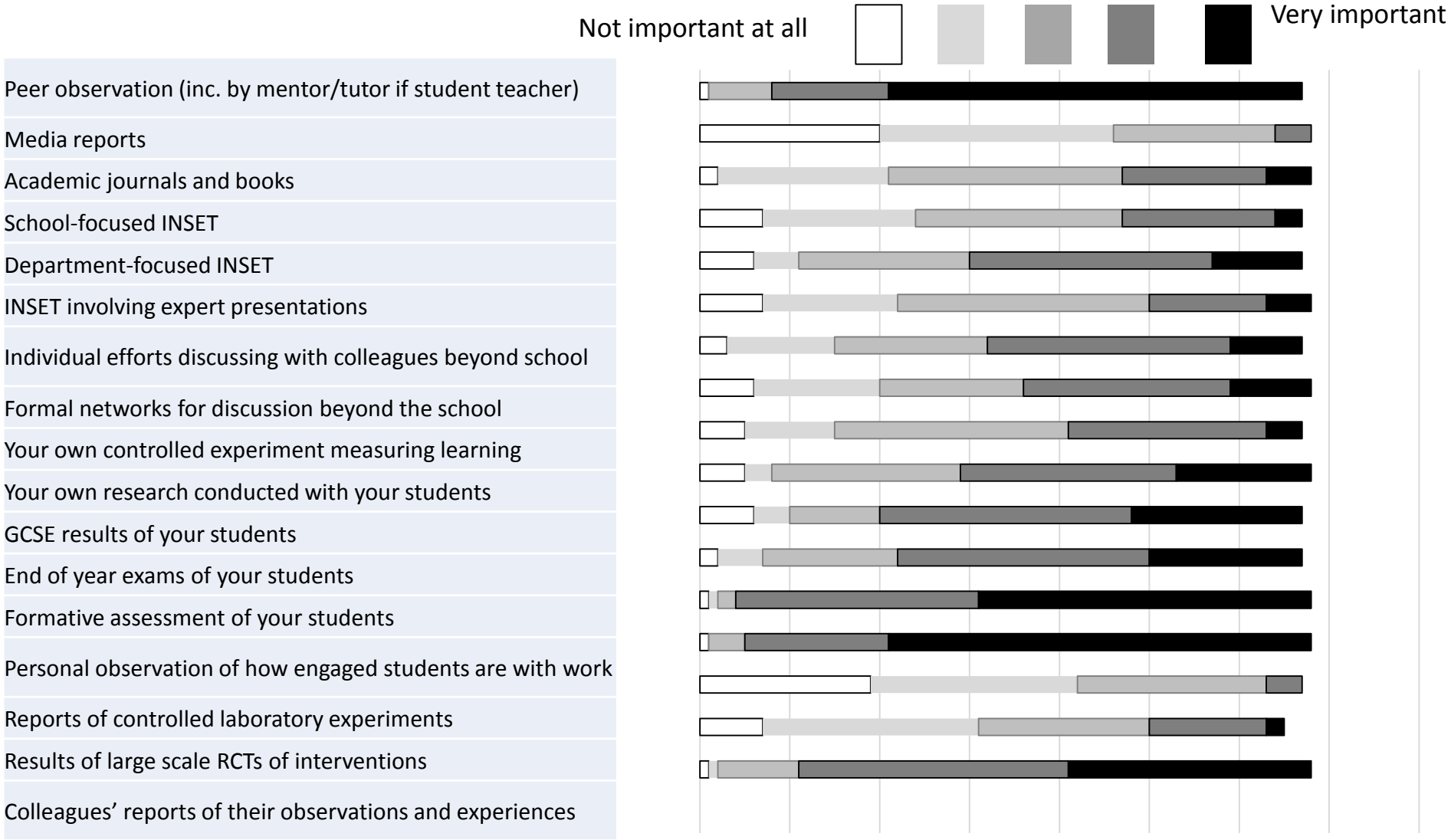
8. Adapt your policy intervention to reflect your findings.
9. Return to Step 1, continually improving understanding of what works.

Exploratory Study - Trainee teacher's attitudes to potential drivers of change in their practice

- 68 trainee PGCE student teachers (27 Maths, 41 Science)

- Completed a questionnaire *prior* to a discussion session on research in January 2016

Importance for prompting/informing change….



Importance for prompting/informing change….

Very important (>5):

Colleagues' reports of their observations and experiences
Personal observation of how engaged students are with their work (e.g. on task)
Formative assessment of your students (answers in class, class work, homework, etc.)
Peer observation (including by mentor or tutor if a student teacher)

Important (>4):

End of year exams of your students
GCSE results of your students
Your own research conducted with your students
Your own controlled experiment with measurement of learning
Formal networks allowing discussion with colleagues beyond the school
Individual efforts to discuss with other colleagues beyond school
Department-focused INSET

Importance for prompting/informing change….

Not important (<3):

Results of large scale randomised-controlled trials of interventions
Reports of controlled laboratory experiments
INSET involving expert presentations
School-focused INSET
Academic journals and books
Media reports

In itself, the prescription of good practices may have limited impact.

a) Teachers always need to adapt a practice. This make prescription – in principle – difficult/impossible.
b) We already know a lot about what constitutes good practice, and is likely to impact positively in the classroom
c) Practices do not predict impact well

e.g. suppose you tossed a coin to predict whether a class would get better or worse with a particular teacher. Pure chance = 50% correct

If you applied an up-to-date analysis of practices, this would rise to 60% of occasions (Coe et al., 2014)

Recommending known practices may not, in themselves, have great impact - **other aspects of what the teacher is doing appear more important**.

“push” of new scientific insight
vs.
“pull” of educational demand

What is the educational demand?

Issues confronting education – UK policy makers

- A long tail back of poorly educated young people
- Poor children have worse educational outcomes at every stage of education
- Considerable variation in attainment by ethnicity, gender and geography
- % pupils with SEN is declining but high (comparing internationally)
- Choice of good local schools isn't a reality for most
- Pupils in need of the best teaching are not always getting it
- We do not get the most out of high performers
- Vocational education is the poor relation

Which of these problems are likely to be changed by prescribing specific practices?

What is the most important school-related factor in student learning? The answer is ~~teachers~~, teaching"

Schwartz, Harvard Graduate School of Education,

OECD Observer N°261 May 2007

"No education system can be better than the quality of its ~~teachers~~ teaching"

OECD's Andreas Schleicher (2016 - and many others):

Teaching is complex

- We know a bit about learning
- We know very little about teaching
- Experts on effective teaching emphasise the importance of a teachers' assumptions and beliefs about the learner's mental world of ideas and how teaching and learning influences that world (Olson and Bruner 1996, Haim, Strauss et al. 2004, Mevorach and Strauss 2012)

Two questions…..

- Is the current model of how neuroscience should enter the classroom likely to be effective?

- Is neuroscientific research focused on the most pressing issues in education?

Two questions…..

- Is the current model of how neuroscience should enter the classroom likely to be effective?

  Possibly not – if it seeks merely to identify practices and ignores the teacher

- Is neuroscientific research focused on the most pressing issues in education?

  Possibly not – if it ignores the importance of the teacher's understanding of learning

Conclusion

- From an educational perspective, a priority for educational neuroscience may be to **communicate an understanding of classroom learning that is accessible, scientifically valid and helpful for understanding everyday practice.**
- This may be more important and meaningful and than a test, refine, adapt cycle that results in identifying specific, prescriptive practices.