

Research-informed pedagogical innovation at scale in school mathematics and science education

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The National Strategies: Pedagogical experiment at systemic scale

- A systemic school improvement programme
 - Introduced to primary schools from 1998 (informally) and 1999 (formally)
 - Extended to lower secondary for student cohorts entering 2001 (mathematics) & 2002 (science)
- Independent evidence of impact provided by regular international study series such as TIMSS and PISA
 - Data gathered about attitude as well as attainment
 - Comparison across systems and between subjects

The National Strategies: The influence of pedagogical research

- Main basis was a predominantly American body of “process-product” research on effective teaching
- Core model of “active teaching” had been validated in relation to basic mathematical knowledge and skills
- Other research suggested that “additional classroom processes... needed to enhance higher order thinking:
 - a focus on meaning and understanding....,
 - direct teaching of higher level cognitive strategies and problem-solving,...
 - co-operative small group work.”

(Reynolds & Muijs, 1999, p. 281)

The National Strategies:

Key features of the pedagogical model

- Derived from “active teaching” linked to “target setting”, placing emphasis on:
 - A detailed schedule of objectives to guide lessons
 - A three-part template for lesson structure
 - Whole-class interaction for pace and progress
 - A system of attainment levels to describe progress
 - Regular target setting, assessment and feedback

The National Strategies: Impact on student attainment

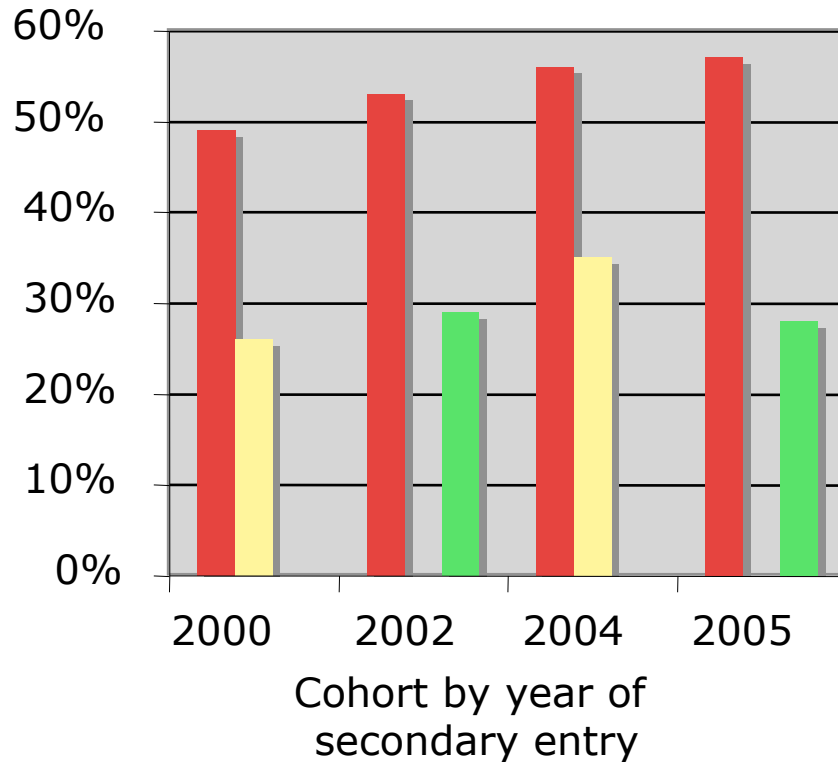
Proportion of
students attaining

KS3 L6+

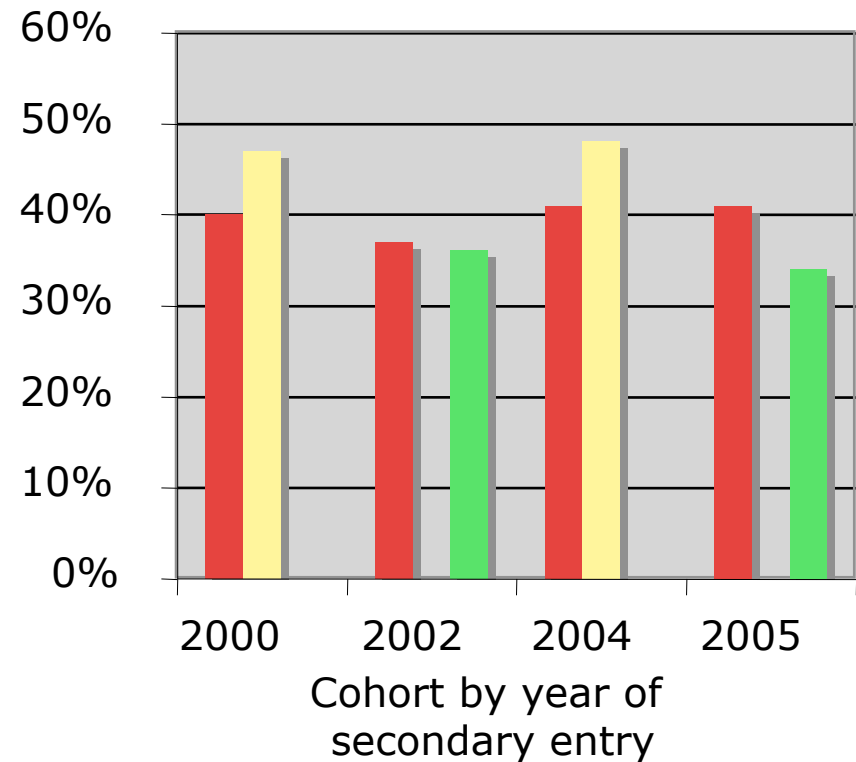
TIMSS LH+

PISA L4+

Mathematics



Science



The National Strategies: Impact on student attitude

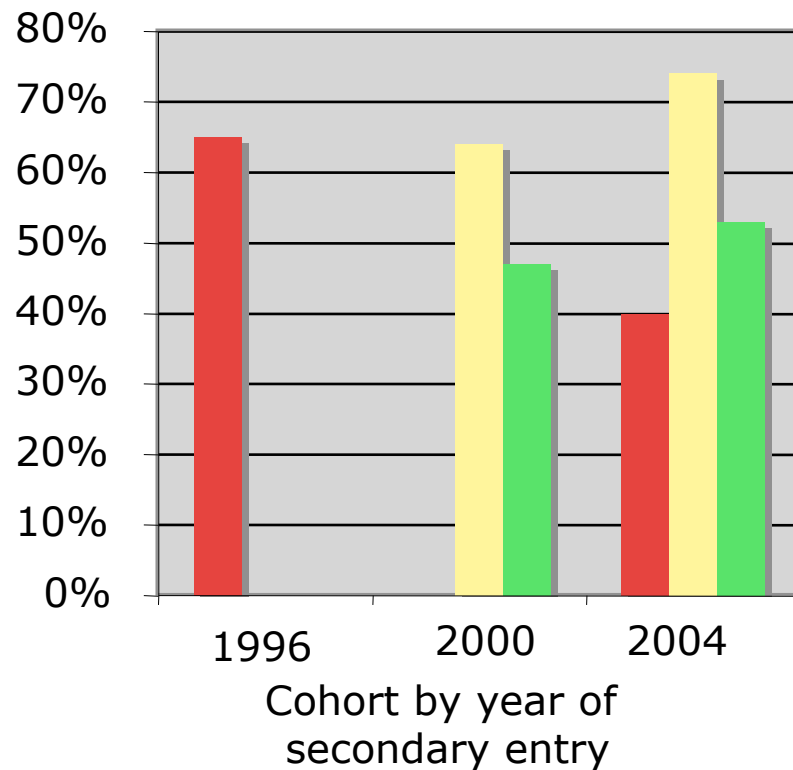
Proportion of
students reporting

Enjoy/Like

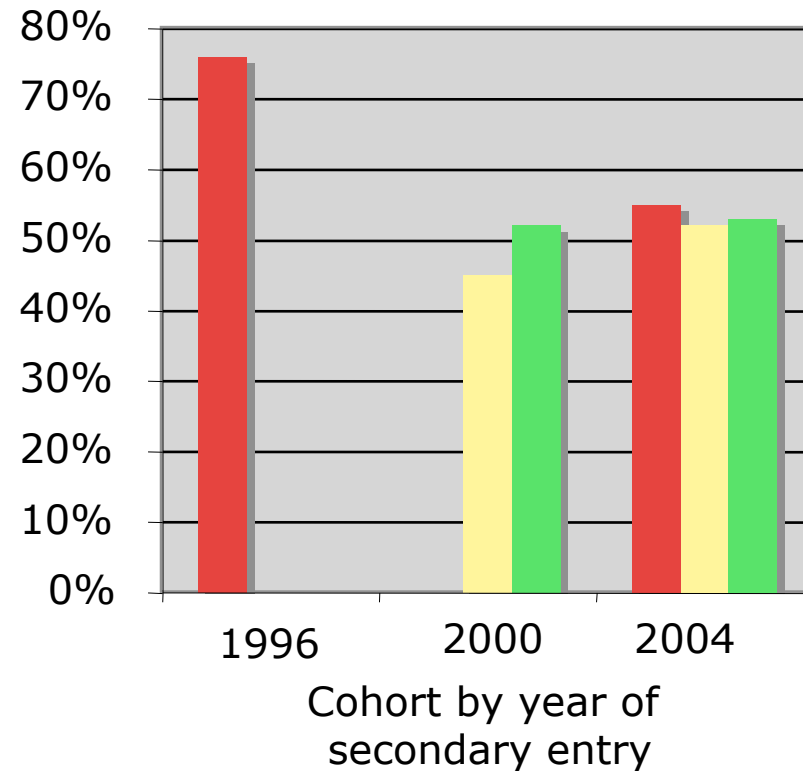
Value

Confident

Mathematics



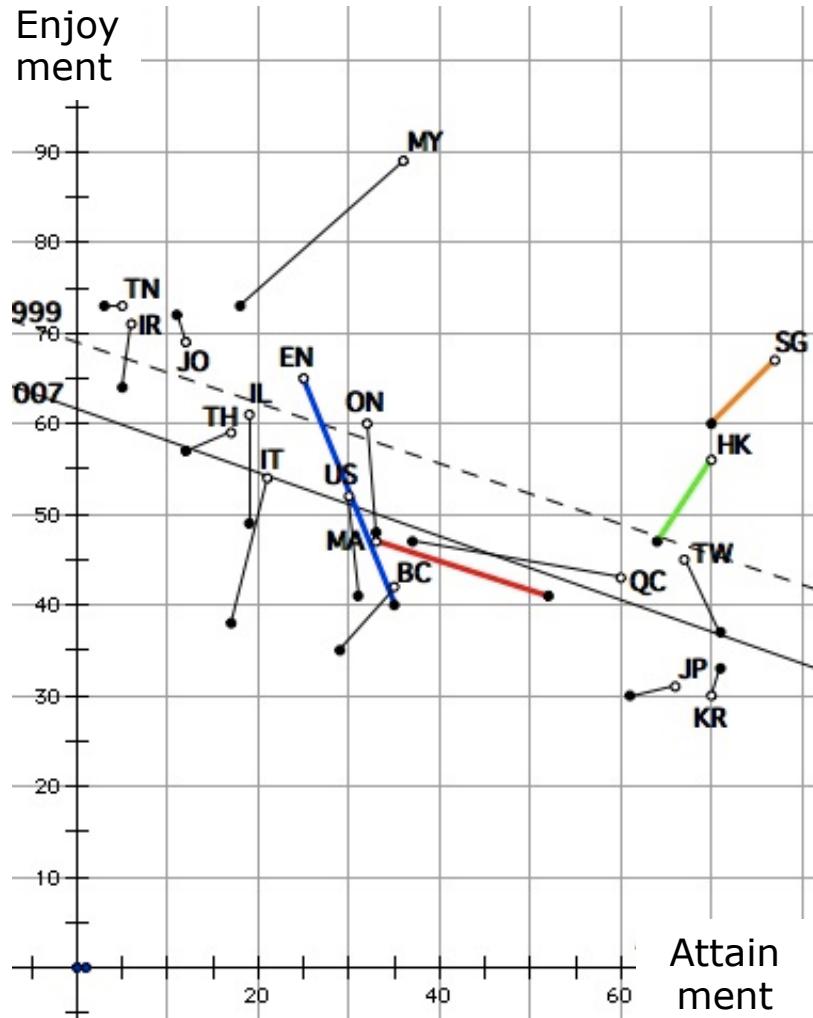
Science



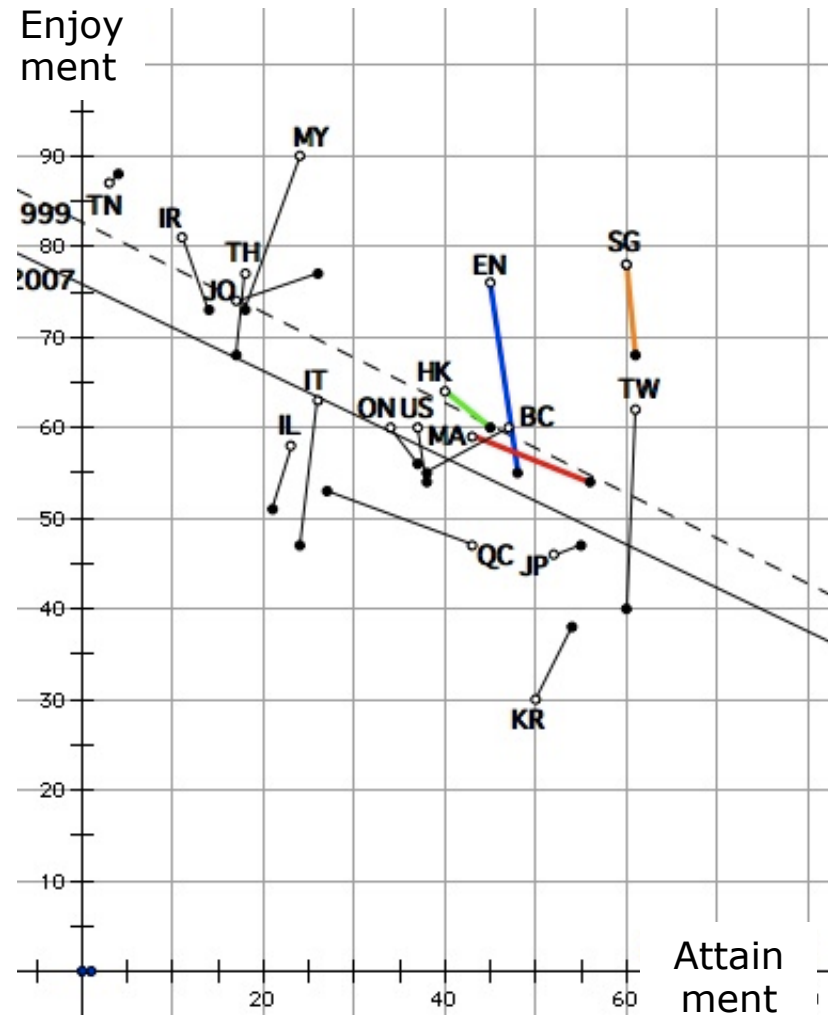
A controlled international overview: Systemic change between cohorts

TIMSS result
 ○ 1996 entry
 ● 2004 entry

Mathematics



Science



A controlled international overview: Systemic reform in Massachusetts

- Systemic improvement programme
 - based on establishing common professional standards and ambitious achievement targets
 - backed by extensive professional development and strong accountability mechanisms
- Normative pedagogical model
 - influenced by more recent research addressing development of higher-order thinking
 - as reflected in *Standards* developed by National Council of Teachers of Mathematics (1989, 2000) and National Academy of Sciences (1995)

Approaches to research synthesis

- Basic pedagogical model for National Strategies formulated through politicised process that filtered out more innovative and recently researched approaches
- Future policy and practice would benefit from taking account of more rigorous approaches to synthesis:
 - Systematic review
 - Best evidence synthesis iteration
 - Meta-analytic approaches

Approaches to research synthesis:

Systematic review

- Programme established by UK Department for Education via the Evidence for Policy and Practice Information and Coordination Centre (EPPI-Centre)
 - Follows standard stages
 - Aims to use explicit, transparent methods
 - Involves range of users to ensure relevance
- Example of the review of *Strategies to raise pupils' motivational effort in Key Stage 4 Mathematics*
 - Very specific focus over limited time period
 - 25 relevant studies identified
 - Only one study provided high weight of evidence

Approaches to research synthesis: Iterative best-evidence synthesis

- Programme established by NZ Ministry of Education
 - Uses research literature to identify what is effective in education for diverse learners
 - Adopts health-of-the-system view that requires dialogue across professional constituencies
- Example of *Effective Pedagogy in Mathematics*
 - Drew on NZ literature complemented by work from other countries with similar characteristics.
 - Identified seminal “landmark” studies to pinpoint how quality teaching might be characterised
 - Derived a common pedagogical principles that appear to hold good across people and settings

Approaches to research synthesis: Meta-analysis incl. best-evidence synthesis

- Meta-analysis is a well-established approach to summarising studies of the effects of teaching processes on student learning
 - systematically searches for relevant studies and screens them according to explicit criteria
 - classifies the types of teaching process and learning outcome in each accepted study
 - estimates effects through statistical aggregation
- Meta-analytic best-evidence synthesis (Slavin, 1986) adds summary description of each contributing study

Recent research synthesis on pedagogy: Triangulating the meta-analytic studies

	<i>Schroeder et al. (2007)</i>	<i>Seidel & Shavelson (2007)</i>	<i>Slavin et al. (2008, 2009)</i>
Subject	Science	Both Ma & Sc	Mathematics
Conceptual framework	Science teaching	Cognitive modelling	Instructional interventions
Teaching construct	Teaching strategies	Learning components	Instructional programs
Field location	Restricted: Only US	Unrestricted: Mainly US, Eur	Unrestricted: Mainly US
Public' n. date	1980-2004	1995-2004	1970-2008
Duration	Unrestricted	Unrestricted	At least 12 wks
Outcomes examined	Achievement	Achievement Attitude	Achievement

Recent research synthesis on pedagogy: Triangulating meta-analytic screening

	<i>Schroeder et al. (2007)</i>	<i>Seidel & Shavelson (2007)</i>	<i>Slavin et al. (2008, 2009)</i>
Research design(s) accepted	Experimental comparison or evaluation Prior control not required	Correlational survey or experimental comparison Prior control	Randomised or matched experimental comparison Prior control No large gaps
Effect sizes included	Relative Absolute	Relative only	Relative only
Outcome measures accepted	Unrestricted: Generally researcher developed	Unrestricted: Standardised & researcher developed	Screened for intervention bias: Mainly standardised

Recent research synthesis on pedagogy: Meta-analytic findings on attainment effects

	Mathematics		Science	
	<i>Slavin et al.</i>	<i>Seidel & Shavelson</i>	<i>Seidel & Shavelson</i>	<i>Schroeder et al.</i>
Domain-specific inquiry	No cognate category	0.37 [22]	0.63 [28]	0.65 [12]
Co-operative groupwork	0.36 [17]	-0.04 [42]	0.00 [35]	0.96 [3]
Enhanced context	No cognate category	No cognate category	No cognate category	1.48 [6]
Active teaching	0.43 [10]	No cognate category	No cognate category	— [0]

Recent research synthesis on pedagogy: Meta-analytic findings on attitude effects

	Mathematics	Science
	<i>Seidel & Shavelson</i>	<i>Seidel & Shavelson</i>
Domain-specific inquiry	— [<5]	0.35 [7]
Co-operative groupwork	0.02 [9]	0.41 [14]
Enhanced context	No cognate category	No cognate category
Active teaching	No cognate category	No cognate category

Recent research synthesis: Triangulating wider findings on identity and attitude

BES iteration on effective mathematics teaching

- Teaching that takes students' mathematical thinking seriously is underpinned by principles such as:
 - all students being empowered to develop mathematical identities and knowledge
 - interpersonal respect, sensitivity, fairness and consistency being shown to all students

EPPI review on motivational effort in mathematics

- Effective pedagogical strategies are characterised by:
 - a caring and supportive classroom climate
 - activities which pupils find challenging and enjoyable
 - pupils gaining deeper understanding of mathematics
 - opportunities for pupils to collaborate

Recent research synthesis: Triangulating wider findings on co-operative groupwork

BES iteration on effective mathematics teaching

- Small-group work can support engagement
- Students may need opportunities to think quietly
- Many students are reluctant to share their thinking

EPPI review of group discussions in science teaching

- Students often struggle to express coherent arguments, and demonstrate a low level of engagement with tasks
- Groups function best, understanding improves most:
 - with groups constituted so that differing views voiced
 - when students receive training on group processes
 - when “cues” support the structuring of discussions

Research-informed conclusions for pedagogical improvement at scale

- In mathematics, varied sources agree that the active teaching model promoted by the Strategies is effective in securing content knowledge and skills but less so in developing higher-order and functional thinking
- There is little support for this teaching model in science
- Domain-specific enquiry that takes students' thinking seriously strengthens attainment and (plausibly) attitude
- Co-operative groupwork strengthens attainment and (at least in science) attitude, as long as students are properly prepared and activity well supported
- Enhanced context, linked to student experiences and interests, is beneficial (at least for science attainment)



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