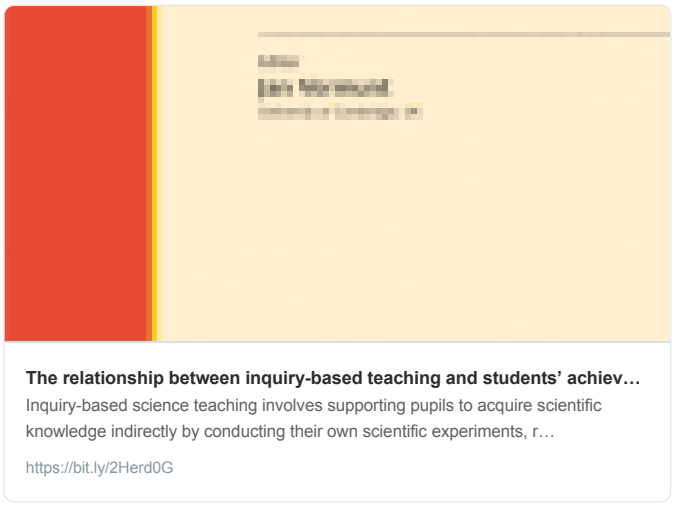
Sam Sims @DrSamSims

15 Jan 19 • 12 tweets • DrSamSims/status/1085147982805250048

Everyone agrees that science is important. But many disagree on the best way to teach it.

Thread on a new paper

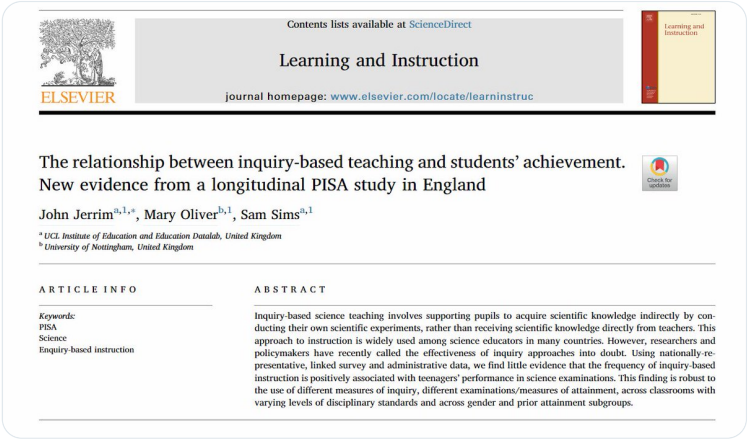


The relationship between inquiry-based teaching and students' achiev…

Inquiry-based science teaching involves supporting pupils to acquire scientific knowledge indirectly by conducting their own scientific experiments, r…

https://bit.ly/2Herd0G

with @JohnPeterJerrim and @Mary_C_Oliver 👇



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The relationship between inquiry-based teaching and students' achievement. New evidence from a longitudinal PISA study in England

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ABSTRACT

Inquiry-based science teaching involves supporting pupils to acquire scientific knowledge indirectly by conducting their own scientific experiments, rather than receiving scientific knowledge directly from teachers. This approach to instruction is widely used among science educators in many countries. However, researchers and policymakers have recently called the effectiveness of inquiry approaches into doubt. Using nationally-representative, linked survey and administrative data, we find little evidence that the frequency of inquiry-based instruction is positively associated with teenagers' performance in science examinations. This finding is robust to the use of different measures of inquiry, different examinations/measures of attainment, across classrooms with varying levels of disciplinary standards and across gender and prior attainment subgroups.

One big disagreement is between:

1) Direct instructors: knowledge should be imparted directly by teachers (because, cognitive load theory)

2) Inquiry-based teachers: knowledge should be acquired indirectly, by conducting experiments (because, more meaningful).

🤔

We investigate the link between inquiry teaching & science achievement using nationally representative data on 4000 pupils. NB: it's an observational (not experimental) study. But we use v good prior achievement measures, rich controls & compare pupils within the same schools.

We define inquiry-based teaching using the standard NSES definition and measure it using a single score summarising 9 questions from PISA pupil surveys (see below). We split pupils into four categories based on frequency of inquiry-based teaching experienced (lowest to highest).

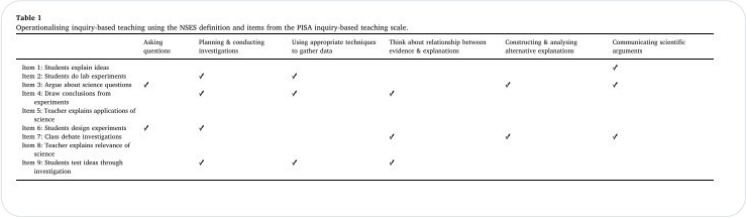

Table 1
Operationalising inquiry-based teaching using the NSES definition and items from the PISA inquiry-based teaching scale.

	Asking questions	Planning & conducting investigations	Using appropriate techniques to gather data	Think about relationship between evidence & explanations	Constructing & analysing alternative explanations	Communicating scientific arguments
Item 1: Students explain ideas						✓
Item 2: Students do lab experiments		✓	✓			
Item 3: Argue about science questions	✓				✓	✓
Item 4: Draw conclusions from experiments		✓	✓	✓		
Item 5: Teacher explains applications of science						
Item 6: Students design experiments	✓	✓				
Item 7: Class debate investigations				✓	✓	✓
Item 8: Teacher explains relevance of science						
Item 9: Students test ideas through investigation		✓	✓	✓		

Main results. Focus on Model 4, which uses best controls. 0.02 in the Third Quartile row = "being in second highest quartile of inquiry associated w/ +0.02 effect size in achievement, compared to lowest quartile". Associations all small & not statistically distinguishable from 0.

Table 2
Estimated association between inquiry-based teaching and students' GCSE science grades.

	Model 1		Model 2		Model 3		Model 4	
	Effect	SE	Effect	SE	Effect	SE	Effect	SE
Inquiry-teaching scale								
Bottom quartile (Reference)	Reference		Reference		Reference		Reference	
Second quartile	**0.11***	**0.04**	**0.06***	**0.03**	**0.05***	**0.02**	0.02	0.02
Third quartile	**0.16***	**0.04**	**0.09***	**0.03**	**0.06***	**0.03**	0.02	0.03
Top quartile (extensive use)	−0.05	0.04	**0.10***	**0.03**	**0.10***	**0.03**	0.06	0.03
Observations	4361		4361		4361		4361	
Controls								
Demographics	Yes		Yes		Yes		Yes	
Key Stage 2 scores	–		Yes		Yes		Yes	
PISA science scores	–		Yes		Yes		Yes	
Science subjects studied	–		Yes		Yes		Yes	
School fixed effects	–		–		Yes		Yes	
Science study minutes	–		–		–		Yes	
Sense of belonging	–		–		–		Yes	
Test anxiety	–		–		–		Yes	
Parent emotional support	–		–		–		Yes	
Before school activities	–		–		–		Yes	
After school activities	–		–		–		Yes	
Perception teacher fairness	–		–		–		Yes	

Notes: All figures in the effect column can be interpreted in terms of effect sizes. SE = Standard error. Bold coefficients with a * indicate p < 0.05.

Is relationship stronger for prior-achievement / FSM subgroups? No ❌

Is it stronger in schools with better behaviour? Not consistently ❌

Is it stronger using PISA tests of "real world" sci skills instead of GCSE? No ❌

(b) PISA science scores as outcome

	Model 1		Model 2		Model 3		Model 4	
	Effect	SE	Effect	SE	Effect	SE	Effect	SE
Inquiry-teaching scale								
Bottom quartile (Reference)	Reference		Reference		Reference		Reference	
Second quartile	**0.10***	**0.04**	**0.08***	**0.03**	**0.07***	**0.03**	0.04	0.03
Third quartile	**0.08***	**0.04**	0.05	0.03	0.05	0.03	0.02	0.03
Top quartile (extensive use)	**−0.22***	**0.04**	**−0.10***	**0.03**	**−0.09***	**0.03**	**−0.10***	**0.03**
Observations	4977		4977		4977		4977	

Some defenders of inquiry claim pupils should still acquire knowledge through inquiry, but must be told precisely how to do it (bit.ly/1iTsM2S). We find some *suggestive* evidence that moderate levels of inquiry + high guidance relate to improved achievement.

Table 3
Estimated association between different types of inquiry-based teaching practices and students GCSE science grades.

Guidance Measures	Low Guidance			High guidance		
	Q2	Q3	Q4	Q2	Q3	Q4
The teacher gives students extra help when they need it	**0.17*** (0.07)	0.09 (0.10)	−0.10 (0.12)	0.02 (0.04)	0.04 (0.04)	0.02 (0.04)
A whole class discussion takes place with the teacher	0.02 (0.04)	0.01 (0.04)	−0.02 (0.05)	0.09 (0.07)	**0.16*** (0.07)	0.12 (0.06)
The teacher tells me how to improve my performance	0.02 (0.04)	0.03 (0.04)	0.03 (0.05)	0.07 (0.05)	0.09 (0.05)	0.06 (0.05)
The teacher advises me how to reach my learning goals	0.03 (0.04)	0.01 (0.04)	0.02 (0.05)	0.09 (0.05)	**0.12*** (0.05)	0.08 (0.05)

Notes: All coefficients can be interpreted in terms of effect sizes, with the lowest discovery quartile as the reference group. Standard errors are shown in parentheses. Bold coefficients with a * indicate $p < 0.05$. Estimates all based upon model specification 4 (see notes to Table 2 for further details on controls included). Q2, Q3 and Q4 refers to quartiles of the inquiry teaching scale.

Our study suggests that if inquiry-based science teaching is used at all, it should be sparingly and only with high levels of guidance. Teachers can provide guidance by: reducing no. of pupil decisions; modelling & using worked examples; timed prompts to direct pupil attention.

Our results are consistent with experimental evidence (

Meta-Analysis of Inquiry-Based Learning: Effects of Guidance - Ard W.…
Research has consistently shown that inquiry-based learning can be more effective than other, more expository instructional approaches as long as students are s...

https://bit.ly/2HbhZ5C

) & predictions of cog load theory. We add to this by using representative data on inquiry as implemented in real classrooms, rather than among experimental subjects in controlled settings.

Our research has important limitations – not least the observational nature of the data. Future research should also look at the relationship between inquiry-based teaching and pupil progression to post-compulsory science. Our research is silent on this important outcome 👨‍🔬👩‍🔬

Thanks @NuffieldFound for supporting this study. CC: @DrDavidBoyce @FergusonMr1 @profbeckyallen @cazgerrard @EfratFurst @A_Weatherall @StaufenbergJ @primarypercival @teacherhead @HFletcherWood @CatScutt @tombennett71 @adamboxer1 @chemDrK @whazell

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