# Improving young people's STEM engagement and participation: A *science capital* approach

Professor Louise Archer

Karl Mannheim Professor of Sociology of Education

UCL Institute of Education, UK

ASPIRES 2
science and career aspirations: age 10-19

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

# Why do we need to improve young people's relationship with STEM?

- The STEM participation 'crisis' – key issue for governments, employers and industry internationally
- STEM skills 'gap' – important for national economic prosperity and social mobility
- Social justice argument – currently participation is uneven (esp. in physical science, computing and engineering), we need to address inequalities by gender, social class and ethnicity
- Importance of science literacy for active citizenship

# Science aspirations

- Lots of time and money has been invested in efforts designed to engage more young people with science …
- … but little change in participation rates (and participation profile)
- Most initiatives have focused in trying to increase interest in science (make it ‘fun’)
- But our research suggests this is not the main issue …

# Aspires/ Aspires 2 study

Ten year study of children's science and career aspirations

**Phase 1 (age 10/11)**

- Survey of 9,319 Y6 students, 279 primary schools, England
- Interviews with 92 children and 84 parents

**Phase 2 (age 12/13)**

- Survey of 5,634 Y8 students (69 secondary schools)
- Interviews with 85 children

**Phase 3 (age 13/14)**

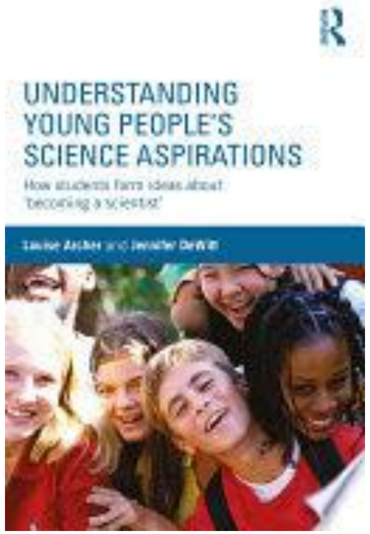
- Survey of 4,600 Y9 students
- Interviews with 83 students and 73 parents

**Phase 4 (age 15/16)**

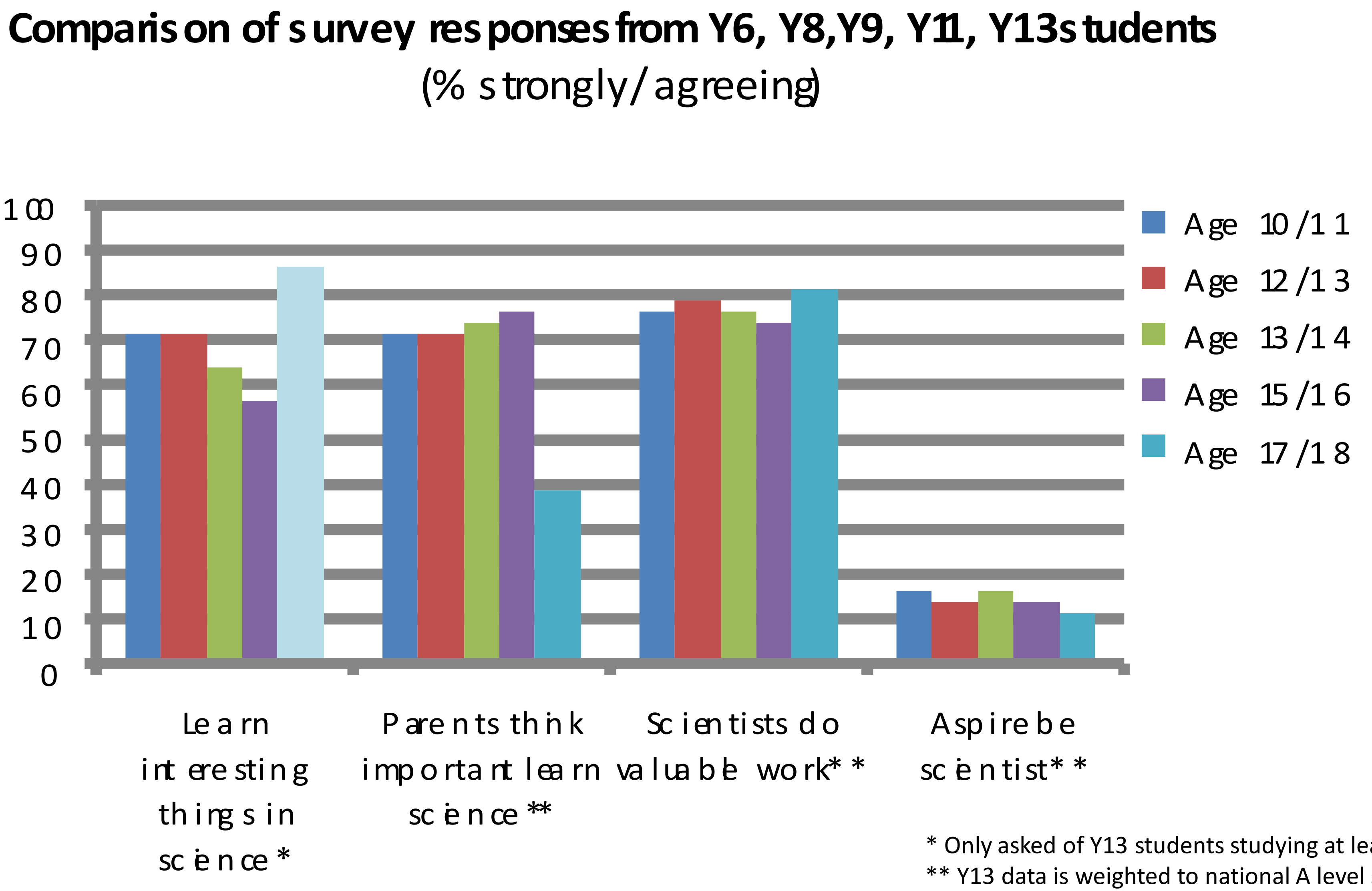
- Survey of 13,421 Y11 students
- Interviews with 70 students and 67 parents

**Phase 5 (age 18/19)**

- Survey of 7,013 Y13 students
- Interviews with 61 students and 65 parents

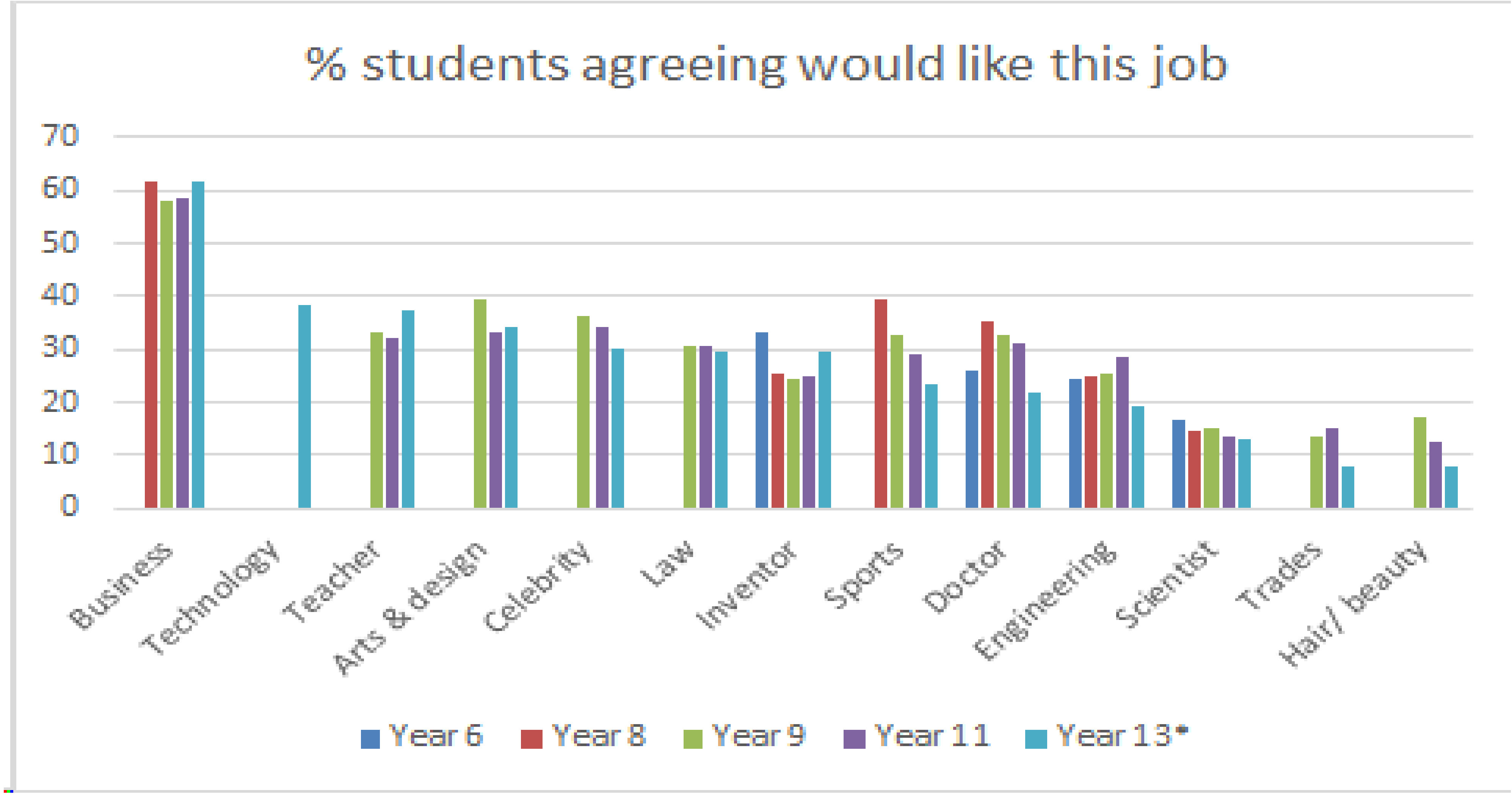


# Science is interesting – but not for me



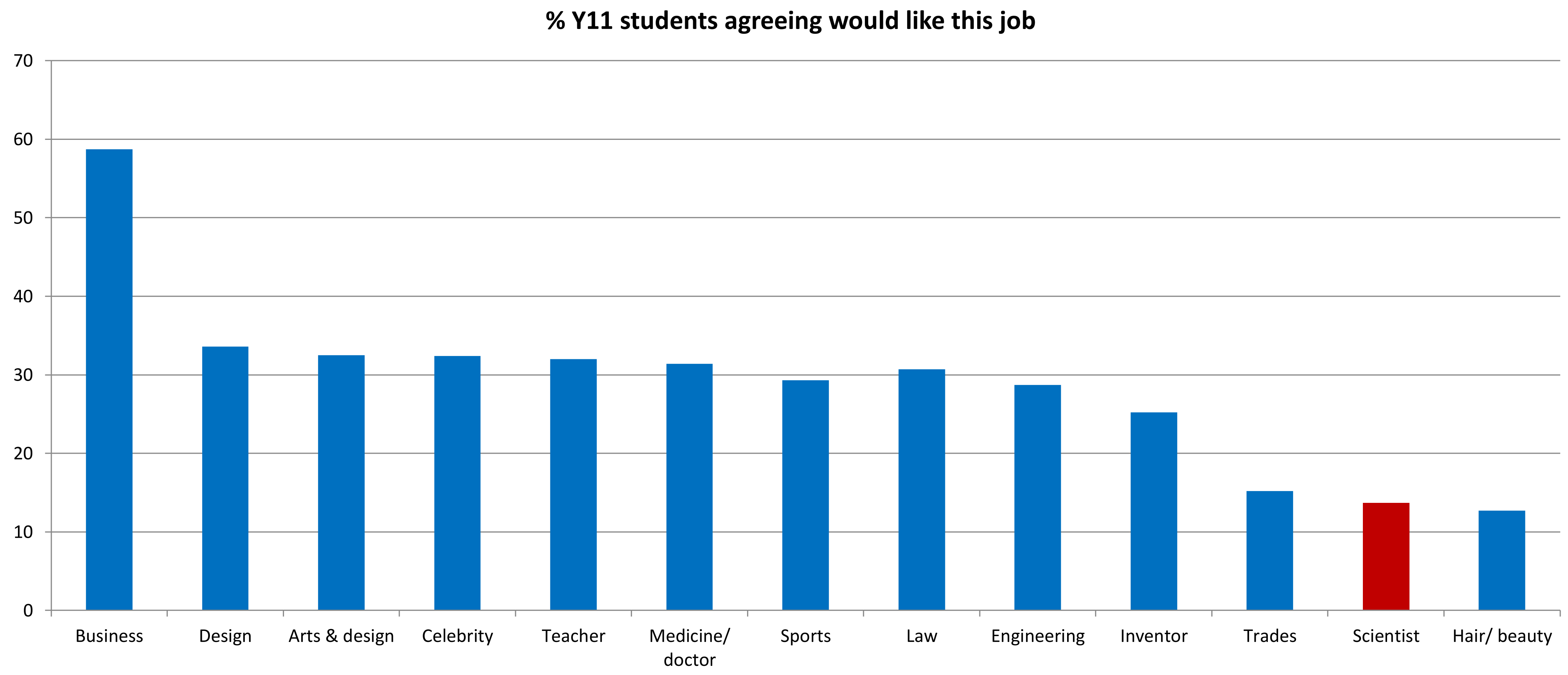

* Only asked of Y13 students studying at least one science A level
** Y13 data is weighted to national A level science entries

# Aspirations age 10 -18




* Y13 data is weighted to national A level science entries

# What careers do students aspire to?



# What shapes these patterns?

- Schools, teachers and education system
- Careers education
- Popular representations
- ‘Science capital’

# Schools, teachers and education system

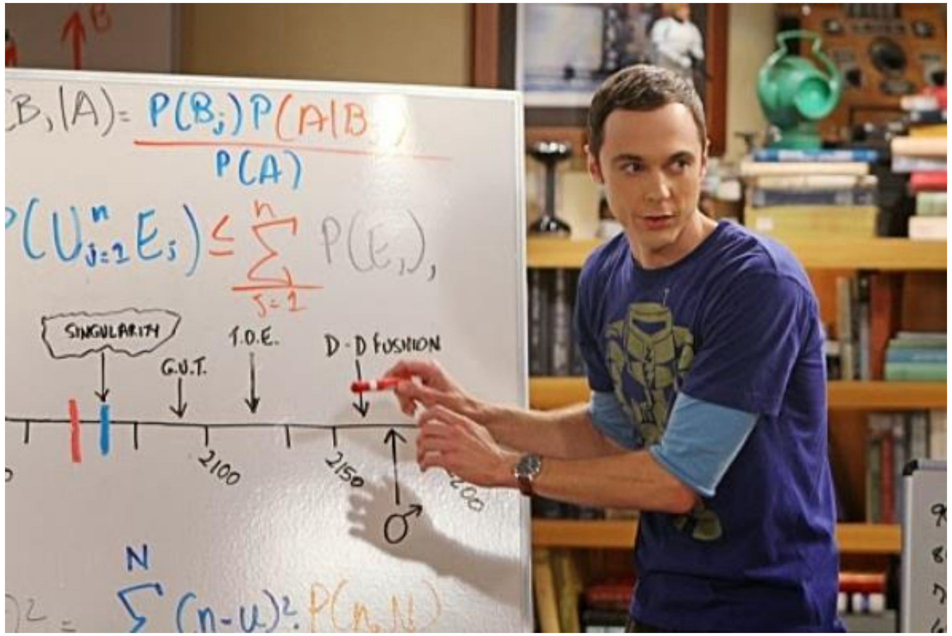
- Differential expectations and stereotyping (e.g. ‘you need a boy brain to study physics’; see also Heidi Carlone’s research)
- Teacher supply, retention and specialism
- In England:
  - Stratification of science age 13 (‘Double’ and ‘Triple’ routes – school choice and channelling; inequalities in which schools can offer high status Triple);
  - Restrictive entry / gatekeeping to Advanced Level Physics;
  - Grade severity in Advanced Level Physics;
  - Culture of early specialisation

# Careers Education – patchy and patterned


- Cuts to provision in England
- Not reaching all students (e.g. 63% of age 15/16 year olds report careers education)
- Girls, minority ethnic, working-class students, those in the lower sets, and those planning on leaving education post-16 are all significantly less likely to report receiving careers education
- ‘Too little, too late’
- Problem of self-referral model
- Perceptions of generality and bias

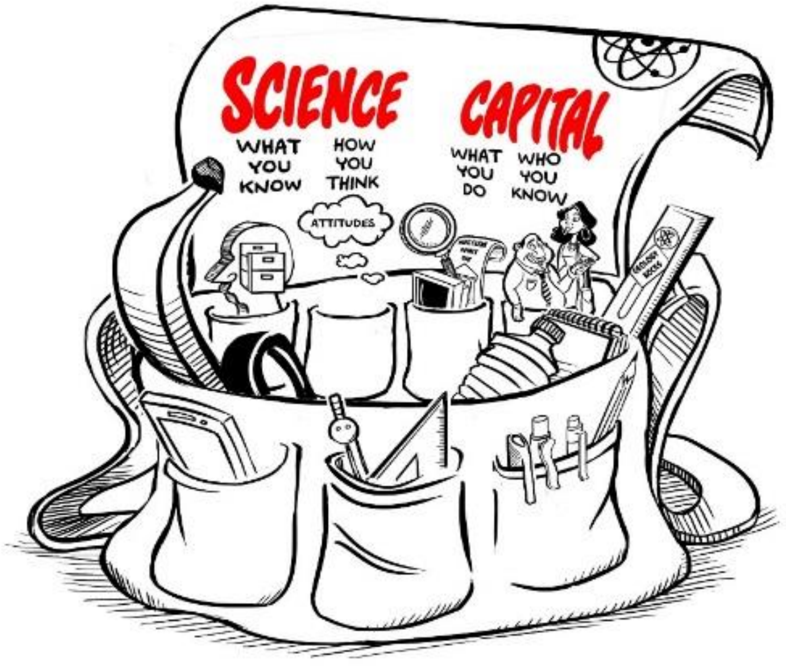
# Popular representations

- Alignment of physics and engineering with (white) middle-class masculinity
- The ‘genius’ physicist (white, male, middle-class)
- Also reinforced through the structures and practices of school science



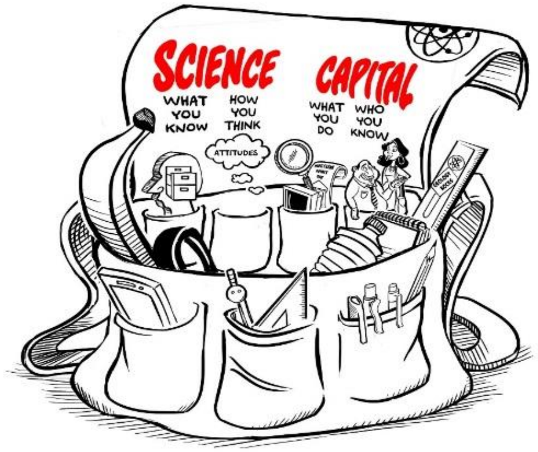
# Science capital

- Developed in Aspires project and extended in Enterprising Science project
- ‘Science capital’ is a ‘conceptual holdall’, combining habitus, cultural and social forms of capital
- Nationally, about 5% of 11-15 year olds have high science capital and 27% low science capital
- The more science capital a student has, tl more (significantly) likely they are to aspi to post-16 science and have a ‘science identity’



# Main dimensions of science capital

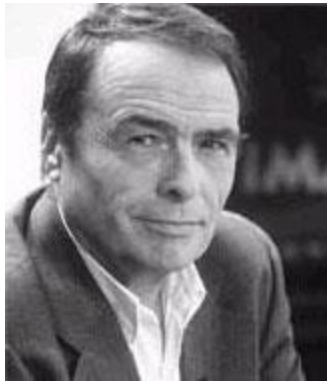
1. Science literacy (“what you know”)
2. Science-related attitudes and values (“how you think”)
3. Out of school science behaviours (“What you do”)
4. Science at home (“who you know”)



# ‘STEM capital’

- The more science capital a student has, the more (significantly) likely they are to aspire to post-16 science and have a ‘science identity’
- *Emergent ASPIRES2 analyses of age 17/18 year old data set:* Science capital relates particularly strongly to attitudes and aspirations in Science and Engineering, but also relates to attitudes/aspirations in technology and mathematics
- Within ‘science’, science capital most strongly predictive of Physics participation. Also strong link with engineering
- E.g. High science capital students are 10.5x more likely to intend to study physics at university and 4.4x more likely to study engineering
- Students with high science capital had significantly higher cumulative maths, engineering, and technology perceptions than students with medium and low science capital

# A sociological lens



Interactions of *habitus*, *capital* and *field* produce patterns in science engagement and participation:

- ***Habitus*** - socialised, embodied dispositions shape whether science is 'for me', or not, formed through classed, gendered, racialized experiences: Gives a 'feel for the game'
- ***Capital*** – cultural, social economic and symbolic resources possessed and accrued, shaped by social axes: the 'hand' you can play in the game
- ***Field*** – socio-spatial 'space of positions and position-taking': the 'rules' of the game

Extent of 'fit' between habitus, capital and field shapes whether students experience education as a 'fish in water', or not and produces differential trajectories

# Habitus

- Socialisation and inculcation over time - power of habitual practices and values ("what people like us do")
- Daily reinforcement of some career paths as more 'natural' or 'thinkable' for particular children. Eg. Girls and nurturing professions
- Particularly shaped by home and school

# Interaction of habitus + capital

- Produces sense of whether science is for ‘people like me’, or not
- Differences between high and low science capital families:

“The other day in the car we were laughing about chemical symbols and things, so I guess it does come into the discussion quite subliminally really” (Mother, white middle class).

“Science is just where it’s at in my family” (Davina, white, middle-class)

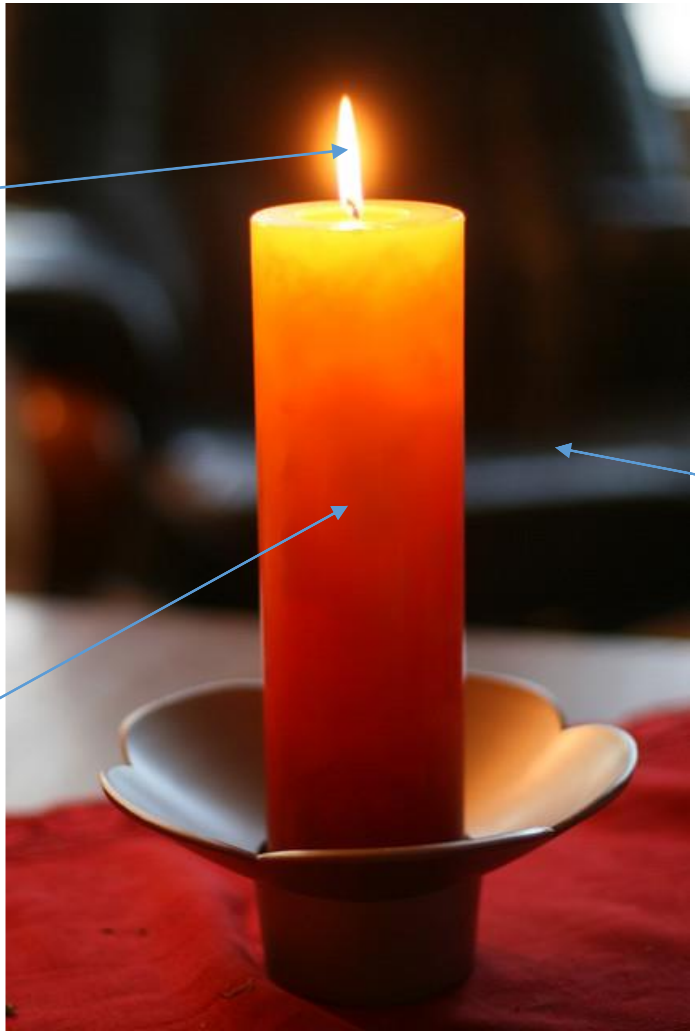
“I suppose in everyday life you don’t get that much to do with it [science]” (Mother, white, working class)

“They never talk about science” (Jack, Black, working-class)

# Interaction with the ‘field’

- Elitism and specialisation in the English education system makes it difficult to continue with science!
- System advantages those with high science capital
- ‘Non-traditional’ students are both channelled and ‘self-select’ out of STEM

# An analogy



Educator = heat

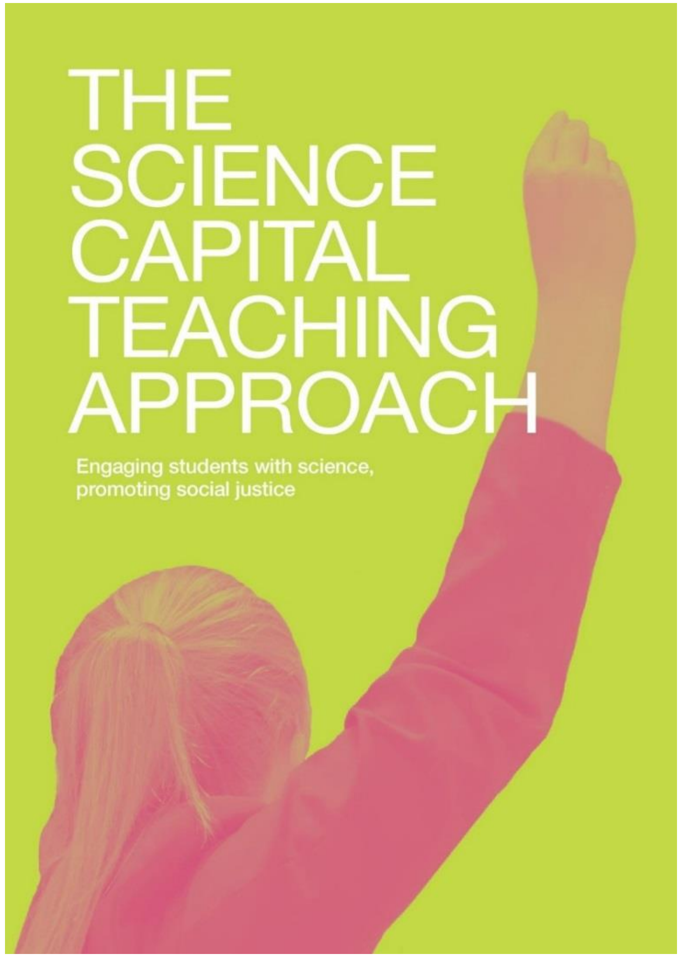
**ENGAGEMENT = burning flame** (produced at interface of habitus, capital and field)

**FIELD = air and conditions around the candle (oxygen, wind, etc)** Influences if and how the candle burns (e.g. how bright, how long, flickering or steady)

**HABITUS & CAPITAL = candle ('fuel'):** socialised dispositions, and (science-related) economic, social and cultural resources

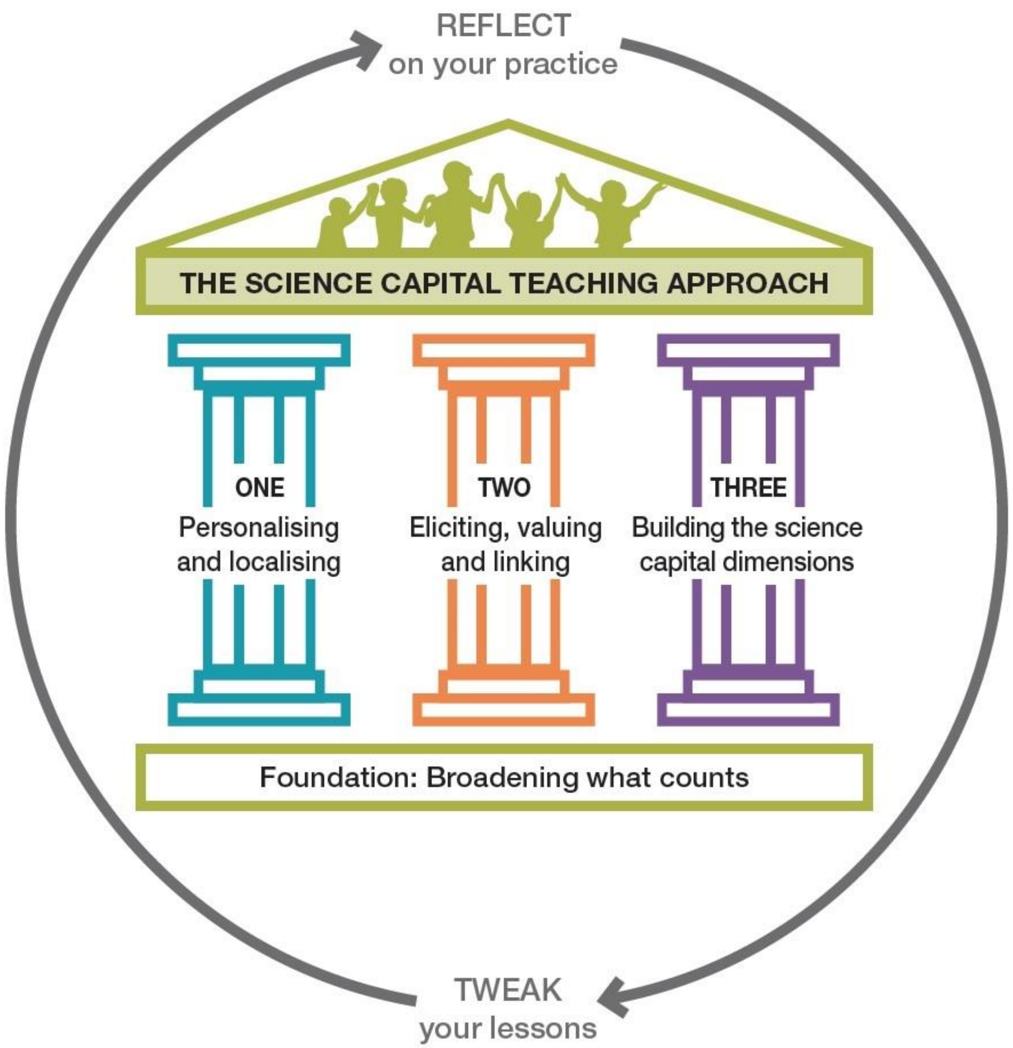
# What can be done?

# The Science Capital Teaching Approach



# Enterprising Science project

- Integrates existing good teaching practice with science capital theory and evidence
- Worked 43 secondary science teachers over four years to co-develop a science capital teaching approach. Two year long trials:
- 2015/16 London data: 9 London secondary science teachers and their classes, c.200 students
- 2016/17 Northern schools data: 16 secondary science teachers and their classes, c. 480 students
- Professional development model (2 x Saturday sessions plus regular support)
- Data collection over 9 month academic year: teacher observations, student discussion groups, teacher and student individual interviews, student surveys (beginning and end of year)


REFLECT
on your practice
THE SCIENCE CAPITAL TEACHING APPROACH
ONE
Personalising and localising
TWO
Eliciting, valuing and linking
THREE
Building the science capital dimensions
Foundation: Broadening what counts
TWEAK
your lessons

# Foundation: Broadening what counts

- Students do not just find science concepts difficult – some struggle to identify and engage with science, it feels alien to them
- First step is to change the *field*, rather than the student
- Recognise broader range of experiences, skills and behaviours as legitimate
- Challenge stereotypes and dominant ideas and representations of science, such as ‘who does science’ and what constitutes ‘doing’ science.

# Why broaden what counts? (Carlone et al.)

| | 4th Grade: Ms Wolfe | 6th Grade: Mr. Campbell |
|---|---|---|
| Teaching approach | Encouraging students to share their knowledge and ideas, ask questions, engage in collaborative, active inquiry | More traditional approach (teacher initiation, student response, teacher evaluation), emphasis on compliance, bookwork |
| Teacher role | Co-learner/facilitator | Authority/expert |
| Who is 'scientific'? | Those who ask good questions | Well-behaved and articulate |
| **Aaliyah (African-American girl)** | *Enthusiastic, engaged, active and creative questioning* | *Disengages from science, cannot 'fit' with celebrated subject positions* |
| **Amy (White, middle-class girl)** | *Top student, problem-solver* | *Near perfect performer – but less scientific behaviours (less questioning, creating experiments etc.), just 'doing school'* |
| **William (Latino boy)** | *Conscientious, good student, tries to understand not just complete tasks* | *Studious and conscientious but not seen as 'good at science' by teacher because seen as too cautious and quiet* |

US-based study from Carlone, Scott and Lowder (2014)

# Pillar One: Personalise and Localise

- Go beyond contextualising science - personalise and localise it to make relevant to students’ everyday lives
- ‘When a child’s worldview is left unvalued and expressionless in an educational setting, what should we expect in terms of engagement, investment and learning from that child?’ (Calabrese Barton et al., 2011, p.5)

# Examples

- Teachers facilitate examples that are meaningful to their particular students
- E.g. Mr. Hobbes' East London – 'chicken and rice!"
- Local area, football, beauty, etc – Newcastle
- Farming/ rural – Leeds area
- Family, self (e.g. personal health and experiences), leisure activities, things feel 'good at' in outside life – across all

# Pillar Two: Elicit, Value and Link

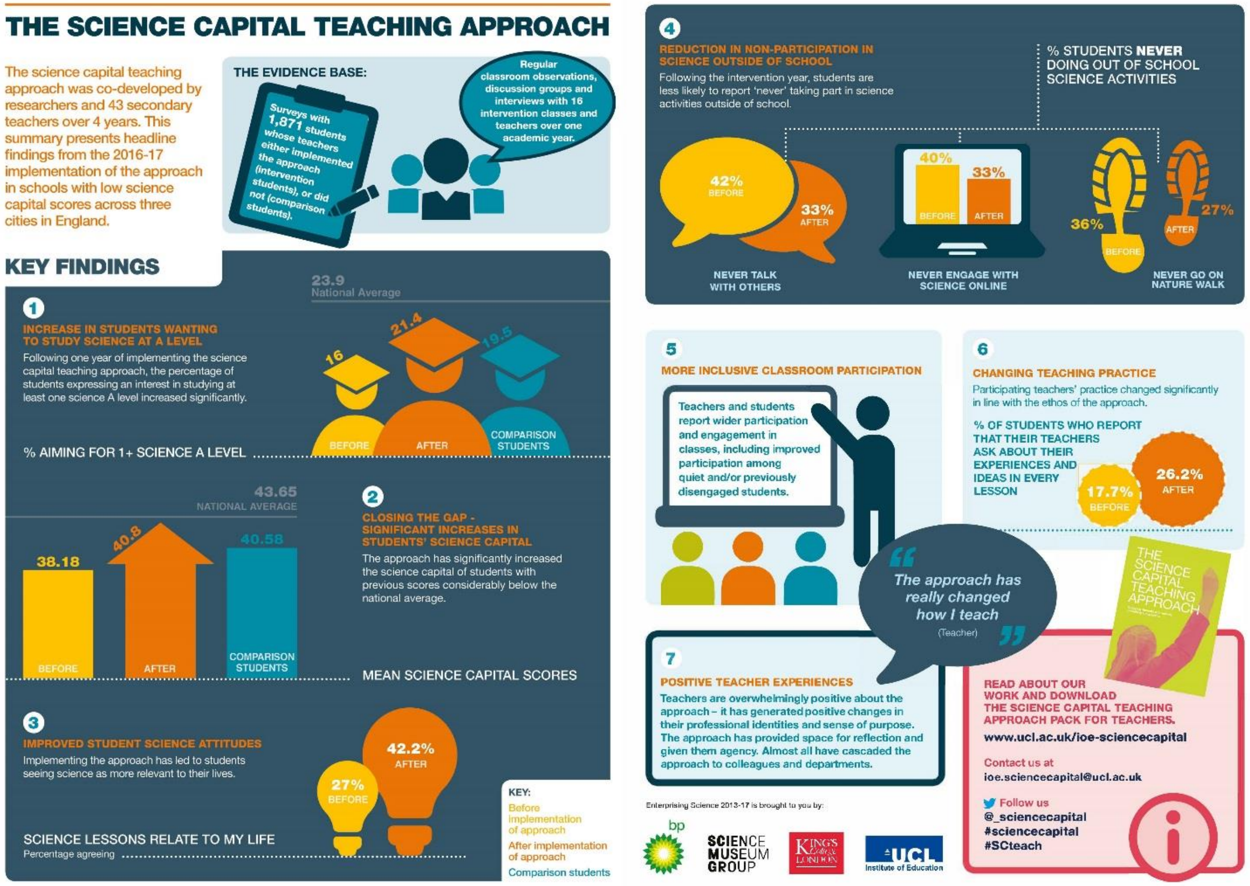
- A technique for helping to broaden what counts and personalise and localise
- Way to support students to feel valued and connected to science
- Teachers elicit student experiences, skills and home knowledge (what students ‘bring with them’) in relation to a topic, value (and legitimate) these, and highlight the science connections

# Pillar Three: Building the science capital dimensions

- Actively cultivate, develop and build science capital dimensions
- E.g. build students' understanding of how science is everywhere in life; build awareness of the transferability of science to any job

- Examples of how teachers applied these ideas in their classes plus annotated lesson plans and resources are all available in the handbook
- 2 minute animation explaining the approach
- Short film made with our teachers about their experience of applying the approach
- All available on: http://www.ucl.ac.uk/ioe/departments-centres/departments/education-practice-and-society/science-capital-research/science-capital-teaching-approach-pack

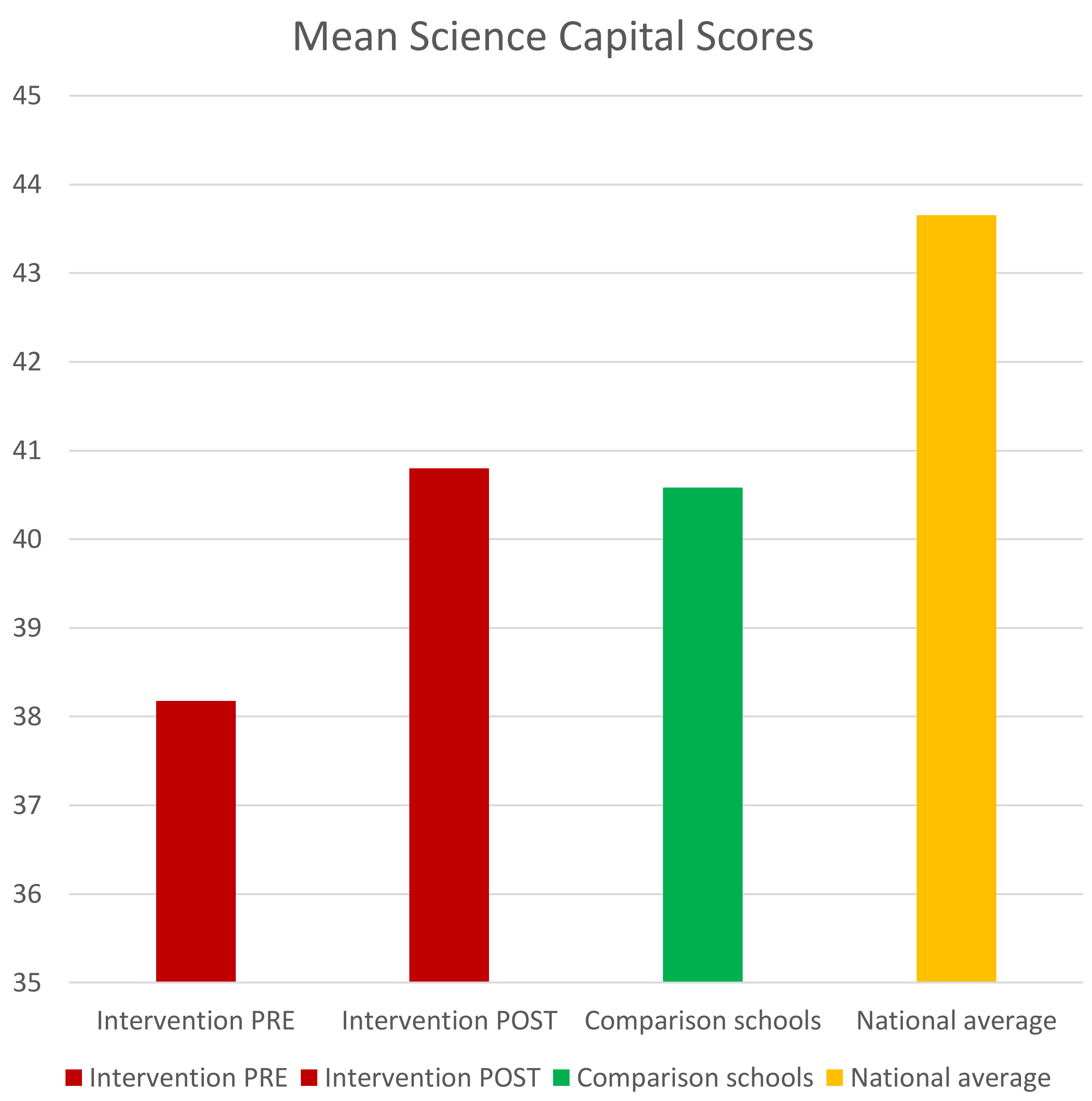
# Outcomes



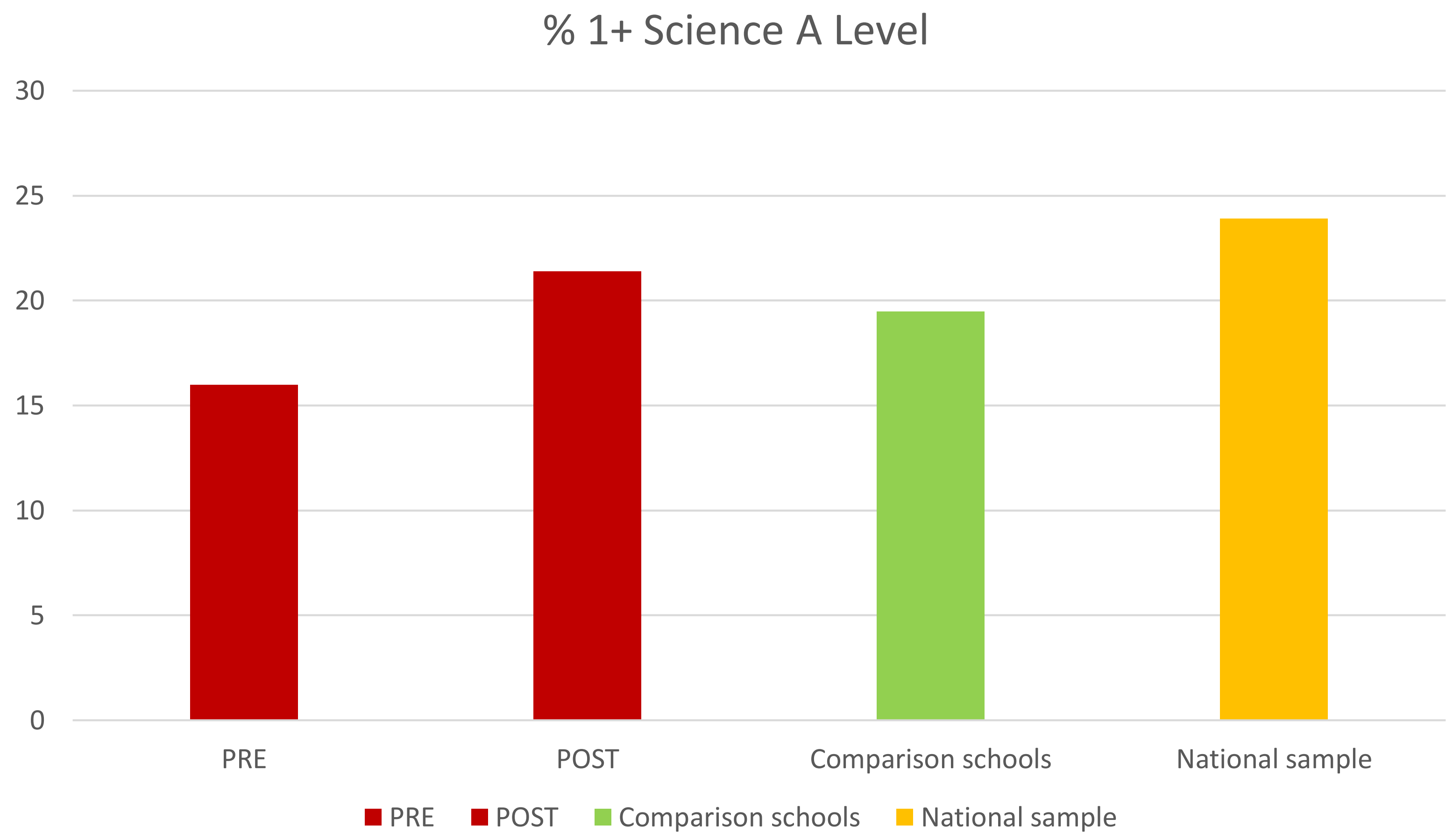
THE SCIENCE CAPITAL TEACHING APPROACH
The science capital teaching approach was co-developed by researchers and 43 secondary teachers over 4 years. This summary presents headline findings from the 2016-17 implementation of the approach in schools with low science capital scores across three cities in England.
THE EVIDENCE BASE:
Surveys with 1,871 students whose teachers either implemented the approach (intervention students), or did not (comparison students).
Regular classroom observations, discussion groups and interviews with 16 intervention classes and teachers over one academic year.
KEY FINDINGS
1
INCREASE IN STUDENTS WANTING TO STUDY SCIENCE AT A LEVEL
Following one year of implementing the science capital teaching approach, the percentage of students expressing an interest in studying at least one science A level increased significantly.
23.9 National Average
16
21.4
19.5
BEFORE
AFTER
COMPARISON STUDENTS
% AIMING FOR 1+ SCIENCE A LEVEL
43.65 NATIONAL AVERAGE
38.18
40.8
40.58
BEFORE
AFTER
COMPARISON STUDENTS
2
CLOSING THE GAP - SIGNIFICANT INCREASES IN STUDENTS' SCIENCE CAPITAL
The approach has significantly increased the science capital of students with previous scores considerably below the national average.
MEAN SCIENCE CAPITAL SCORES
3
IMPROVED STUDENT SCIENCE ATTITUDES
Implementing the approach has led to students seeing science as more relevant to their lives.
42.2% AFTER
27% BEFORE
SCIENCE LESSONS RELATE TO MY LIFE
Percentage agreeing
KEY:
Before implementation of approach
After implementation of approach
Comparison students
4
REDUCTION IN NON-PARTICIPATION IN SCIENCE OUTSIDE OF SCHOOL
Following the intervention year, students are less likely to report 'never' taking part in science activities outside of school.
% STUDENTS NEVER DOING OUT OF SCHOOL SCIENCE ACTIVITIES
42% BEFORE
33% AFTER
NEVER TALK WITH OTHERS
40% BEFORE
33% AFTER
NEVER ENGAGE WITH SCIENCE ONLINE
36% BEFORE
27% AFTER
NEVER GO ON NATURE WALK
5
MORE INCLUSIVE CLASSROOM PARTICIPATION
Teachers and students report wider participation and engagement in classes, including improved participation among quiet and/or previously disengaged students.
6
CHANGING TEACHING PRACTICE
Participating teachers' practice changed significantly in line with the ethos of the approach.
% OF STUDENTS WHO REPORT THAT THEIR TEACHERS ASK ABOUT THEIR EXPERIENCES AND IDEAS IN EVERY LESSON
17.7% BEFORE
26.2% AFTER
The approach has really changed how I teach
(Teacher)
7
POSITIVE TEACHER EXPERIENCES
Teachers are overwhelmingly positive about the approach – it has generated positive changes in their professional identities and sense of purpose. The approach has provided space for reflection and given them agency. Almost all have cascaded the approach to colleagues and departments.
THE SCIENCE CAPITAL TEACHING APPROACH
READ ABOUT OUR WORK AND DOWNLOAD THE SCIENCE CAPITAL TEACHING APPROACH PACK FOR TEACHERS.
www.ucl.ac.uk/ioe-sciencecapital
Contact us at
ioe.sciencecapital@ucl.ac.uk
Follow us
@_sciencecapital
#sciencecapital
#SCteach
Enterprising Science 2013-17 is brought to you by:
bp
SCIENCE MUSEUM GROUP
KING'S College LONDON
UCL Institute of Education

- Teachers changed their practice (qualitative and quantitative evidence)
- “That’s been a best part, you know - it really has changed how I teach” (Ms. Smith)
- Students agree that also notice consistent changes in practice in line with the approach (“going off topic”)
  - “She teaches you based on what you know”
  - “Like she's linking it [science] to jobs that we can have, that was quite interesting”.

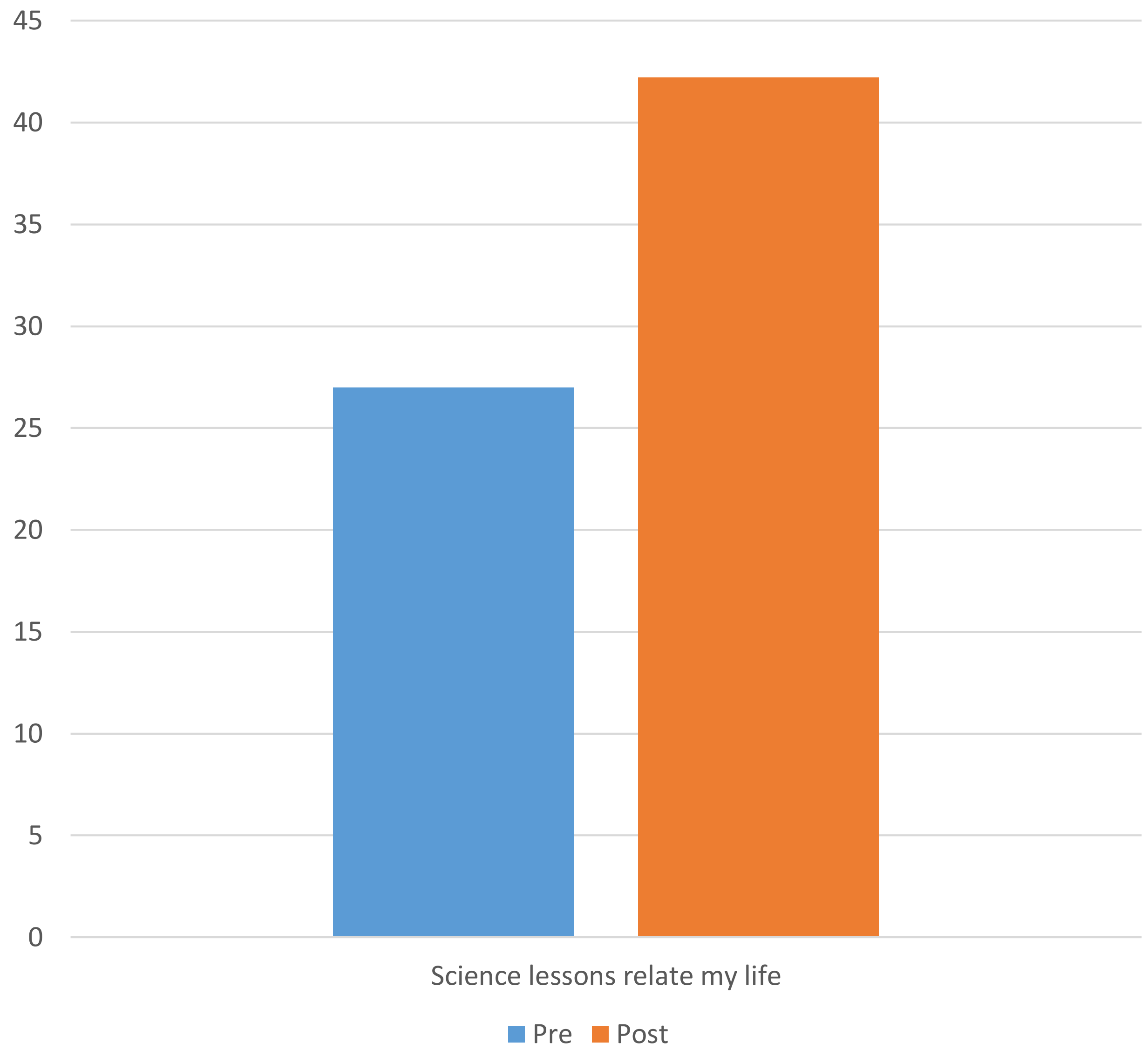
- Student science capital significantly increased



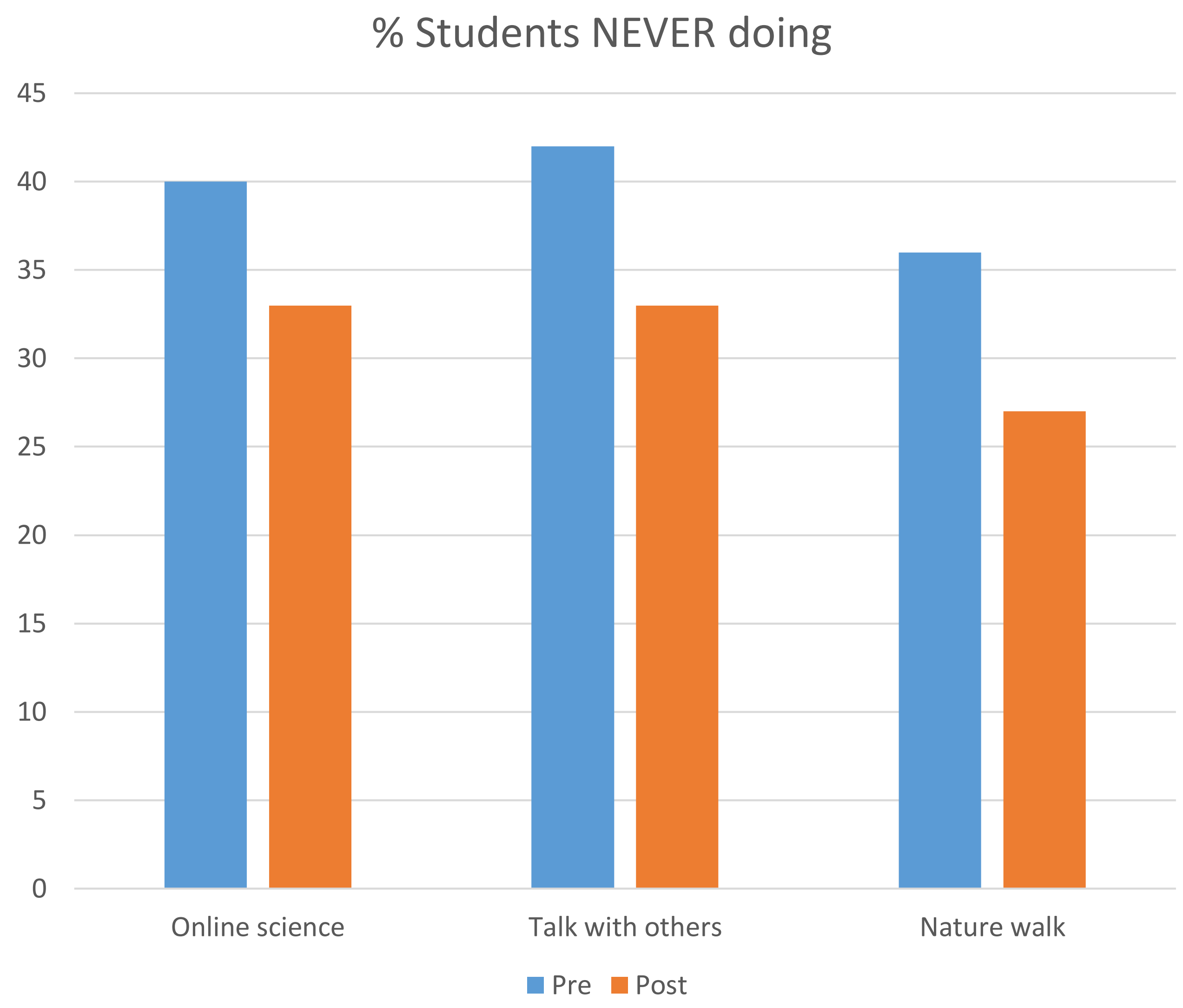
- Student aspirations to study A level science significantly increased



- Students attitudes to science improved significantly – e.g. seeing the relevance of science to their lives



- Students reported doing more out of school science activities – increase in those doing everyday and once or more a week, and a decrease in those never doing science outside school



- Increased interest and enjoyment of lessons
- Improved engagement:

  "So [Y10 bottom set] are a very challenging group of students [...] Through the year what I've noticed is when [I use the approach] I can see it their eyes … they kind of … like a meerkat, they pop up and you can see the engagement and you can see that they talk about it a bit more".
- Improved understanding: "Yeah, I feel like we get a better understanding because we can relate to what she's teaching us" (Alfie)
- Improved behaviour
- More inclusive classroom participation
- Attainment: "Its been better than the target …. I'm really surprised" (Teacher)
- 'Happier' teachers and shared practice

# Issues and limitations

- Enactment of the approach was varied and takes time – still a developing process
- Difficulty of balancing with demands of performativity, esp. at high stakes national test years (GCSE)
- Two students were less keen/ sceptical
- No change in % of students aspiring to be a scientist or science-related job and marginal decrease in % aspiring to medicine (13%-11%)
- Only focused on secondary – whereas issues are evidence in primary

# Messages for decision-makers

- Support young people's encounters with science (in and beyond the classroom) to be based on the science capital educational approach principles
- Focus on changing institutional settings and systems – rather than young people
- Take the long view: Move from one-off to more sustained approaches
- Use science capital survey tools appropriately
- Improve connectivity within and between settings: pathways, progression and partnerships

# Conclusions and Implications

- Our relationship to science is socially patterned and formed through complex interactions of multiple factors
- It is particularly shaped by the interaction of our science capital, habitus and the ‘field’
- If we want to improve people’s relationships with science, increasing interest is not enough – we need to build science capital
- Building science capital does seem possible … but means making changes to the field, rather than just focusing on trying to change young people
- More support for educators to engage with more complex & nuanced understandings of inequality and to have spaces and resources for professional reflection and taking ‘risks’
- No simple or one-off intervention will change STEM participation – we need policy change and longer term initiatives and support. But we think it is possible!

# 10 further thoughts for applying SCTA principles in STEM outreach

1. DO share and apply SCTA principles to all forms of outreach and activity!
2. Do provide support, time and fora for staff to get to grips with the approach and reflect (individually and collectively)
3. DON'T just focus on 'external' and one-off STEM activities, interventions and opportunities (e.g. external visitor) – DO look at mainstreaming and everyday practice
4. DON'T just focus on the value of STEM for STEM destinations - DO emphasise the transferability of STEM for *any* job/ career
5. DO personalise, localise and link the STEM content to what matters most to these particular young people

6. DO take an assets-based approach (value what they bring with them – no ‘empty bags’)

7. DO use STEM as a vehicle for social justice – not an end in itself or a ‘civilising mission’

8. DO join up across primary/ secondary and informal sectors where possible

9. DO focus on diversity, representation and implicit messages that are conveyed within and by you, your activity and setting – how/are students experiencing a culture of science as ‘for all’?

10. DON’T forget – widening access will require reducing privilege (zero sum game)

# More info/ resources

- **Science Capital Teaching Approach manual, films and infographic:** http://www.ucl.ac.uk/ioe/departments-centres/departments/education-practice-and-society/science-capital-research/science-capital-teaching-approach-pack
- **2 minute animations**:
  - What is science capital? buff.ly/1FmfXsi
  - A science capital approach to building engagement: https://www.youtube.com/watch?v=NDuEZFRt59M
  - The science capital teaching approach: www.ucl.ac.uk/ioe-sciencecapital
- **Teacher films:**
  - Science capital teaching approach film:
  - https://www.youtube.com/watch?v=XDCekYVTkws
  - Science capital teaching approach trailer: https://www.youtube.com/embed/AxJP789Zu8U
- **Summaries, reports and papers**:
  - Science Capital Made Clear: buff.ly/1XerGPE
  - Selection of research briefs, publications and short reports on our website
  - TedX talk: **https://www.youtube.com/watch?v=g8D3fr-0aJ0**

# Thank you! Feel free to contact us:

Website: http://www.ucl.ac.uk/ioe/departments-centres/departments/education-practice-and-society/aspires

www.ucl.ac.uk/ioe-sciencecapital

Twitter: @ASPIRES2science

Email: ioe.aspires2@ucl.ac.uk

ASPIRES 2
science and career aspirations: age 10-19

E·S·R·C
ECONOMIC
& SOCIAL
RESEARCH
COUNCIL