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Understanding Young Women's STEM Aspirations: Exploring aspirations and attitudes between the ages of 10 and 19 in England

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ASPIRES 2

science and career aspirations: age 10-19

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Outline

- Context – Importance of addressing the STEM participation ‘crisis’
- Overview of ASPIRES project aims and methods
- Key findings relating to contributing factors (with a gender focus)
  - Science capital
  - Systemic issues
  - Careers education
  - Gendered culture and association of science with masculinity
- Focus on physics (and gender)
- Implications and recommendations

The STEM skills problem

- In the UK (and most developed countries) widely accepted need for more people studying and working in STEM
- Jobs in STEM predicted to grow at double the rate
- STEM graduates more likely to be employed full-time and earn more and are less likely to be underemployed
- Yet the STEM skills gap persists and is growing
    - The number of STEM graduates has decreased from 43% in 2003 to 30% in 2016 (House of Lords, 2012; NAO, 2018)
- Uneven participation in physics, maths and computing relative to other STEM subjects in higher education

The STEM skills problem (continued)

- Lack of definitive and reliable data on supply and demand
- Questions around how many future scientists and STEM graduates the economy needs
- Concern is growing that there are still no answers to the pressing STEM skills gap
- Britain’s exit from the EU may further negatively impact the availability of workers with STEM skills

The participation problem

- Need to ensure high levels of scientific, mathematical, technical and digital literacy across the population
- Need to broaden the gender, ethnic and social class profile of STEM students post-16 (eg. Physics and Engineering)
- Interventions have had little lasting impact
- Key priority area for the UK government and other Western developed nations

History of issues

- Feminist scholars have been documenting and explaining women's low participation rates in STEM since the 1970s (Long and Frank Fox, 1995; Rossiter, 1982; Rothschild, 1983)
- Structural barriers identified to participation
  - sex discrimination in employment; socialisation & education
- Much early second wave feminism saw main issue of equal access to education and employment
  - Assumption that science was intrinsically open
- Women expected to exchange major aspects of their gender identity without prescribing a similar 'degendering' process for men

History of issues (continued)

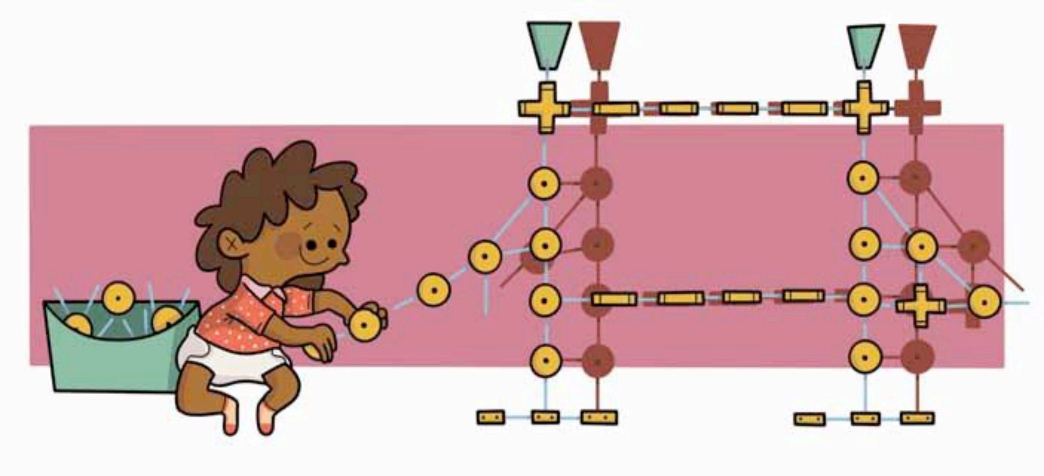
- Limited success of these equal opportunities interventions
- Catalyst for more critical feminist approach
  - Participation issues to do more with sex-stereotyped associations of science and technology
- Feminist critiques of science education evolved from asking the ‘women question’ in science to asking the more radical ‘science question’ in feminism

Project aims

- To understand the changing influences of family, peers, school, careers education and social identities and inequalities on students science and career aspirations
- To relate these to their actual subject choices and attainment on national GCSE examinations and their post-16 choices

Why study children's science aspirations?

- Age 10-14 as 'critical period' for forming views of science and science aspirations
- Probabilistic/ predictive function (e.g. Croll 2008; Tai *et al* 2006)
- Education policy focus



ASPIRES Projects
10 year, longitudinal ESRC funded

- **Phase 1 (age 10/11)**
  - Survey of 9,319 Y6 students, 279 primary schools, England
  - Interviews with 92 children and 78 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 65 parents

Phase 4 (age 15/16)

- Survey of 13,421 Y11 students
- Interviews with 70 students and 62 parents

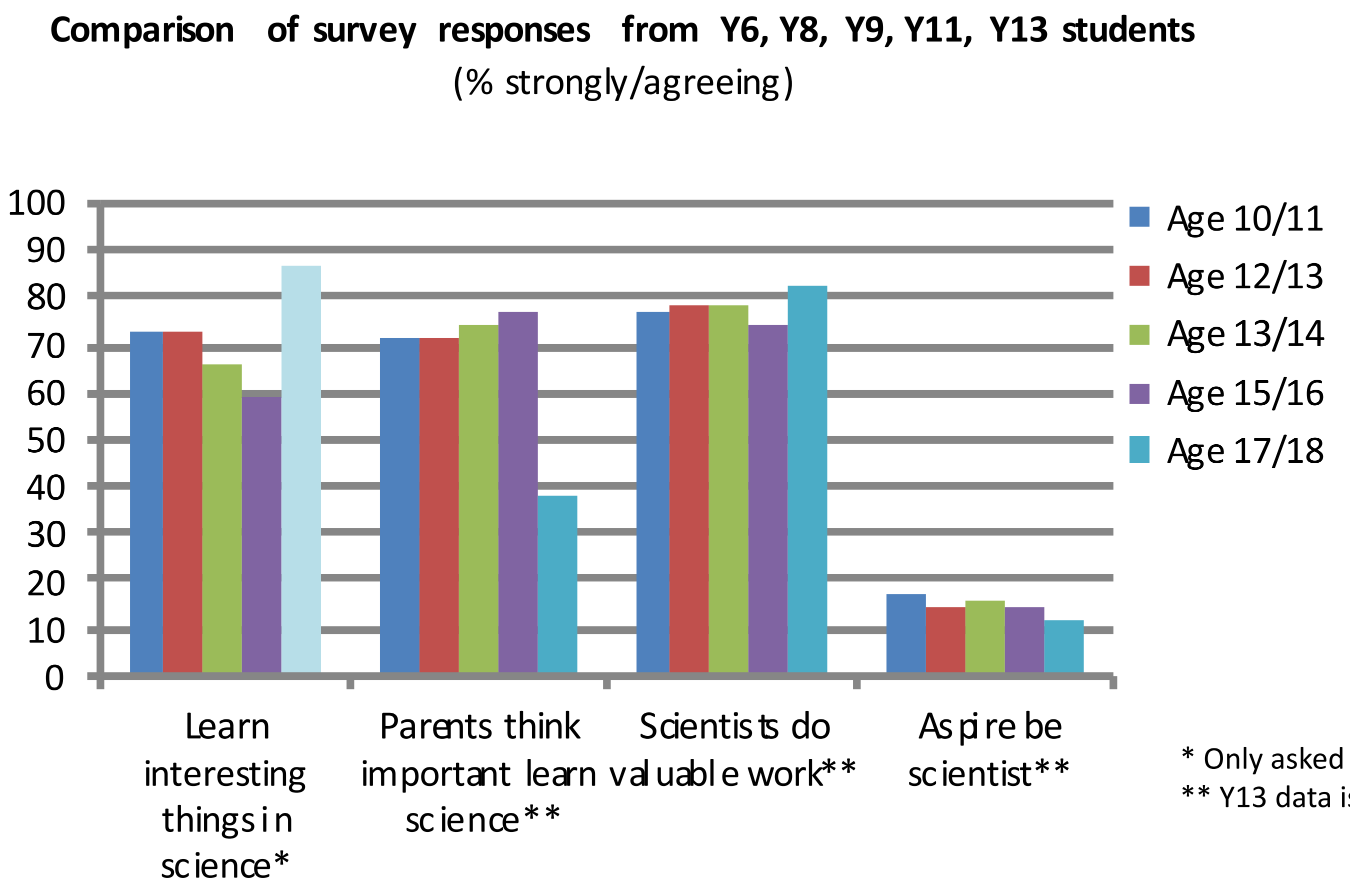
Phase 5 (age 18/19)

- Survey of 7,013 Y13 students
- Interviews with 60 students and 59 parents

What do students aspire to?

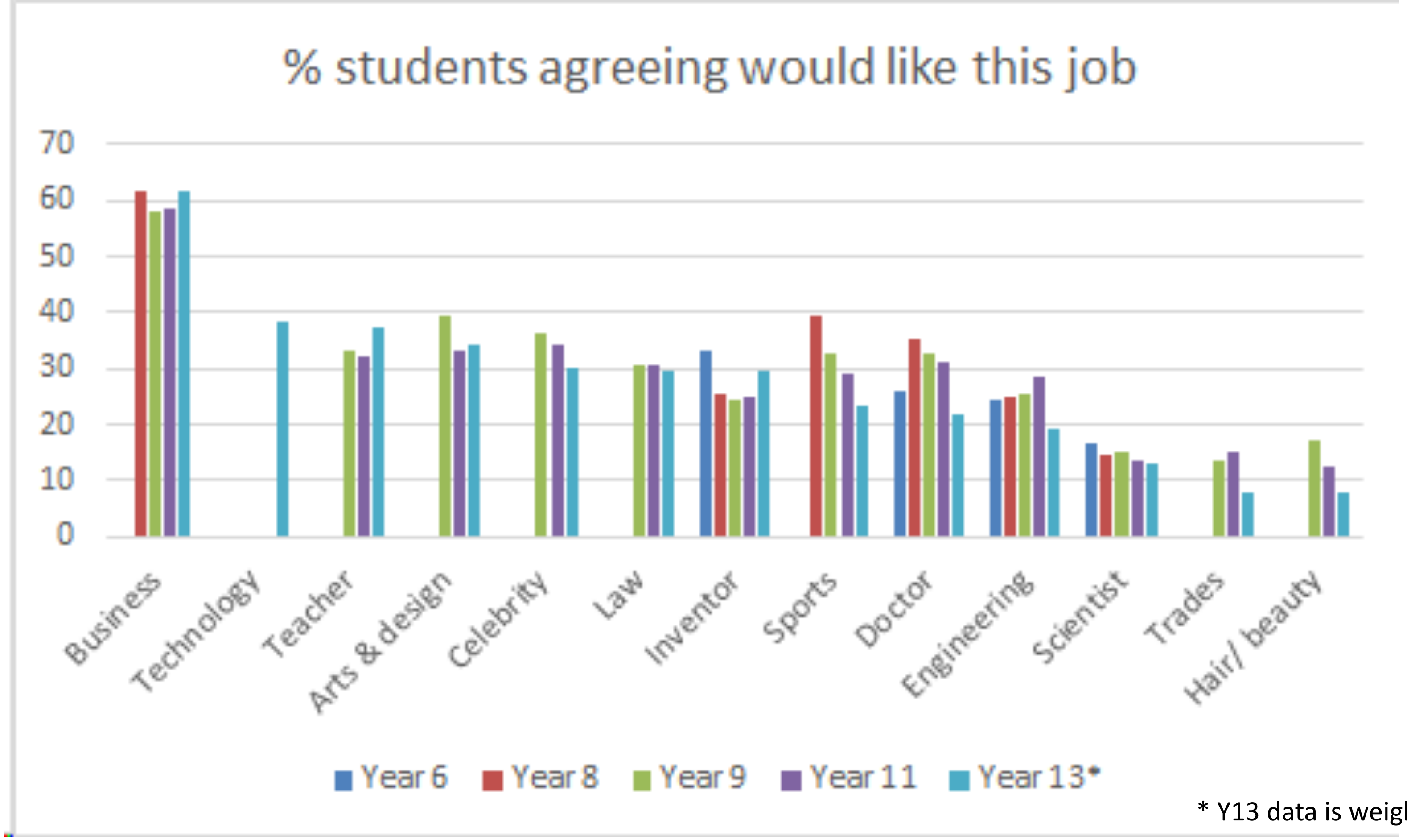
- Generally ‘high’ aspirations
  - Mostly professional, managerial and technical jobs
  - E.g. 87% Y11 agree it is important to make a lot of money
  - 69% Y11 say parents expect them to go to university
- Altruism
  - E.g. Y11 84% aspire to ‘help others’ in their working lives

The sustained 'being/doing' divide



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

What careers do students aspire to?



* Y13 data is weighted to national A level science entries

Who aspires to science jobs

- More boys:
  - 16% boys, 12% girls
- More ‘middle-class’ pupils:
  - *16% of socially advantaged pupils vs. 5% of disadvantaged pupils.*
- More South Asian / minority ethnic pupils:
  - 22% of South Asian pupils cf. 19% of Black students and 12% of White students

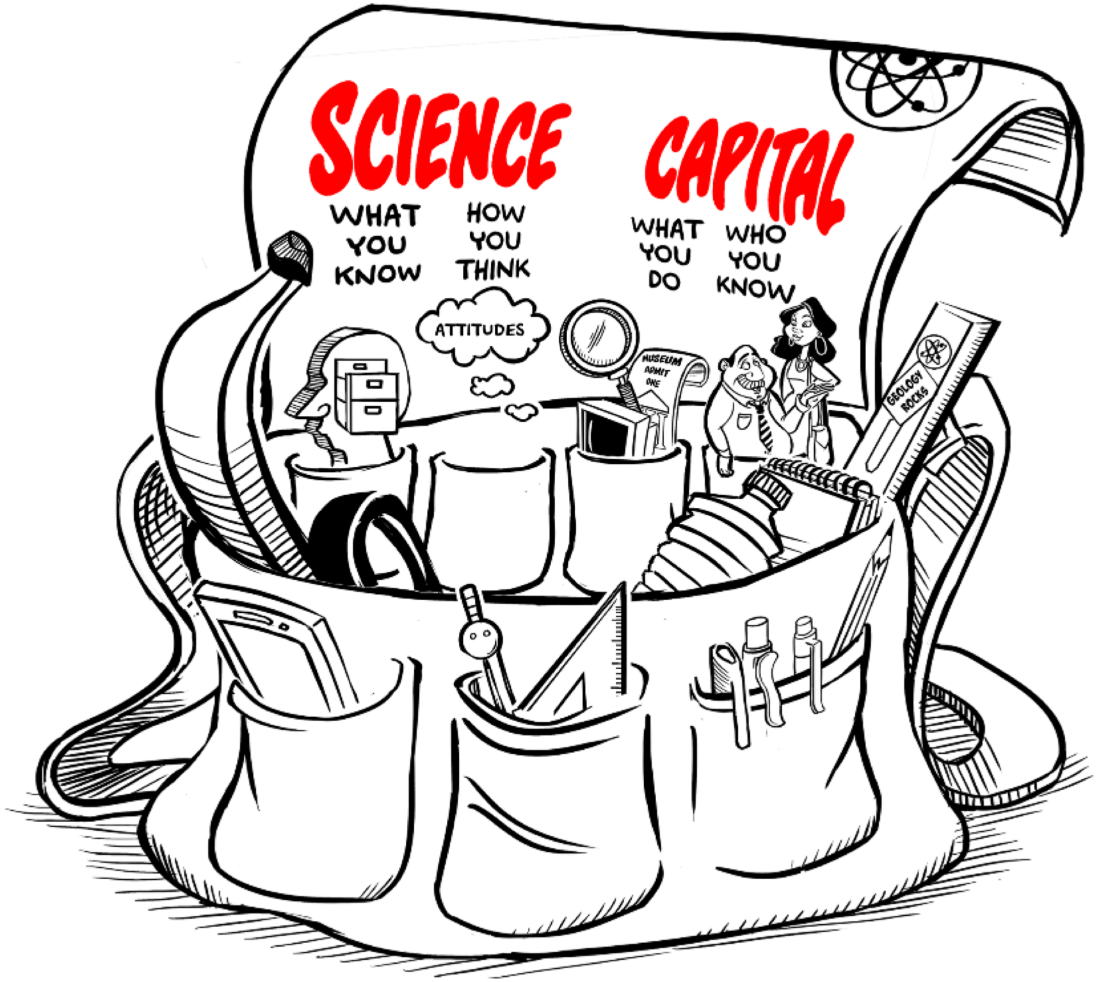
And also more likely to…

- Be in top set for science and take triple science
- Have a family member who uses science in their job
  - e.g. 49% of Y11 students with a family member who works in a science-related job vs. 35% of the whole cohort say that they would like a job that uses science.

What shapes the likelihood of developing science aspirations?

1. Science capital and family habitus (interactions of gender, class and ethnicity within these)
2. Systemic/educational issues
3. Careers education
4. Gendered culture and associations of science

1. Science capital and family habitus



‘Index’ of Science Capital

- Formative measure to get an overview of the distribution of science capital among a wide range of individuals
- Subset of a larger science capital survey
- 14 items identified as particularly key (most closely related to science aspirations and identity – ‘science affinity’)
  - Science literacy, family attitudes, unstructured science experiences and awareness of transferability of science
- *Not comprehensive*-does not ask the *full* range of activities, attitudes, connections that make up science capital
- Science capital ‘score’ with high, medium, low groups created

Science capital - Findings

- 7.8% high, 70.2% medium, 22.0% low (Y13 survey)
- High science capital students more likely to:
  - Come from South Asian or Middle Eastern ethnic groups
  - Have higher levels of cultural capital
  - Be in top set for science
  - Taken triple science
  - Intend to pursue science subjects at university

Science capital interacts with ‘Family Habitus’

- Habitus: matrix of dispositions shaping an individual’s actions and understanding of the world; practical ‘feel’ for the world
- *Family habitus*: family values, practices, sense of ‘who we are’ and ‘what we do’

Interaction of family *habitus* and capital

- 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 (e.g. girls and nurturing professions)
- Almost half of the Y8 interview sample aspired to the same job as a family member or close family friend
- Children with a family member working in a science-related career tend to have stronger aspirations in science than their peers:
  - e.g. 47% of Y8 students with a family member who works in a science-related job express science aspirations vs. 29% of the whole cohort

Science families: Making science 'thinkable'

- Science highly visible and familiar in family life
- Tend to be middle-class families
- Opportunities, resources and support for children to develop practical mastery/ 'feel' for science in everyday family life and cultivation of science as desirable
- Mutually reinforcing: part of 'what we do' and 'who we are'

> "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)

Implications of a lack of science capital

- Lack of awareness of where science can lead
- Science qualifications only seen to lead to: scientist, science teacher, doctor
- Little awareness that science qualifications are transferable and useful for a wide range of careers

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2. Systemic/educational issues in the UK

- At the age of 16 (Year 11) students take national examinations (GCSEs) where they generally choose three or four subjects to specialise in (beyond the core Maths, English, and Science)
- Students then have the option to study multiple routes
    - A level (considered the prestigious route to university entrance)
    - AS level
    - BTEC (more applied training route)
    - IB
- After the age of 16 students are required to remain in education or formal training until the age of 18

UK Science structure at age 16

Key Stage 4, GCSE

- Today, science at GCSE can be taken either as a combined single subject (which is worth two GCSEs) or as the three separate subjects of physics, chemistry and biology (each worth a single GCSE in its own right)
- Practicals are not included in the final mark

The impact of selective practices ('Triple Science')

- Growth in numbers taking three separate sciences at GCSE:
  - 2006: 5.6%
  - 2010: 16%
  - 2014: 26%
- Strong policy support
- But little critical attention?

Restricting participation?

- Triple – chosen by those who know age 13/14 that they want a science career (c.14% of all students) and dropped (if have the choice) by those who know they do not (unless have high science capital)
- Problem – sifts out students from too early an age
- Eg. Georgia:
  - “I was quite gutted that I didn’t get triple science, but obviously I’m not as good in lessons. [...] Because I was planning on doing triple science and then obviously going on and doing a science career, but I didn’t get triple science, I didn’t get picked for it”

Uneven participation in Triple Science

- By gender and social background (e.g. Sutton Trust, 2015)
- Differences in offer by region and level of deprivation (RSA, 2015)
- 46% of our survey sample reported that they were taking Triple Award, 37% double award, 5% applied routes and 4% BTEC, 7% did not know what route they were taking
- Patterns by cultural capital, ethnicity and school set

Not really a choice

- 61% of Triple students and 58% of Double science students reported on the survey that they had no personal choice of which route they took (i.e. the school decided)
- The figure was similar for applied science routes (58%) but lower for other science routes (36%)
- 71% of interview students – no choice

Schools channel students into making the ‘right’ choice with Triple science ‘only for the clever’

- Schools exert ‘pedagogic action’ on students
  - “I think maybe it’s been encouraged like that, so like people who are less clever felt like they weren’t able to take the triple Science GCSE” (Bethany1)
- Working-class students most likely to feel Triple would be ‘too much for me’
- Triple students reproduce/ invest in the discourse of ‘Triple = clever’:
  - “I think to do Triple you need to be clever” (Louise)

Implications – different trajectories

- Triple science students exhibit more positive views of science and stronger science aspirations and science identities
- Multilevel modelling shows that Triple science students plan to take more science subjects at A level
- Compared to Double science students, Triple science students are:
  - 2x as likely to plan to study Biology at A level
  - 2.5x as likely to plan to study Physics at A level
  - Over 3x as likely to plan to study Chemistry at A level

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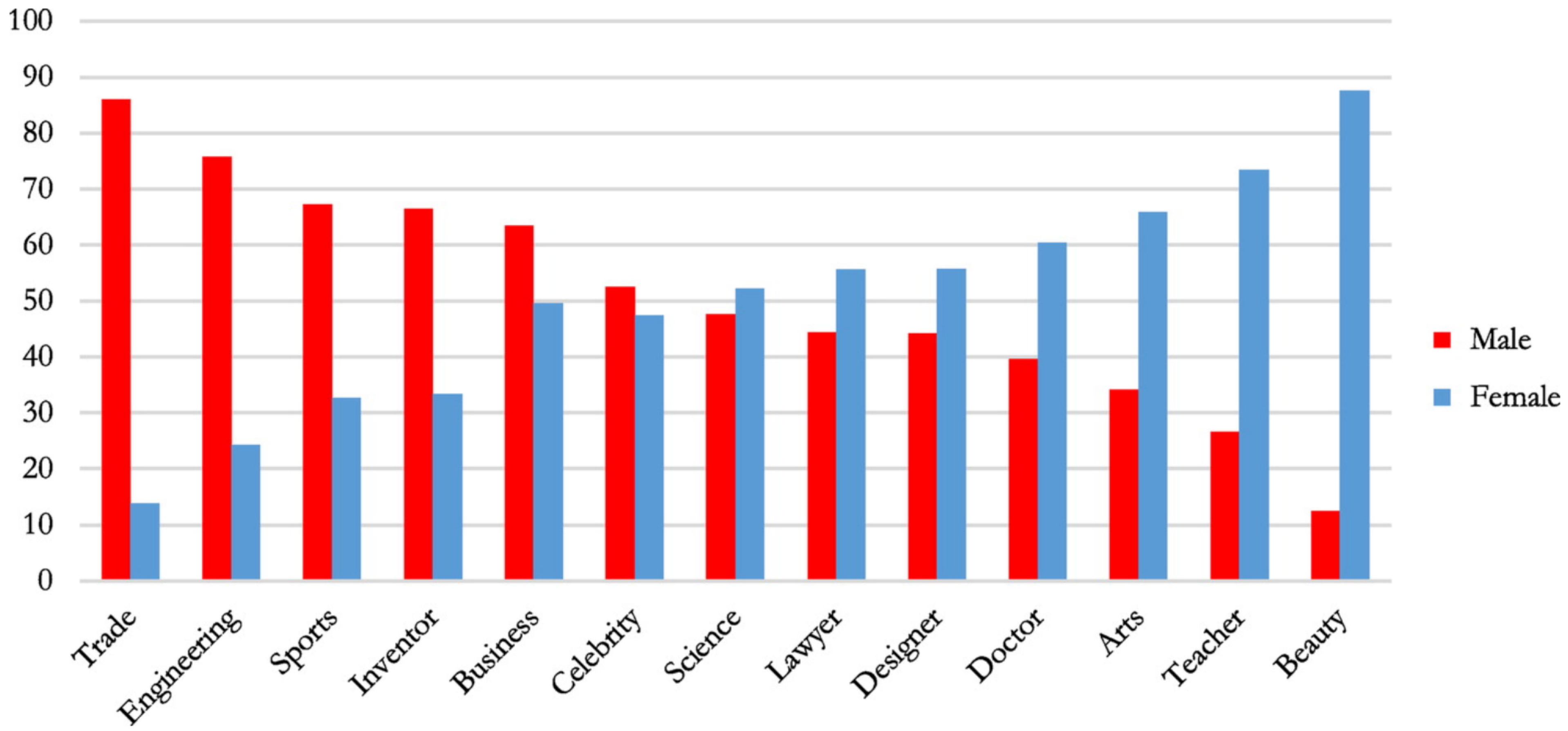
3. Careers Education in England - Patterned Provision

- Less than two thirds of students have received careers education and less than half have had work experience
- Demand from students for more and better careers education
  - 57% of students are satisfied with the careers education they have received
  - Those who report careers support are more satisfied
- Provision is not just ‘patchy’, but is ‘patterned’
  - Boys report receiving significantly more careers education than girls, do more work experience and are significantly more satisfied than girls with the careers education they receive

Aspirations by gender - unmatched careers support



Why are students not accessing support?

- Differences in school resources
- ‘Too little, too late’
  - Subject choices already made, desire for more, earlier and longer-term careers education
- Students from disadvantaged backgrounds less likely to use self-referral model, contributing particularly to gender trends
- Lack of impartial/personalised advice and guidance
  - Schools or colleges ‘biased’ and predominantly just want to channel students into their own routes (e.g. A levels) rather than supporting the student to explore other routes
  - Preference to use other resources

What can be done to address patterned provision?

- Policy needs to focus on careers education *participation*, not just *provision*, to ensure that it reaches ‘underserved’ students
- Support should be provided to schools and careers education providers to enable them to understand, identify and address inequalities in careers education
- Organisations could be provided with resourcing to target, engage and support disadvantaged groups
- Organisations should take particular care with respect to schemes and opportunities that are offered on an ‘opt in’ basis

What shapes the likelihood of developing science aspirations?

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4. Gendered culture/associations of science with masculinity

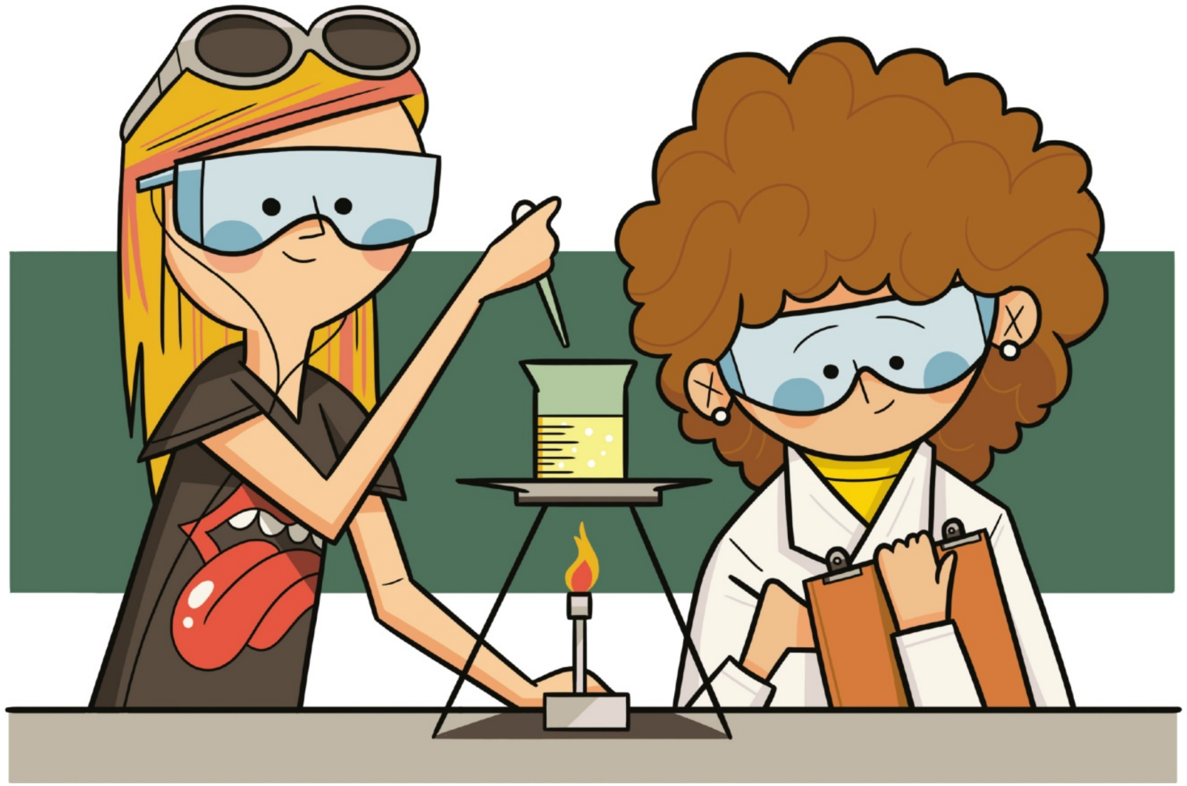
- Views of science as male-dominated ("its not girly, its not sexy, not glamorous")
- More 'girly' girls are less likely to express science aspirations (perceived lack of fit with popular femininity)
- Some negative experiences of science spaces
- Only for 'clever' girls

Differential 'pushing' by gender

- UPMAP project: motivation over time by a significant adult is key to post-16 participation
- However:
  - Boys report higher parental expectations than girls
  - Boys report more motivation from their teachers to pursue Physics/Maths
- Carlone (2003): teachers' gendered constructions of advanced Physics student 'ability' and attainment

Girls who aspire to science

- Two ‘types’: ‘feminine’ and ‘bluestocking’



Girls who aspire to science

- Bluestocking: very academic, ‘not girly’ (“We’re kind of the nerds”, *Hannah, Y8 girl*)
- ‘Feminine’ scientists: academic but work hard to balance science aspirations and femininity

> “I would say there are like two types of people that are into science – either there are the really like geeky people...or there are like people who are like me who aren’t like geeky but they have a knack for it...I play the guitar and do rowing and obviously the girly stuff that other normal girls do.” (*Davina, Y8 girl*)

Decline in ‘feminine’ science girls

- By A level, none of the six females studying physics self-identified as ‘girly’
- Performances of femininity increasingly regulated and downplayed:

> “I wouldn’t say I’m a particularly feminine person at all. I mean you know like I swear quite a lot (laughs) […] I swear like a sailor, it’s ridiculous. You know I don’t … first of all I don’t really dress particularly feminine, like I tend to wear jeans and like band t-shirts and hoodies and stuff, and I wear boys’ like skater shoes. So I mean yeah I’m not … I don’t have a particularly feminine voice either … and I think well so what? – like there’s nothing wrong with that, it’s just like that’s just what I am.” (Davina, Y11)

Girls drifting away …

- Gradual process of erosion over time (no single ‘moment’)
- E.g. Brittney: Y6 ‘something involving chemistry’ or beauty; Y8 less sure, maybe ‘something involving science, maybe chemistry”; Y9: certain ‘primary school teacher’
- Mixed school; friendship group; lack of science capital (cf. “someone in my family is a teacher”) e.g. “there isn’t really much to do about science outside of school, so I don’t really do anything”.
- ‘Lost potentials’ (Aschbacher et al 2010) – families tend to push girls less than boys towards Physics/Maths (UPMAP project)
- Can also be compounded by selective entry to Triple science (e.g. Georgia)

Summary of Key Project Findings

- Most young people have **high aspirations – just not for science**
- **Negative views** of school science and scientists are **NOT** the main **problem**
- **Science capital** is key
- Most students/families are not aware of where science qualifications can lead
- **'Brainy' image** of science/science careers puts many young people off
- The (white) male, middle-class image of science careers remains a problem
- Girls have to **work harder to balance science aspirations** – and are less likely to be 'pushed' towards science by others

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A Focus on Physics:

Key Findings relating to Physics with a focus on gender issues

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Physics participation in the UK

- Post-post compulsory physics participation remains low and unchanged
- Four times as many male students study physics at A level (IOP, 2017)
- Disparity continues into STEM-based employment (women c.21%)
- Shortage of specialist teachers contributing factor
- Increasing need to support wide range of entrants with limited resources

Physics focused publications

New work:

- Archer, L. et al. (article under review) “You can’t handle the truth!” Pedagogic work and the cultivation of student habitus in the reproduction of Advanced Level Physics as an elite subject
- Moote, J. & Archer, L. (article under review). Comparing students' engineering and science aspirations from age 10-16: Investigating the role of gender, ethnicity, social class
- Archer, L. et al (chapter under review) Going, going, gone: a feminist Bourdieusian analysis of young women’s trajectories in, through and out of physics, age 10-19
- Archer, L. et al (chapter under review) Lighting the fuse: Cultivating the masculine physics habitus – a case study of Victor aged 10-18

Previous work:

- The exceptional physics girls (Archer et al., AERJ);
- DeWitt et al paper; reasons for not/choosing Physics A level;
- Francis et al (2016a) physics and the denigration of the ‘girly girl’ (BJSE);
- Francis et al (2016b) construction of physics as masculine subject (Sex Roles)

Who is studying physics?

- Gender was the biggest difference between the science students taking physics and not taking physics at A level
  - 36% of boys in our survey were planning to study A level physics compared to only 14% of girls
  - Pattern followed on from Year 11 ‘intentions’ (64.7% male, 35.3% female)
- More likely to be Asian (or Middle Eastern), have high levels of cultural capital, be in the top set for science, Triple science and have family members working in science

The distinctive physics habitus

- Statistical analysis of Y13 survey data shows that physics students are statistically distinctive (cf. other A level science students and students in general)
  - Higher mathematic and scientific self-confidence
  - Stronger general ‘pro-science’ views
  - More likely to agree that scientists are ‘odd’, ‘male’ and ‘geeky’

Girls and Physics

- 3 girls denied entry/debarred part-way through A level physics (Danielle, Victoria, Thalia)
- 3 girls completed A level but chose not to continue, despite interest (self-exclusion due to inculcation of fantasy of ‘effortlessly clever physicist) (Davina, Kate, Mienie)
- 1 girl entered Physics (Hannah) – highest (and most specific) physics capital

The construction of Physics as ‘masculine’

- “I guess cos it kind of … has like that connotation of manliness” (Hannah)
- Common construction, including among those girls choosing Physics at A level
- Power of the cultural arbitrary of Physics (‘hard’, masculine) – doxa (“it just tends to be kind of just the way it is”, Davina)
- Leads to self-censorship/exclusion, i.e. Physics is ‘not for me’

Femininity and ‘girlyness’ are excluded from physics

- Differences between girls (4 not girly, 2 some performances of hetero-femininity)
- Changes and alignment over time (becoming less girly)
- For girls to be authentic physicists, they must ‘lose’ (or neutralise) their feminine bodies/performances

The added pressure of being 'the only girl'

- Girls within our study discussed being the only girl in their physics classes and the pressure that comes with being in this position:
- *"…I knew I was going to be the only girl, I was getting really worried because then I was like … if I'm the worst in the class it's just going to be like extra pressure because you don't want to … I guess being a girl can put extra pressure on you, cos you don't want to be like 'oh you're bad because you're a girl'. And you don't want to be the worst and then people would be like 'Oh'" - Hannah*

The 'exceptional' Physics/ Engineering girls

- Six 'possible' Physics girls – all highly distinctive, 'exceptional' girls
- Girls who study physics are 'not like your average person'(Davina)

Commonalities:

- White or South Asian, middle-class
- Proud to be different from other girls (like 'surprising' others and 'breaking boundaries')
- Highly competitive – Physics as a way to perform 'brainiest' identity
- Attain highly, secure in their academic abilities/identities
- High levels of science capital (and specific pushing of Physics/Engineering)
- Supportive schools (which push girls explicitly into Physics)
- Prefer the theoretical side of Physics
- Strategic approach to their gender distinctiveness in relation to the field of post-16 Physics/Engineering ("… okay this is a bit cheeky but I guess it would be easier to get into universities")

Danielle: Impossible girl physicist?

- “I love Physics”
- White, working-class girl
- Wanted to study at A level – but dissuaded by her school from taking the subject

But – the ‘wrong body’?

- “I’m a bit of a party girl … I like make-up and hair and stuff like that, but then I do like the kind of school side. Like everyone thinks I’m really dumb, but I’m not. I seem quite dumb I suppose… because like I do all my make-up and hair and just seem a blonde bimbo”
- Positioning of Danielle by peers and staff (e.g. “Well you look like you’d like to do Beauty, young lady”)

The ‘wrong mind’?

- B grade student, “All of my family is not clever”
- Tensions and negotiations:

  “And my dad turned round to me the other night and went ‘you ain’t clever enough to go to college’. I went, ‘yes I am, shut up’. Like he doesn’t know I’m clever. He thinks what everyone else thinks, that I’m not clever because I look like this… But… I’ll prove him wrong”

- ‘Cleverness’ as gendered, racialized and classed discourse (symbolic violence)
  - “Triple science is too hard.. I wouldn’t have done it, I’d have failed, so there was no point”

The wrong capital?

- "No one in my family has ever been to University"
- No conversion of science interests developed through ISL experiences (cf. high science capital students)
- Private decision that 'not good enough' to become a scientist

Last woman (physicist) standing-Hannah

- The only female who applied for a physics degree after completing A level physics (achieving highly, upper-middle class, White)
  - Stood out from her peers in that she did not describe Physics as particularly ‘hard’ and asserted the view that she might be ‘good at physics’ but like the other female students, she also describes having to ‘work’ at the subject
  - Tricky identity tightrope-being ‘good at physics’ aligning with masculinity and having to ‘work to understand things’ as being achieved via feminised diligence
    - Allowing her to maintain an intelligible femininity and identify as a viable physicist

The right capital?

- Hannah possessed the most specifically *Physics*-related capital
- High volume and wide range of science (and Physics)-related informal science learning activities over the years
- Several family members were physicists, same university as her brother (creating 'safe' route) who's wife is a nuclear physicist
- Best friend has shared interest:

  > "She [friend] has the New Scientist and we discuss that as well. […] So it's definitely helped … because if you don't have someone sharing your interests it's really hard to like talk about them, which is kind of hard." (Y13)

- Negotiated the 'loss' of some valued aspects of femininity, Physics as a high status route aligned with masculinity, offers her a chance to 'get on' rather than 'make do'

Key Physics Findings

- **Students' interest, enjoyment and aptitude for the subject are not sufficient** to allow them to pursue Physics post-16
- **Physics is represented as a subject for men** and this lack of representation of women leads to the assumption that women are unable/unsuited to studying/working in Physics
- **Femininity and 'girlyness' are excluded from Physics** with young people and their parents suggesting that 'girly girls' wouldn't continue with Physics because of their focusing on appearance and a lack of intelligence

Key Physics Findings-continued

- **Girls who do Physics are exceptional,** possessing high levels of cultural, social and science capital while not conforming to 'girly' popular femininity
- **Physics is highly effective at maintaining its elite status** by not letting in the 'wrong' students and by ensuring that those students who do gain entry accept the status quo
- **The notion of the 'effortlessly clever physicist'** ensures that students blame themselves for not gaining access to Physics education and careers and maintains Physics status as the 'hardest' science

Key Physics Findings-continued

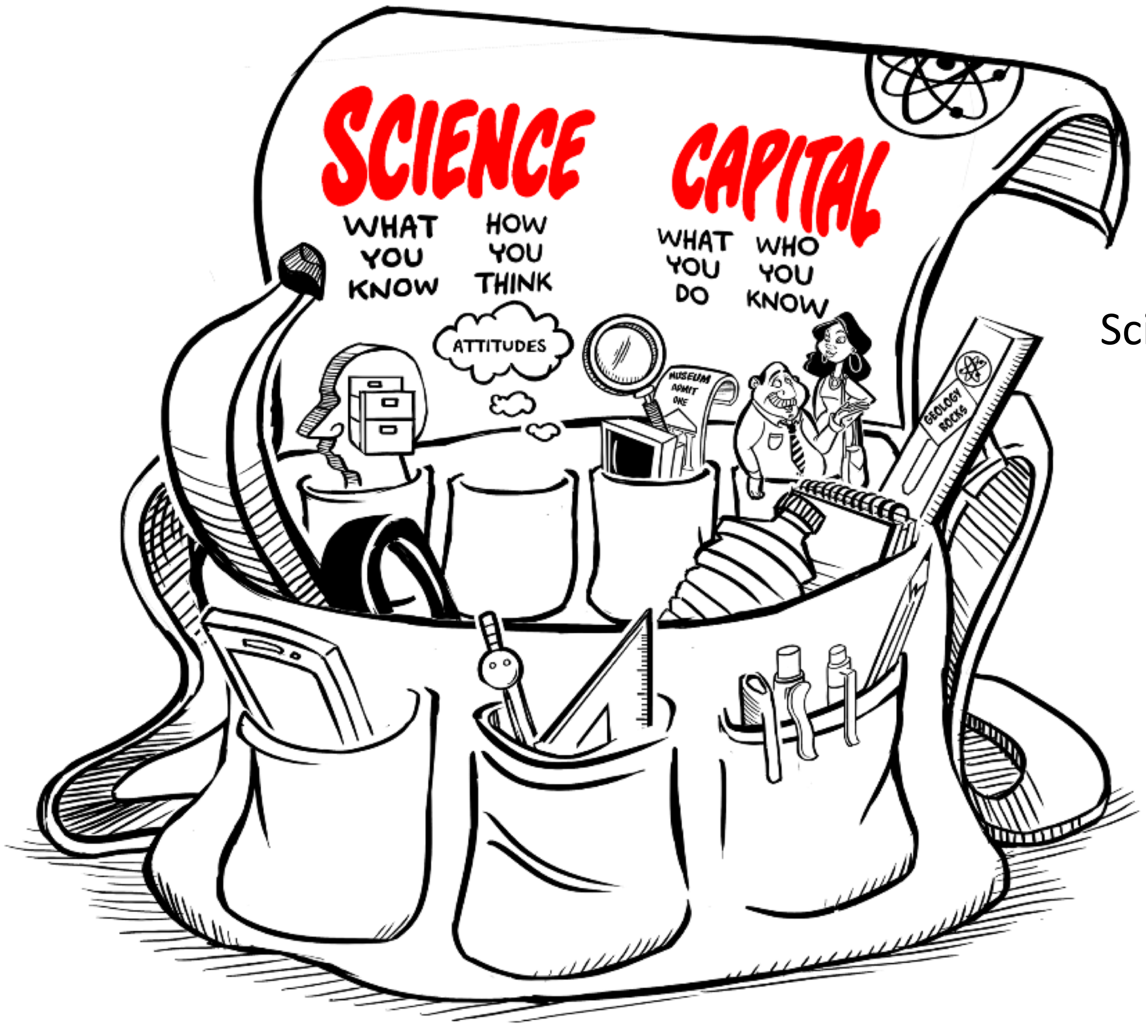
- **Gatekeeping practices by schools** work to disbar potential students from studying Physics and leads other students to self-exclude
- **The separation of 'real' and school Physics** gives the impression that 'real' Physics is only for the privileged few with the endurance to attain it
- **Physics capital may explain why some young women do see Physics as 'for me'** and continue to a Physics degree

Recommendations

- Significant change is needed and this will only be achieved by transforming the field of Physics itself, not the students
- Those people who work within the field of Physics must understand and accept that they must genuinely address the effects of inequality in their field
- The field of Physics must abandon its strict gatekeeping practices and open up the field to more diverse participants
  - Post-compulsory physics should be accessible to more than just the ‘exceptional’ girl. The field of Physics should develop a broader acceptance of who can aspire to and ‘do’ Physics

Recommendations-continued

- Students should be allowed entry onto Physics courses with lower attainment scores
- The split between ‘real’ and school Physics must be addressed
- A more gender equitable culture must be achieved
- We propose changes to the way science- and Physics in particular – is taught in the classroom
  - The syllabus should be re-examined and restructured to be more attainable and relevant for a wider range of students
  - The Science Capital Teaching Approach can help to increase student engagement and participation in Physics



Science capital animations buff.ly/1LNleLK

ASPIRES Resources

Science capital seminar videos on YouTube (Mike Savage, Shamus Khan, Louise Archer, Angela Calabrese Barton, Jonathan Osborne, Charis Thompson, Steph Lawler, Jrene Rahm, Kevin Crowley): https://www.youtube.com/playlist?list=PLun2jODy9M2cvE3bgJ-UCc0dotvrSfRVG

Enterprising Science. (2016). Science Capital Made Clear. London: King's College London.

The Science Capital Teaching Approach

Godec, S., King, H. & Archer, L. (2017). The Science Capital Teaching Approach: engaging students with science, promoting social justice. London: University College London.

Careers Education Spotlight Report
https://kclpure.kcl.ac.uk/portal/files/64130618/ASPIRES_2_Project_Spotlight_1.pdf

ASPIRES 2 Publications

DeWitt, J., Archer, L. & Moote. (2018). 15/16-Year-Old Students' Reasons for Choosing and Not Choosing Physics at A Level. International Journal of Science and Mathematics Education.

Moote, J., & Archer, L. (2017). Failing to deliver? Exploring the current status of career education provision in England. Research Papers in Education.

Archer, L., Moote, J., Francis, B., DeWitt, J., & Yeomans, L. (2017). The "Exceptional" Physics Girl: A Sociological Analysis of Multimethod Data From Young Women Aged 10–16 to Explore Gendered Patterns of Post-16 Participation. American Educational Research Journal pp. 1–39.

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