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Calls to Action

Science Education Tracker 2019

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Every aspect of our lives is shaped by science and many of humanity's greatest challenges require solutions rooted in science. That is why it is vital that every young person has access to high-quality science education, within school and beyond, to allow them to make sense of the world around them and engage in the major debates of our day.

The Science Education Tracker (SET) is a survey of over 6,400 young people in England aged between 11 and 18 that explores their enjoyment of and engagement with science, as well as their future career aspirations. Many of SET's findings are positive: almost all young people engage with some form of science outside of school,[i] and over half express interest in a science-related career.[ii] Students are also more likely to associate success in science with hard work, rather than natural ability,[iii] suggesting they have a 'growth' rather than 'fixed' mindset and believe that they can get better at science through effort.[iv]

However, beyond these headline figures, SET highlights stark inequities: female students, students from disadvantaged backgrounds, and white students are less likely to engage with or enjoy science, or consider it as an option for further study or employment.

SET also finds that over the first three years of secondary school there is a sharp fall in students who say they are interested in school science,[v] while the proportion of young people rejecting science as a future pathway rises in parallel.[vi] Even more concerning is that since SET 2016 there has been a decline in the proportion of young people who believe that understanding science is important for society.[vii]

To explore solutions to these issues and inequities, Wellcome brought together science teachers, policy makers, and representatives from businesses and science education organisations in a workshop. We have used their feedback, alongside SET findings and existing literature to produce a series of "calls to action." Some of these calls are for policy makers and schools to explore. However, learning about science doesn't just happen in formal settings, and for that reason, we have included actions for the science education community, employers and higher education institutions, as well as families, the media and community actors.

SET was conducted before the Covid-19 pandemic. However, measures taken to tackle the virus and particularly school closures, are likely to disproportionately disadvantage students from low income backgrounds, as they are less likely to have links to science or access to information in the home. This makes the need to address inequities in science learning even more pressing to ensure that when schools re-open we do not see a growing equity gap between the most and least disadvantaged students.

The actions suggested are deliberately not prescriptive. Rather they are designed to spark conversations and encourage everyone with an interest in science education to engage in a way that puts equity first.

Actions for government to explore

1) Students from disadvantaged backgrounds are less likely to have links to science in their family and home environment,[viii] or to take part in STEM activities outside of lessons. They are also less likely to study triple science at GCSE.[ix] Taken alongside existing research,[x] this suggests that curriculum narrowing, such as making early GCSE choices, disproportionately reduces the opportunities for young people from disadvantaged backgrounds to engage in science. The Government and Ofsted should commission research to better understand the relationship between a shortened key stage 3 and uptake of triple science by students from disadvantaged

backgrounds. Where possible Ofsted should recognise the work of schools in challenging areas who encourage a high triple science uptake.

2) Practical study motivates students in science.[xi] However, students report less exposure to science practicals as they get older.[xii] Students also report fewer opportunities for practical study in 2019 compared to 2016.[xiii] The Government could ask Ofsted to conduct a thematic review into practical science to assess if this self-reported decline is consistent with their findings, and if so, why this change is occurring. As part of this review, Ofsted could explore what support schools need to meet Gatsby good practical science benchmarks[xiv]

3) The Government is a major funder of schemes to promote STEM education. However, the evidence from SET[xv] and elsewhere[xvi] suggests these schemes are more likely to be accessed by affluent students. To tackle this inequity the Government could:

    a. Bring forward planned work to develop an evaluation framework for these schemes[xvii] to ensure they are improving young people's outcomes and promoting equity. Any framework should reflect non-cognitive outcomes, such as aspirations and self-belief, which are also associated with future success,[xviii] as well as attainment and progression measures.

    b. Promote and incentivise STEM learning opportunities in youth programmes. The Government has announced a five-year £500 million Youth Endowment Fund on top of existing schemes, such as the National Citizens Service. Many of these schemes target young people from disadvantaged backgrounds. As such, working with the providers of these schemes to encourage them to include STEM focused work can potentially provide a ready-made route to engaging this group of young people in STEM.

4) Students report that a teacher's ability to 'explain things well' is a key factor in helping them learn science.[xix] For that reason, high quality, predominantly subject-specific, continuing professional development (CPD) for all teachers should be an annual entitlement. Our research shows that this will allow teachers to build their knowledge and develop their practice.[xx] To support this the Government might consider funding a trained CPD Leader in each school to coordinate and champion CPD.

5) The Government's plan to invest in the UK's scientific base is welcome, but it should avoid limiting its focus to elite academic career tracks. SET shows that compared to 2016, young people are less likely to think that understanding science is important for them in their future career.[xxi] However, meeting the ambitions of 'global-Britain' and the 2.4% target for Research and Development spending will require a scientifically-literate, technical workforce. The Government could boost this workforce by:

    a. Continuing the public campaign to promote science and engineering apprenticeships, and ensuring schools fulfil their responsibilities under the Baker Clause[xxii] to do so.

b. Working with employers of scientists, training providers, research institutes and universities to help them recruit a more diverse range of apprentices[xxiii] and support them in delivering high-quality apprenticeship training.

Action for schools to explore

1) Consistent with other research,[xxiv] SET shows that girls' perceived self-ability in science is lower than that of boys.[xxv] Girls are also more likely to report that science exams make them feel anxious.[xxvi] Both factors can cause girls to opt out of STEM learning and career paths[xxvii]. Schools can work to tackle this by:

    a. Being clear that scientific ability is the result of hard work and effort, and using proven interventions to help reduce students' exam anxiety.[xxviii]

    b. Taking steps to avoid gender stereotyping in schools, which can have a profound effect on girls' performance in STEM.[xxix] School INSET training should include unconscious bias training as it relates to gender, race and socio-economic status.

2) Young people from disadvantaged backgrounds are equally as likely as more advantaged students to aspire to a STEM pathway when making post-16 choices and in a career.[xxx] However, they face more barriers in pursuing this vision: their perceived self-ability in science is lower[xxxi] and by year 10 they are less likely to aspire to attend university.[xxxii] Schools can work to change that by improving the quality of careers education, which may include:

    a. Dispelling the idea that there is one type of scientist and promoting STEM role models from these underrepresented groups, including those from the local community.

    b. Promoting the range of scientific career paths across both academic and vocational pathways that are open to young people.

    c. Supporting students from disadvantaged backgrounds in finding STEM work placements and work experience.

3) SET shows students from disadvantaged backgrounds and those with fewer family connections in science have fewer opportunities to engage with STEM outside of school.[xxxiii] One effective use of Pupil Premium funding[xxxiv] is to ensure young people can experience the full range of educational experiences beyond the classroom. Schools should consider how they can use the Pupil Premium to support young people's informal science learning outside of the classroom, for example by funding science related school trips or science clubs within school.

4) School governors and academy trustees play a vital role in providing support and challenge to school leadership teams. As such, they should feel empowered to ask questions about how schools are promoting engagement and equity in science education. That could include asking questions about the amount of practical science young people are exposed to, whether science teachers have access to suitable CPD, or what efforts are made to expose young people from disadvantaged backgrounds to a wide range of STEM opportunities.

Action for the science education community to explore

1) There are many schemes designed to promote engagement with STEM. One survey found 600 schemes for engineering alone.[xxxv] SET and other research shows that these schemes are more likely to be accessed by more affluent students.[xxxvi] To tackle this, we encourage:

    a. Science education organisations to consider how they can intentionally reach out and support students from underrepresented and disadvantaged backgrounds and their families. This may include looking at how to build long term, as opposed to one-off, support and engagement to a more targeted group of young people.

    b. Science education networks and informal science education providers to work together rather than in competition to build on work, such as the STEM directory, to map out gaps in provision and tackle regional disparities.[xxxvii] Outreach work could be done in partnership with other organisations that already engage young people, such as youth and volunteering clubs.

2) Informal learning opportunities, such as science centres and after-school clubs need to appeal to a diverse range of young people. To help ensure they do, the science education community should, where possible, take a co-design approach with young people to creating interventions. Evidence shows that co-design can help to create interventions that are more engaging, satisfying, and useful to young people.[xxxviii] As with outreach, co-design should not just involve those already engaged in science but should be informed by a diverse range of voices.

3) The science education community should continue to build on existing work to tackle perceptions of who can be a scientist and what it means to be a scientist. In order to appeal to a diverse range of young people they could: promote the variety of jobs that are available in STEM fields, highlight the wide range of pathways available, and showcase stories of accomplished scientists from different backgrounds as role models.

4) SET shows that students with more family science connections are far more likely to engage with science outside of school.[xxxix] The science education community should consider how to make it easier for families to access STEM content beyond the classroom. One way to do that is for science education stakeholders to collaborate in creating roadmaps for families to help them navigate the different offers, and to select the right ones for their children. This information should be accessible in language, format and distribution to target families who are usually not engaged in informal science activities.

Action for higher education providers and employers to explore

1) Employers should be more proactive in providing information on the variety of science career pathways available, both academic and vocational, to students from disadvantaged backgrounds. In doing so:

    a. All STEM employers, including SMEs should seek to offer work experience and placements. Where possible they should target them beyond major ‘STEM hubs,’ such as major cities and the south of England.[xl]

b. Employers should also consider the barriers young people face to accessing work experience and provide funding, where possible, so that young people can afford to take them up.

c. As new technical qualifications are rolled out, SME's should work with Government to explore what additional support they need in order to offer the work placement element of T-Levels.

2) Gender, relative to other aspects of identity, is by far the most common target for bullying, harassment and discrimination in research workplaces.[xli] This causes women to leave STEM careers and deters new entrants. Employers and research institutions should prioritise tackling discrimination and improve conditions for women in the workforce to make careers in science more appealing.

3) Access work by universities and other higher education institutions plays a key role in raising aspirations, particularly among underrepresented groups.[xlii] Universities should consider how they can introduce more STEM-specific content into their access work. They should target those groups that SET shows are less likely to consider further study in STEM, such as female students and students from disadvantaged backgrounds.[xliii]

4) Families are central to the choices that young people make about their future pathways in education and employment.[xliv] For that reason, employers and universities need to work directly with families to provide them with information about the study and career options available for their children. As with signposting of informal learning opportunities, employers and universities should make sure this information is accessible and directly targeted at those who do not have a background in science or higher education.

Action for families, community actors and media to explore

1) The information that young people absorb from the media and the entertainment industry influences their aspirations and career plans.[xlv] However, the popular portrayal of science and scientists can reinforce stereotypes. For instance, women are much less likely to be portrayed as scientists in films than men[xlvi] and media coverage of female scientists is much more likely to emphasise their appearance.[xlvii] To avoid perpetuating stereotypes:

    a. The entertainment industry should consider how characters in scientific roles are portrayed in film, TV and gaming, and actively seek to challenge the idea that all scientists are affluent white men through their casting.

    b. The media should be proactive in dispelling science gender stereotypes.[xlviii] Some ways they could do that include: increasing the visibility of women working in STEM, not commenting on female scientists' appearance, and ensuring stock images accompanying science articles are diverse.

2) As highlighted, families are a key driver of young people's future aspiration. For that reason, families themselves need to work to actively challenge gender and ethnic stereotypes among children from a young age and be clear that no profession is off limits because of gender or ethnicity. Where possible, parents should be conscious of not transmitting STEM anxiety to their children and avoid statements such as 'I'm not good at numbers.'[xlix]

3) Community and volunteering groups can encourage children's interest in STEM by linking STEM interventions with problems that the local community might be grappling with, such as air pollution. This provides an easy way to demonstrate the real-world value of STEM to young people. In order to do this, community groups should proactively reach out to science education networks who can provide ideas and support.

4) Science centres,[l] museums and other cultural organizations are working hard to engage families and young people in science. We encourage them to build on these efforts and to think about equitable access more intentionally throughout their work. This includes considering how to represent diversity in exhibitions, involving underrepresented groups in the creation of exhibitions, and moving exhibitions outside of London and major cities.

Next steps

As these actions show, there is no single silver bullet when it comes to improving engagement and equity in science education. What is required is a concerted effort from Government, schools and colleges, science education stakeholders, the wider science community and others. We look forward to having conversations over the coming months to discuss how each of us can play our role and tackle the many factors that impact student engagement, attitudes and aspirations.

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[i] SET: 94% of students in years 7-13 had engaged with some form of science content outside school in the past year.
[ii] SET: 55% of year 7-13s were interested in a STEM career.
[iii] SET: 61% of year 7-13 students associated exam success with hard work, 19% with natural ability and 20% thought both factors were equally important. By contrast, students in older years were increasingly likely to see maths and English as being more about natural ability.
[iv] Dweck, C. (2007) Mindset: The New Psychology of Success (New York: Penguin Random House)
[v] SET: The proportion who were 'very interested' in science lessons declined from 26% in year 7, to 23% in year 8, and to 14% in year 9.
[vi] SET: The proportion who said that they did not plan to study science after GCSE increased from 26% in year 7 to 41% in year 9.
[vii] SET: The proportion agreeing 'understanding science is important for society in general', has dropped from 67% to 56%, and the proportion disagreeing has increased from 8% to 15%. SET 2016 was a survey of young people aged 14-18.
[viii] SET: 37% of students who had been eligible for free school meals in the past six years had a low FSCI score compared to 23% of students not on free school meals. FSCI is a composite measure of the connections that a young person has to science in the family. Eligibility for free school meals over the past six years is a Government measure of pupil-socio economic disadvantage
[ix] SET: 25% of students eligible for free school meals said they were studying triple science compared to 39% of students who were not on free school meals.
[x] Spielman, A. (2017) HMCI's commentary: recent primary and secondary curriculum research, *Ofsted.*
[xi] SET: Enjoying practical work was the top reason for feeling encouraged to learn science: overall, 42% of students in years 7-13 selected this as a motivating factor. 63% of year 7-11 students in the most deprived IDACI quintile vs. 56% in the least deprived quintile wanted to do more practicals. The Income Deprivation Affecting Children Index (IDACI) measures the proportion of all children aged 0 to 15 living in income deprived families.
[xii] SET: In year 7, 63% reported doing hands-on practicals at least once a fortnight, this proportion falls steeply by school year such that only 33% reported similar levels of frequency in year 11.
[xiii] SET: The proportion of students in year 10-11 doing hands-on practical work in the past fortnight has fallen since 2016 (from 44% to 37%) as has observing a teacher demonstration of a practical (from 47% to 38%)
[xiv] Holman, J. (2017) Good Practical Science, *Gatsby*, Available: https://www.gatsby.org.uk/education/programmes/support-for-practical-science-in-schools
[xv] SET: 37% of young people from the least deprived IDACI quintile had participated in an extracurricular activity related to science, compared to 32% of all young people. Of those young people with the most family science connections, 46% had participated in the last year.
[xvi] DeWitt, J. and Archer, L. (2017) Participation in informal science learning experiences: the rich get richer? *International Journal of Science Education, Part B*, 7(4), 356-373.

[xvii] BEIS, research areas of interest, interim update. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/862777/beis-areas-research-interest-interim-update-2020.pdf

[xviii] Gutman, L. and Schoon, I. (2013) The impact of non-cognitive skills on outcomes for young people, *The Institute for Education.* Available: https://educationendowmentfoundation.org.uk/library/the-impact-of-non-cognitive-skills-on-outcomes-for-young-people-full-report

[xix]SET: When selecting from a list asked to select the most important characteristics of science teachers, 55% of students in years 7-13 mentioned the ability of a teacher to explain things well.

[xx] Wellcome (2020) "Progress towards the Wellcome CPD Challenge: first interim evaluation report." 50% of respondents found that they had increased their subject knowledge, whilst 62% of respondents agreed that they had improved their knowledge surrounding pedagogy, thus enabling them to teach their subjects more effectively. Available: https://wellcome.ac.uk/reports/progress-towards-wellcome-cpd-challenge-first-interim-evaluation-report

[xxi] SET: In 2016, 42% of year 10-13 students agreed with the statement "understanding science is important for me in my future career," this dropped to 38% in 2019.

[xxii] The Baker Clause is an amendment to the Technical and Further Education Action, which requires schools to allow a "range of education and training providers" to speak to pupils in secondary school so that they can be informed about what technical and vocational opportunities are available for further study.

[xxiii] Data from Department for Education's Apprenticeship and traineeships: annual data, Available: https://www.gov.uk/government/statistical-data-sets/fe-data-library-apprenticeships#apprenticeship-and-traineeships-annual-data

[xxiv] Anderson, J. (2017) To see more women in science, deal with test-taking anxiety in girls, *Quartz.* Available: https://qz.com/1109075/the-lack-of-women-in-science-is-down-to-test-taking-anxiety-in-girls/

[xxv] SET: 60% of boys consider themselves 'good' at the subject, compared to 51% of girls.

[xxvi] SET: 53% of year 10-11 girls felt anxious about science tests or exams 'most times' compared with 28% of year 10-11 boys and there were similar gender divides in years 7-9, and for both science and maths.

[xxvii] SET: males in years 10-13 (56%) were more interested in a STEM career than females (41%). Females expressed a wider range of reasons for being disinclined towards a STEM career, and were more likely than males to be discouraged by a lack of enjoyment or preference for other subjects, or because they lacked confidence either in their ability or to reach the required grade thresholds.

[xxviii] Harris, R. B., Grunspan, D. Z., Pelch, M. A., Fernandes, G., Ramirez, G., and Freeman, S. (2019) Can Test Anxiety Interventions Alleviate a Gender Gap in an Undergraduate STEM Course? *CBE life sciences education*, 18(3), ar35.

[xxix] Carlana, M. (2019) Implicit Stereotypes: Evidence from Teachers' Gender Bias, The Quarterly Journal of Economics, 134(3), 1163‑1224.

[xxx] SET: There was no difference in STEM aspirations at HE or interest in a career by disadvantage measures (IDACI quintiles and free school meals eligibility).

[xxxi] SET: 12% of respondents who have been eligible for free school meals in the past six years say they are very good at science compared to 18% of those who have not.

[xxxii] SET: 56% of those not entitled to free school meals in the past six years intended to go to university compared to 46% who were entitled.

[xxxiii] SET: 56% of those from the least deprived IDACI quintile reported having attended a science attraction in the last year compared to 49% in the most deprived quintile.

[xxxiv] The Pupil Premium: How schools are spending the funding successfully to maximise achievement. (2013). *Ofsted*.

[xxxv] Morgan, R. and Kirby, C. (2016) The UK STEM Education Landscape, *Royal Academy of Engineering.*

[xxxvi] SET: 47% of FSM eligible students have attended science attractions in the past year, compared to 53% of FSM non eligible students. DeWitt, J., Archer, L. (2017) "Participation in informal science learning experiences: the rich get richer?" This study used a survey of 6,000 children aged 11-16 to find that students from more privileged social backgrounds participate more in informal science learning experiences.

[xxxvii] APPG Meeting 3: Regional Disparity. (2018), *British Science Association*. Available: https://www.britishscienceassociation.org/appg

[xxxviii] Thabrew, H., Fleming, T., Hetrick, S., & Merry, S. (2018) Co-design of eHealth Interventions with Children and Young People. *Frontiers in psychiatry*, 9, 481.

[xxxix] SET: 62% of students with many family science connections have participated in at least one science related activity outside of school in the past month, compared to only 36% of students with few family science connections.

[xl] Careers and Enterprise Company (2020) "Closing the Gap: Employer engagement in England's schools and colleges in 2019" found that more rural LEPs had a higher percentage of students who missed out on experiences of workplaces than urban LEPs. Available: https://www.careersandenterprise.co.uk/sites/default/files/uploaded/closing_the_gap_2019_report_0.pdf

[xli] Wellcome (2020) "What Researchers Think About the Culture They Work In", Available: https://wellcome.ac.uk/sites/default/files/what-researchers-think-about-the-culture-they-work-in.pdf

[xlii] Universities UK, Opportunity for Everyone, https://www.universitiesuk.ac.uk/opportunity-for-everyone

[xliii] SET: Among students who were considering higher education, 34% of boys were interested in studying a STEM subject, compared to 29% of girls. 30% of White students were considering a STEM subject at university, compared to 36% of Black and Asian students respectively.
[xliv] SET: Young people in years 8-9 who had chosen their GCSE options mainly consulted parents about GCSE choices (64%). Parents were the most important source of careers advice for students in year 10-13 (68% had consulted their parents about careers advice).
[xlv] Shapiro, M., Martin, K., Grossman, D., and Hammer, D. (2012) Dreaming Big: What's Gender Got to Do with It? The Impact of Gender Stereotypes on Career Aspirations of Middle Schoolers. CGO insights Briefing Note 35, *Simmons School of Management*.
[xlvi] Steinke, J., Paniagua Tavarez, P.M. (2018) Cultural Representations of Gender and STEM: Portrayals of Female STEM Characters in Popular Films 2002-2014. *International Journal of Gender, Science and Technology*, 9(3), 244-277.
[xlvii] Gehrau, V., Brüggemann, T., and Handrup, J. (2016) Media and Occupational Aspirations: The Effect of Television on Career Aspirations of Adolescents, *Journal of Broadcasting & Electronic Media*, 60(3), 465-483.
[xlviii] Wang, M. T., and Degol, J. L. (2017) Gender Gap in Science, Technology, Engineering, and Mathematics (STEM): Current Knowledge, Implications for Practice, Policy, and Future Directions. *Educational psychology review*, 29(1), 119–140.
[xlix] Maloney et al. (2015) Intergenerational Effects of Parents' Math Anxiety on Children's Math Achievement and Anxiety. *Psychological Science*, 26(9), 1480–1488.
[l] The European Network of Science Centres and Museums. (2008) The Impact of Science & Discovery Centres: A review of worldwide studies.

Wellcome would like to thank representatives from the following organisations for attending our Science Education Tracker Calls to Action workshop in January 2020:

- Association of Science Education
- British Science Association
- Careers and Enterprise Company
- Chartered College of Teaching
- Copthall School
- Department for Business, Energy & Industrial Strategy
- Engineering UK
- Gatsby Foundation
- Microsoft
- Natural History Museum
- NESTA
- Raspberry Pi Foundation
- STEM Learning
- UCL Institute of Education
- UKRI
- University of Nottingham
- WISE Campaign

Wellcome exists to improve health by helping great ideas to thrive.

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Wellcome Trust, 215 Euston Road, London NW1 2BE, United Kingdom
T +44 (0)20 7611 8888, E contact@wellcome.ac.uk, wellcome.ac.uk