A.T. Kearney

Tough Choices

The real reasons A-level students are steering clear of science and maths

A report developed by A.T. Kearney in partnership with the Your Life campaign

YOUR LIFE

Foreword

Reducing the skills gap between the school gate and the workplace has risen to the top of the public agenda over recent years. We have witnessed significant progress on engagement between business and schools—which Your Life and the CBI are testament to—but more needs to be done to improve the job prospects of young people and secure the future of the UK's economy.

At a time when Tim Peake is the first British astronaut on the International Space Station, consumers can interact with the Internet via their watch and every business needs a digital presence for success, the achievements made possible through science, technology, engineering and maths are well evidenced. However, students need to be better informed about how relevant maths and science subjects are in the job market.

The skills gap is set to grow, not diminish, demonstrating that huge challenges remain. This report aims to help inspire change by providing an insight into students' thinking and the choices they face, and, through unique interviews with them, lift the lid on the decision-making process of those that chose to move away from science and maths before A-level.

The Your Life campaign and the CBI welcome this report and A.T. Kearney's use of comprehensive data supported by the best business and academic credentials. We warmly thank the academics from King's College London and University College London who have been so generous with their data and their expertise. We are also grateful to all the young people who were prepared to share their personal experiences.

For parents, businesses and educators, this student perspective is vital. It provides the insight we, as a society, need to understand: not whether change is needed but rather how it can be achieved. This report demonstrates the scale of opportunity for change and pinpoints the ages when action will be most effective.

Businesses will be increasingly dependent on digital knowledge and numerical analytics, which puts a high premium on maths and physics skills in young adults. As the report shows, the challenge for us is that science and maths subjects in school are still seen by students as too abstract and theoretical, with little real life application and suited only to the very bright. It also shows that students are unaware of the opportunities that even a basic knowledge in these subjects can provide them: opening doors to almost any job, across almost any sector. These skills are in high demand in the working world, but if students are unaware of this, it naturally impacts whether they choose to take maths and physics to A-level stage. The additional, unfortunate consequence of this means that British firms may struggle to find the skills they need in the future.

But this can change—everyone can play their part. This is a society-wide issue and *Tough Choices* aims to encourage everyone to do their bit. The commitment of parents, teachers and businesses to enlighten students about the opportunities maths and physics knowledge will provide them is the starting point for success.

Your Life and the CBI will continue to play their part in helping to transform the relationship between UK schools and UK business. We urge you to play yours too.

Edwina Dunn
Your Life Campaign Chair

Paul Drechsler
CBI President

Executive Summary

The UK has a serious shortage of science, technology, engineering and mathematics (STEM) skills. While this is not new, the outlook is deeply concerning: only one in four English secondary school students chooses two STEM subjects or more at A level and only one in 11 chooses both maths and physics, the combination of subjects that underpins so many careers in technology-dependent sectors of the economy.[1]

Yet when students enter secondary school, research shows that 74 per cent of them are interested in and enjoy science lessons.[2] Other countries present a more positive picture: half of French 16-18 year olds study a science-oriented Baccalaureate.[3] In the UK something is going wrong during secondary school: what causes such a drastic change, and what can be done about it?

This report combines the rich insights from two recent and extensive academic research programmes (ASPIRES from King's College London and UPMAP from University College London, both described in Appendix 1 along with a summary of methodology) together with tailored qualitative interviews. Our objective was to present a holistic analysis of the evolution of secondary school students' thinking with regard to STEM subjects, thereby explaining the decisions that lead to what popular culture might term the "Great British Science Turn-Off".

Many surveys have targeted this issue, which is of concern to schools, universities, employers and policymakers. They often point to a single root cause, be it curriculum difficulty or gender stereotyping (the percentages listed above are worse for girls). While all of these factors play a role, the most startling finding of our research is that the low uptake of science and maths beyond the age of 16 reflects apparently rational decision-making. Students focus on subjects they believe will be useful for their future career and where they can be successful. In tens of thousands of survey results, conducted under rigorous academic research protocols, the message shines through that most young people see STEM study as a dead end, for them personally and indeed more generally.

Unfortunately for both them and the UK economy, this decision-making is ill-informed and harmful.

- Young adults have an alarming lack of knowledge of the many career paths dependent on STEM qualifications, despite employers calling for these skills
- As they progress through school, students lose interest because maths and physics lessons become less practical, reinforcing their perception that there is limited career relevance
- Many teachers and parents push students to prioritise good grades and as a result steer them away from STEM; students say that they listen to this guidance
- Students selecting their subjects for A level (or equivalent) hear a clear message from teachers, parents and peers: STEM study is only for the "ultra-bright"; school policies on streaming often reinforce this

1 Department for Education data from 2014-2015 academic year; ratio based on pupils entered for at least one A level
2 ASPIRES1 King's College London, survey of 10-11 year olds, 2009
3 French Ministry of Education, 2015; ratio based on students taking the general French Baccalaureate

- Evidence does suggest that historically it has been more difficult to earn high grades in STEM subjects than in nominally vocational subjects[4] and that it remains harder to achieve high marks in physics than in media studies[5]

These root causes are common among both girls and boys, but the effect on girls tends to be more extreme. Girls are additionally put off studying STEM because certain science-related careers seem to have a "masculine" image.

The result is a collective failure on two fronts. Too many school-leavers are not given the best chance of future success, and too few UK employers will get the skills they need to compete.

A shift is urgently needed to stop turning 16 year olds off STEM subjects and start encouraging them to carry on with these studies. Of course, not everyone is suited to STEM and there are many worthwhile careers that depend on studying humanities and social sciences. Yet the mismatch between what boys and girls study and what they need in adult life is too severe to ignore.

As summarised in Appendix 2, there have been multiple policy interventions and campaigns in recent years, including the Your Life campaign, which commissioned this report. Your Life was launched in 2014 with the backing of leading employers and the UK Government and is committed to following up on this report with a series of actions, supported by the CBI and employers. This research suggests that interventions must be broad in terms of who is included, and must focus on removing the misconceptions and the disincentives to studying STEM beyond the age of 16. The present situation demands the engagement of all participants in the education system, as well as employers and Government. Much depends on how we collectively fix the problems we have ourselves created.

[4] Durham University Centre for Evaluation and Monitoring, "Relative Difficulty of Examinations in Different Subjects", 2008

[5] Dave Thomson for Education Datalab, *Is A-level physics too hard (and media studies too easy)?*, 2015

STEM in the UK—the Skills Gap

The UK is suffering from a serious lack of people qualified in science, technology, engineering and mathematics (STEM). The Royal Academy of Engineering estimates that the UK needs 104,000 STEM graduates per year, and 56,000 technicians, between now and 2020. However, the total number of graduates from UK universities in these subjects is approximately 80,000, with 18,000 of them going into non-STEM careers. As a result, the Campaign for Science and Engineering has suggested the shortfall of STEM workers in the UK is as high as 40,000 each year.[6]

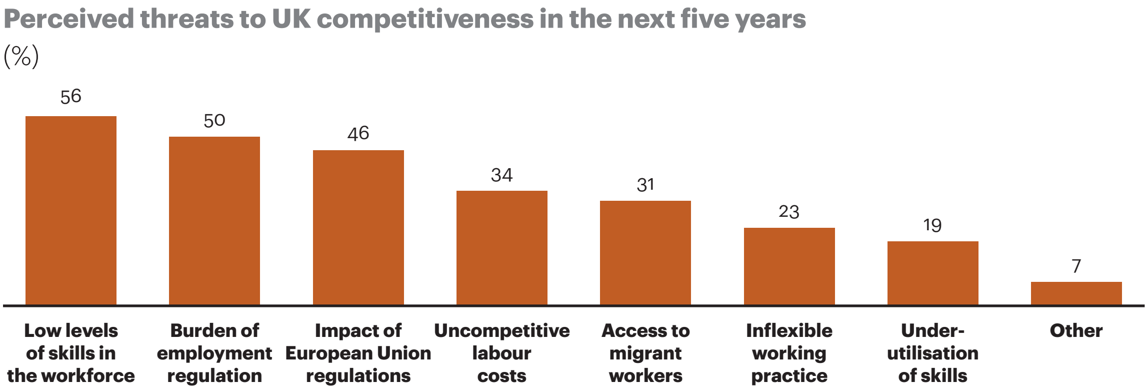
The Institution of Engineering and Technology annual survey in 2014 found that the gap between the engineering, IT and technology skills needed by employers and the skills evidenced by graduates and school-leavers has widened—for the ninth year running.[7]

The implications for UK competitiveness are depressing. In fact the Confederation of British Industry's recent survey of likely threats to competitiveness in the labour market puts skills levels at the top of its list of concerns, ahead of regulation (see figure 1).

The skills shortage issue begins at school. England is floundering relative to its European neighbours. In France, of the students sitting the Baccalaureate, 52 per cent choose to major in "sciences" (compared with 31 per cent for social sciences and 17 per cent for literature).[8] The nearest equivalent would be students taking two or more STEM subjects at A level: in today's schools, this accounts for 25 per cent of all A-level students.[9] Comparisons on the global stage are not encouraging either: in South Korea, for example, maths is essentially compulsory for all students, and 39 per cent of students choose to take science.[10]

Fundamental forces are at work here. Before they even make their A-level choices, young people aspire to careers and lifestyles that have little in common with the economic needs of

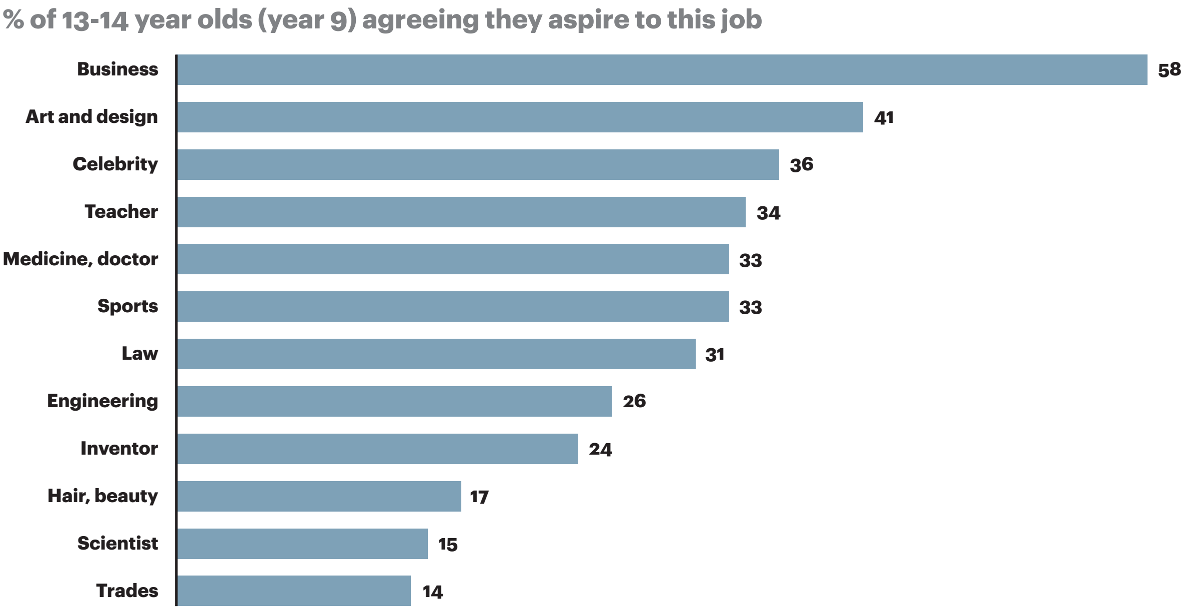
Figure 1
Low skills are the biggest threat to UK competitiveness



Source: *The Path Ahead: CBI/Accenture employment trends survey 2015*

[6] Campaign for Science and Engineering, *Improving Diversity in STEM*, 2014
[7] Institution of Engineering and Technology, *Skills and Demand in Industry, Annual Survey*, 2014
[8] French Ministry of Education, 2015
[9] Department for Education data from 2014-2015 academic year; ratio based on pupils entered for at least one A level
[10] Korean Ministry of Education, 2015

Figure 2
Few young people aim for careers such as engineering or science



Source: *ASPIRES1* study, King's College London

the UK or the student's individual reality. The number of students who say they want to be a celebrity or professional sportsman/woman far exceed those who want to work in engineering (see figure 2). Only one in seven wants to be a scientist—slightly fewer than those who see their future as a hairstylist or beautician.

Although beyond the scope of this report, there appears to be a disconnect between these aspirations and what society values. We are faced with a failure on two fronts: employers struggle to get the skills they need to be competitive; many young people are deprived of their best shot at a successful career.

It is worth adding that STEM relevance is not merely about one or two specific sectors of the economy. Modern organisations deploy technology across many functions, so an ever-greater proportion of the workforce has to understand more than their direct area of expertise. For instance, marketing professionals need to be very comfortable with digital technology and with the statistical underpinnings of customer experience research; lawyers find themselves working on disputes over software intellectual property rights or valuation matters. STEM skills are transferable to a majority of careers, yet too many secondary school students see them as niche.

The STEM Decision Funnel

A.T. Kearney has analysed this situation via the concept of a STEM Decision Funnel. This is a way of representing the student perspective, starting with their interest in STEM, then their aspirations to STEM careers, their intention to choose STEM subjects beyond age 16 and finally their actual subject choice. It is very similar to the concept that consumer goods companies use to understand how they can increase sales of their brand through awareness, brand engagement and trial. In this report, we use the funnel to frame STEM decision-making holistically through the secondary school years and identify the key points of "leakage" as well as the root causes of this leakage.

This concept and approach appear to be new to the study of STEM engagement. However, we benefited greatly from primary research already undertaken. Two important and extensive academic studies stood out, both funded by the Economic and Social Research Council: ASPIRES1 and 2, led by King's College London, and UPMAP, led by University College London.

Academic studies

ASPIRES1 and 2: A 10-year longitudinal project led by King's College London on children's science aspirations and career choice. To date, the study has undertaken four surveys covering different age groups between 10 and 16 with a total of 32,621 respondents, between 5,000 and 13,000 per age group, in addition to longitudinal interviews of 80 students throughout the period.

UPMAP (Understanding Participation rates in post-16 Maths And Physics): A three-year study (2008-2011) led by UCL involving two surveys to understand participation in maths and physics, with a total of 30,000 respondents between 12 and 15 years old and 70 longitudinal interviews with respondents 15-17 years old.

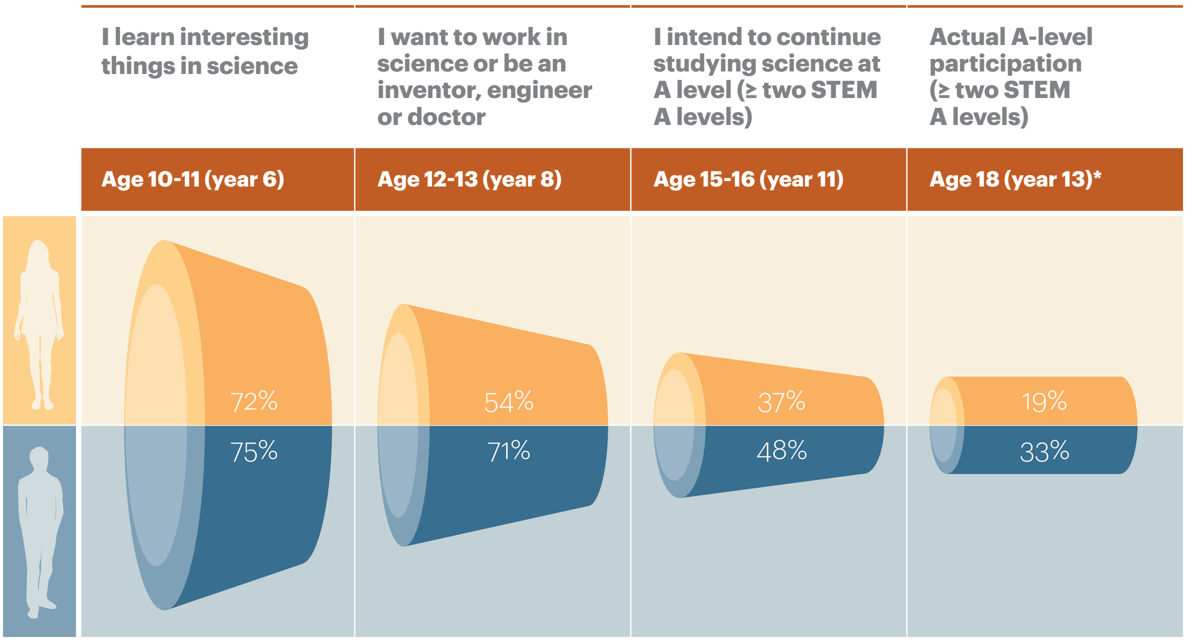
A.T. Kearney partnered with the academics who led these research programmes. This report is therefore based on multiyear surveys covering a total of more than 60,000 respondents, with careful sampling and normalising to ensure a representative picture, as well as rigorous multilevel regression analysis to deepen and validate findings. The analysis also benefits from the expertise of the academic researchers who have worked in this field for decades.

To complement the survey results with a retrospective view, A.T. Kearney undertook 30 qualitative interviews in the summer of 2015 with A-level students who had not chosen STEM, despite having received good grades at GCSE level in science and/or maths. The interviews provided additional understanding of this important group's reasons for dropping STEM studies.

STEM Decision Journey Results

Figure 3 summarises the dramatic decline in STEM engagement that happens throughout secondary school.

Figure 3
STEM engagement declines dramatically for older students



Notes: STEM is science, technology, engineering and mathematics.
*Percentage is based on pupils entered for at least one A level.
Sources: *ASPIRES1* and *2* studies, King's College London; *UPMAP* study, UCL Institute of Education

This is very much a secondary school phenomenon. Among students coming in from primary school, 75 per cent of boys and 72 per cent of girls state they are interested in science and enjoy it.[11] By the time they sit A levels, only one student in four is studying two STEM subjects and one in 11 is studying maths and physics. Among girls, the dropout rate is even worse, with one girl in five taking two STEM subjects and a shocking one in 31 taking maths plus physics.[12]

The key dropout points along the STEM journey are different for boys and girls. Boys start to drop out as they approach their A-level subject choices; after that they progressively opt out of STEM. Girls on the other hand start showing lower aspirations for STEM early in their secondary school career. Just before they start A levels, there is another similar fall in participation.

To understand what is driving this pattern of behaviours, A.T. Kearney reviewed the analysis undertaken in the UPMAP and ASPIRES studies. Both had used multilevel modelling to pinpoint the independent influences on aspirations and participation.

[11] ASPIRES1 King's College London, survey of 10-11 year olds, 2009
[12] Department for Education data from 2014-2015 academic year; ratio based on pupils entered for at least one A level

It became clear that both boys and girls are being discouraged from studying STEM for four common reasons, while girls' participation is additionally hampered by lower aspirations towards science-related careers. Figure 4 summarises the drivers in order of importance and shows the types of questions used to assess these in the ASPIRES and UPMAP surveys; for further details see Appendix 1.

Studying the drivers of STEM participation (figure 4), we found that students are not just uninformed—they are ill-informed: about the value of STEM for their future careers and livelihoods, and about the value of STEM in the labour market in general. Secondly, as they progress towards A levels, they increasingly doubt their own ability to do well at STEM subjects. Thirdly, although encouragement by teachers and parents is crucial to students' interest in and confidence about STEM, it is not usually forthcoming except in certain circumstances (for example parents who themselves are qualified and/or work in STEM). Fourthly, as students lose confidence, their initial high level of interest drops off throughout secondary school reflecting the evolution of the curriculum.

Figure 4

Four factors drive boys' and girls' STEM participation, with an additional one for girls

Key drivers by order of importance for participation		**Sample statements from survey (students asked if they agree or disagree)**	**Differences by subject or area**
Boys and girls	Career relevance	"Studying science is useful for getting a good job in the future"	Higher impact for physics
	Ability to do well	"I am good at science" "I do well in maths and physics tests"	Similar for maths and physics
	Adult encouragement	"My teacher and parents think I should continue with maths and physics"	Higher impact for maths
	Interest and enjoyment	"I learn interesting things in science"	Similar for maths and physics
Girls only	Low appeal of science careers	"When I grow up, I would like to work in engineering" "When I grow up, I would like to be a scientist"	Higher impact on engineering aspirations

Note: STEM is science, technology, engineering and mathematics.
Sources: *ASPIRES2* study, King's College London; UPMAP study, UCL Institute of Education

Both boys and girls are affected by these factors, but girls appear to be more heavily influenced. Girls also have lower aspirations for STEM careers. We include in this report some of the stories told to researchers to bring to life the decision process undergone by tens of thousands of young people every year; the stories are true but names have been changed.

Ellie's story

Ellie is 18 and comes from a lower-income family.

She achieved A*AA in science at GCSE but chose to study English, sociology, psychology and religious studies at A level.

When she described her A-level decisions, Ellie started by stating: "I really wish someone had told me how important this choice is."

Given her GCSE grades she wanted to study chemistry, but she was advised by her mother not to do chemistry: "It's the hardest one...play to your strengths." The deputy head of her school told her: "The first thing universities ask for is AAA, then they look at your subjects." She therefore "played safe to get good grades."

Having achieved a B in GCSE maths, Ellie didn't even consider maths at A level. She described herself as having a strong intuition for maths, but experienced poor teaching where the basics weren't explained.

Now she wants to study psychology at university but is realising her choices have narrowed her options: "I didn't know anything about the Russell Group...that it's good to do two core subjects for university." And no one told her that, if she wanted to do psychology at university, it was preferable to study science. She states: "I could have done it (taken A-level chemistry)."

Concluding, Ellie stated that she found out too late how much her choices at 16 "mattered for the rest of her life."

Source: A.T. Kearney interviews with 17- to 18-year-old non-STEM students, 2015

Exploring Drivers of STEM Choices

In figure 4 we showed the most important drivers of the choice made by 16-year-old students to opt out of STEM subjects in their post-16 studies. This section provides more detail on these drivers in order of importance, as well as the stories of more interviewees.

Perceived career relevance

It is clear that children in England's secondary schools lack quality information about how to achieve their career ambitions. Although 45 per cent of 16 year olds say they will choose their A levels based on their future career, results suggest they make their decisions from a limited knowledge base.[13]

Only a couple of the 30 students we spoke to said they had based their decision on a discussion with a career adviser.[14] This echoes research undertaken by the Association of Accounting Technicians which found that, for 43 per cent of 14-19 year olds, formal career advice had limited influence on their career choice.[15] The issue is evident to employers too, with the CBI's finding that three in every four employers think career advice is not good enough. In fact, because they consider it so weak, 60 per cent of employers are willing to take on a greater role in delivering career advice.[16]

Arguably much more unsettling is the widespread ignorance among students about the careers each subject actually leads to. Consider the comment by a Year 9 student, Jake, in the ASPIRES study: "Jobs that use the study of science are important, but there's not really many there that I know of." His mother's limited understanding of STEM career paths no doubt contributed to this situation. She remarked: "Jake loves science, but what can I do? If you do science, what can you be later on?" Comments like these are repeated in the research time and time again.

In the interviews conducted by A.T. Kearney, one in ten students was unable to identify any career that involves maths. Accountancy was the top guess for half of those interviewed, with teaching maths a close second.[17]

The situation for physics was even worse. When students were asked which careers are based on physics, the most common answer was "I don't know." For those who were able to name a career related to physics, engineering was, quite reasonably, the most popular answer. Beyond that was a general expectation that someone who studies physics will end up in a white coat, doing scientific research.

Chemistry and biology have strong associations with medicine and pharmacy. Just over three-quarters of our sample saw biology leading to medicine; more than half associated medicine with chemistry.[18] Industrial applications of these key sciences were not at all clear to the respondents.

This lack of knowledge of STEM transferability is confirmed by the ASPIRES1 study which found that young adults and their parents are unaware of the wide range of careers that STEM opens the door to. The study found that science qualifications are predominantly seen as leading only to careers as a scientist, science teacher or doctor.

[13] ASPIRES2, King's College London, survey of 15-16 year olds, 2014

[14] A.T. Kearney, Interviews with 17- to 18-year-old non-STEM students, 2015

[15] Association of Accounting Technicians, survey of 14-19 year olds, 2014

[16] *Inspiring Growth*, CBI/Pearson education and skills survey, 2015

[17] A.T. Kearney, Interviews with 17- to 18-year-old non-STEM students, 2015

[18] A.T. Kearney, Interviews with 17- to 18-year-old non-STEM students, 2015

Interestingly the subject with by far the highest perceived usefulness for finding a job was English. Almost one in three of our respondents put it at the top of their list.[19] Note that these were respondents who had made a conscious decision against STEM subjects despite being good at them, so that their views may not be representative of all students, but they are pertinent to understanding the dropout phenomenon. Furthermore they are aligned with the findings of the much larger sample in ASPIRES2.

The poor information on subject choice and careers is exacerbated by the structure of the A-level system, which forces a narrowing down of how many subjects can be chosen (most commonly to three or four) while offering a very broad choice of potential subjects. A typical 16 year old staying in mainstream education can choose from over 80 subjects—none of them mandatory. Compare this with the situation in France, where four or five subjects are compulsory and a further couple of optional choices are made from a narrow list. The general pros and cons of the A-level system have been debated elsewhere and are beyond the scope of this report.[20] It does, however, seem to worsen the STEM dropout problem. Arguably, it is harder for students to select the right subjects when they have to choose from so many. At the same time, by constraining their ultimate choice so tightly, it narrows the options they might have in future. Given this exam structure, good career information is surely of paramount importance to students choosing A levels—but they are not getting it.

Careers advisers—"a waste of time"

Mary performed well in STEM-related subjects at GCSE. Keen to have a career in psychology or counselling, she wanted to study psychology at university. Her teachers encouraged her to take science subjects at A level, because, as Mary remembers, "they said universities are looking for those who study harder subjects. I probably should have listened to them."

To get more information about her future path, Mary attended a session with a careers adviser, as well as school open days. In her experience, "careers advice was a waste of time." Eventually, she found most of the information she was looking for online, and chose art, psychology and English literature for A level.

Her rationale was clear: "I'd rather study something that I know I can get a good grade in than something that is potentially harder." However, having made her choices, Mary then found that biology or another science was needed for the university programme she was interested in.

Although originally she would have been happy taking biology, she changed her mind because she perceived it would be harder than her other subjects. "I would have taken it if I knew that was desirable for the university," she says. Mary herself chose to ignore her teachers, but stronger and more clear-cut careers advice might have helped her avoid a poor choice of A levels.

Lack of confidence in ability to do well

The second major driver of student choices is a lack of self-confidence in their own performance in STEM subjects. This matters on two counts. A wealth of psychological research has shown how confidence affects performance, in fields from sport to the arts to the workplace. So when students lack confidence around STEM, they are already potentially disadvantaged in terms of what they might be able to achieve. Secondly, when students are choosing their A-level

[19] A.T. Kearney, Interviews with 17- to 18-year-old non-STEM students, 2015

[20] For instance in John Cridland's speech, *Festival of Education*, June 2015

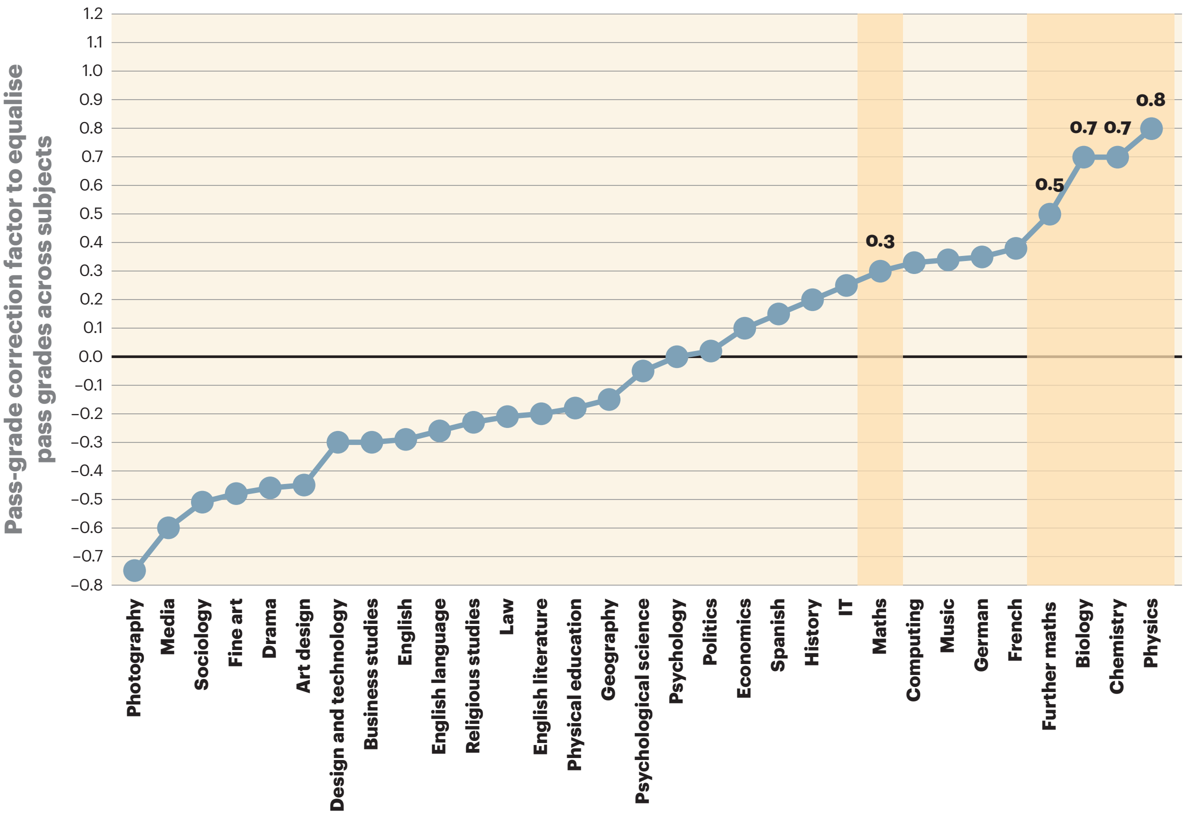
subjects based on the grades they think they might get, rather than the utility or interest of the subject, they will gravitate towards the subjects they believe they can do better in.

Their lack of confidence in their ability to do well has some basis in fact. Historical data shows that getting good grades has been harder in STEM than in other subjects at A level (see figure 5). A similar picture is painted in a more recent study comparing student achievement in a range of subjects in UK state schools.[21] While students taking physics at A level tended to have shown better previous performance than was the case for the other subjects, their achievement at the end of the course was not significantly better. In essence, this study indicated that grading across subjects is not consistent, with media studies and physics at opposite ends of the "difficulty" scale.

The Department for Education has attempted to rectify this imbalance, but the perception unfortunately remains among both students and teachers. When we interviewed a group of 17 and 18 year olds who chose not to continue STEM at A level, three-quarters of them thought those subjects were harder; many of them had been told by teachers that this is the case. The message is reinforced by open days, and by students in the year above.[22]

Figure 5
The most challenging A-level subjects are STEM

Historical A-level relative difficulty (2008)



Notes: STEM is science, technology, engineering and mathematics. The representation is an average of five different statistical methods for comparing the grades achieved by comparable (or same) candidates in different subjects.
Source: *Relative Difficulty of Examinations in Different Subjects,* Durham University Centre for Evaluation and Monitoring

[21] Dave Thomson for Education Datalab, *Is A-level physics too hard (and media studies too easy)?*, 2015
[22] A.T. Kearney, Interviews with 17- to 18-year-old non-STEM students, 2015

Studying a STEM subject at A level is perceived to be a step change from GCSE, and only for the "ultra-bright" who are in a league of their own. As one student told us: "Science is a difficult subject and you have to be pretty smart to understand it." Another student in the ASPIRES study said: "Most people who like science are really good at everything. I just don't really talk to them." Overall, many children and their parents seem to see careers in science as only for the exceptional. Those students who like science but do not see it as a career for themselves tend to describe themselves (and/or be described by their parents) as "normal" or "middling" students.

Physics is judged to be the hardest subject, followed closely by chemistry, with biology seen as the easiest of the three. A common view is that only students who achieve an A or A* at GCSE should carry on to A level; we understand that some schools have formally put this restriction in place.

Only for the "ultra-bright"

Around 79 per cent of students gaining an A* in GCSE maths go on to study maths post-16, compared with 48 per cent of those gaining grade A, 15 per cent with grade B, and almost none of those with grade C (1 per cent).

By contrast, twice as many students (about 30 per cent) with a grade B in English, history or geography continue after 16, as do about 10 per cent of those with a grade C.

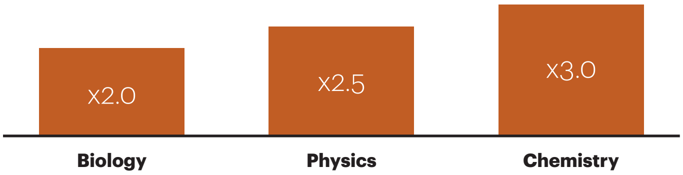
In physics, only 43 per cent of those with A* in GCSE physics continue to study it post-16. Fewer persevere having attained a grade A (about 30 per cent), grade B (16 per cent) or grade C (4 per cent).[24]

Unfortunately, in 2014 only 23 per cent of students in the UK achieved A or A* in science at GCSE and only 15 per cent did this well in maths.[23] Without a concerted effort to attract more students, at least those who score a B aged 16 (and perhaps those who scored a C and have confidence they can succeed in further study), the dearth of STEM graduates and workers will only continue.

An especially negative impact on confidence appears to come from the practice of streaming students into science groups. The ASPIRES2 study found that a student taking triple science at GCSE is two to three times more likely to take science at A level (see figure 6).

Figure 6
Triple science matters to intention to study STEM

Intention to study STEM at A level likelihood for triple science GCSE students vs. double science



Note: STEM is science, technology, engineering and mathematics.
Source: *ASPIRES2* study, King's College London, 15-16 year olds (year 11)

[23] JCQ, GCSE Results, 2014
[24] DFE Research Report, GCSE to AS level and continuation to A level, 2012

Gloria's story

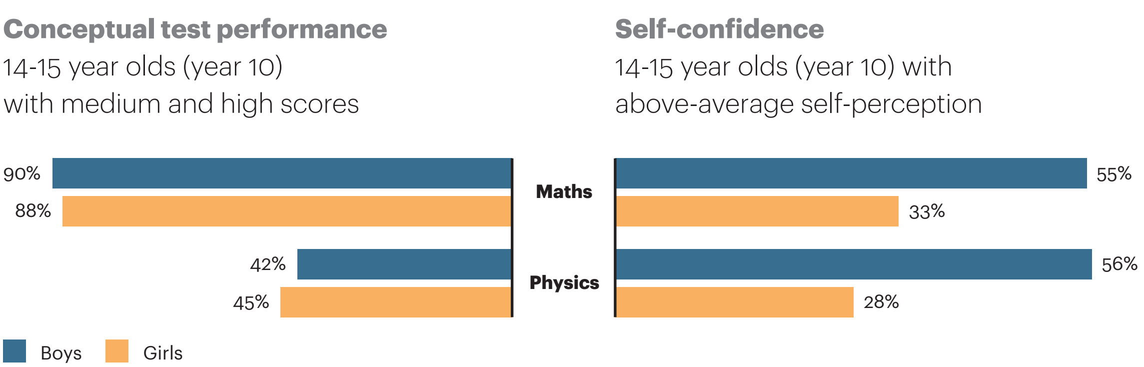
In interviews with Gloria between the ages of 10 and 13, she consistently expressed a very strong interest in science and aspired to become a marine biologist. She had a supportive family who also took part in a range of science-related activities with her in their leisure time. However, by age 14 she seemed to lose her aspiration to become a scientist; the turnaround seemed to derive from her experience in Year 8 of not being allowed to study triple science at school. As both Gloria and her mother Isobel described in their respective interviews, this decision negatively affected Gloria's confidence and her identification with science.

Source: ASPIRES2 King's College London longitudinal interviews

Streaming has two effects. It sends the message to many double science students that "science is not for you". It also means that, if they do choose to proceed with an A level, they are starting at a disadvantage, as they have covered less of the curriculum than their triple science peers. In 2012 around 23 per cent of students were in triple science.[25] Significantly, for about 60 per cent of students the school decides whether they take triple science.[26]

The problem of lack of self-confidence and the "difficult" image of STEM subjects is even more drastic among girls. Although girls' performance in maths and physics tests is very similar to boys', their self-confidence is 40-50 per cent lower (see figure 7 and figure 8 on page 15).[27] We have not identified any studies which have undertaken similar assessments for other subjects. Nevertheless as one girl said in the ASPIRES research: "Physics has always been seen as really hard…you have to be so clever to understand it that only the male side think that they're fit enough to do it, not the ladies."

Figure 7
Conceptual test: Similar results for boys and girls, but girls are less confident

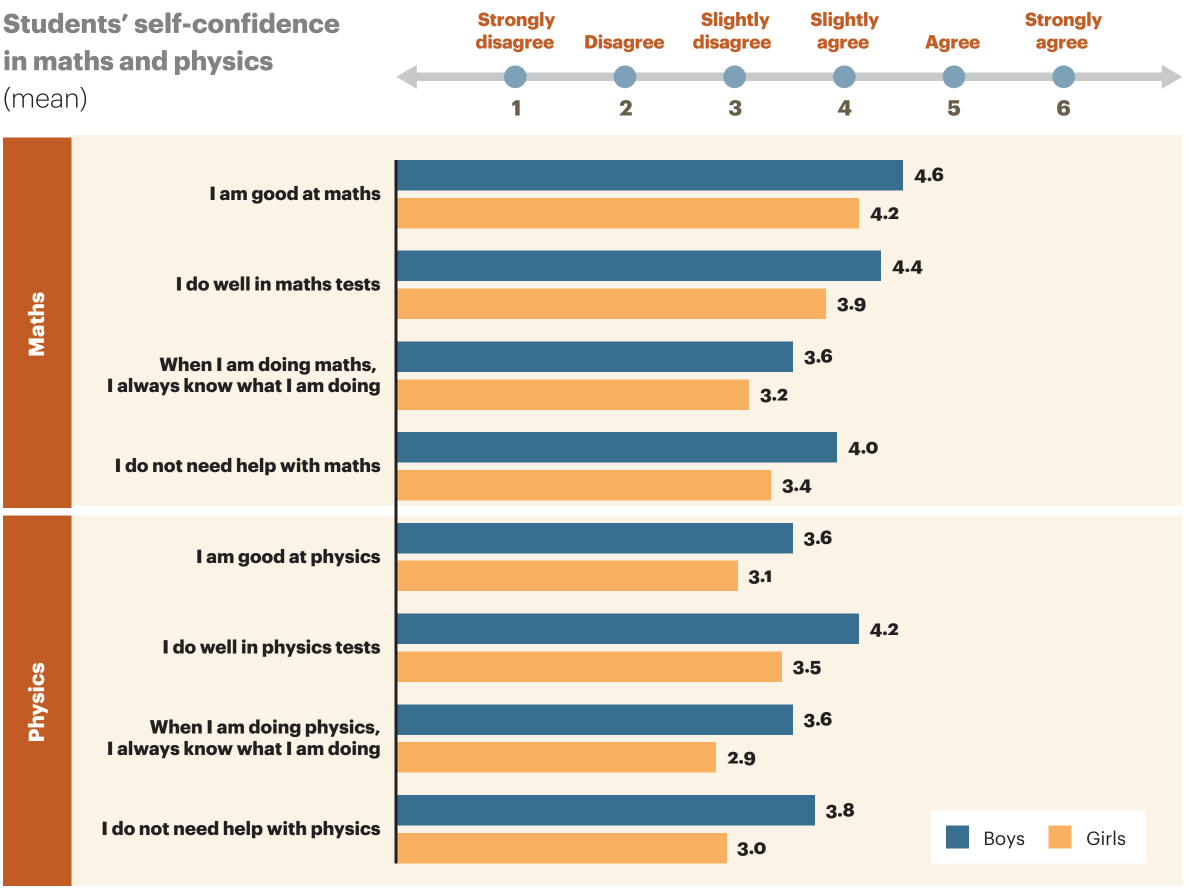


Sources: *UPMAP* study, UCL Institute of Education

[25] Wellcome Trust, Questions for Governors
[26] ASPIRES2, King's College London, survey of 15-16 year olds, 2014
[27] UPMAP, UCL, survey of 14-15 year olds, 2008

Figure 8

Overall lower confidence for girls in maths and physics despite similar academic results



Sources: *UPMAP* study, UCL Institute of Education, 14-15 year olds (year 10)

Absence of adult encouragement

Lack of encouragement and example from key adults is the third major driver of the low STEM participation. Teachers and parents have a crucial role to play in student decisions. Not only do they influence such decisions directly, they also indirectly affect the other drivers of participation—through the information and advice they provide, the way they support students' self-confidence (or not) and their contribution to helping students enjoy science and science-related activities.

One student told us: "When we were considering A levels, teachers warned us not to take science unless we are good at it." Others were put off by students in the year above: "Older students say it's such a jump from GCSE."[28]

On the home front, the ASPIRES2 study found that students from families where one or more adults have degree-level STEM qualifications and/or STEM careers are much more likely to consider STEM-related careers themselves. This is partly due to the fact that such a family is more likely to possess more science-related knowledge and understanding and take a keen interest in science-related activities, TV programmes, books and conversations. Moreover, the

[28] A.T. Kearney, Interviews with 17- to 18-year-old non-STEM students, 2015

Teachers and parents—a big influence[29]

55% **of students consider their parents to be the most important people to talk to about their subject decisions.**

19% **said teachers are the most important.**

40% **say teachers are the second most important.**

Source: ASPIRES2 King's College London interviews with 15-16 year olds

adults are in a good position to share information about the value and transferability of science qualifications in the labour market. They can talk credibly about the different types of jobs available to STEM-qualified people, and perhaps the salary premiums that can be achieved. ASPIRES2 has put forward the concept of "science capital" to explain this overall phenomenon and demonstrate that the likelihood of participating in science post-16 increases with the level of family "science capital".[30]

Given the extent of this influence in school and at home, it is unfortunate that so many students are being told by adults to focus so heavily on grades. Obviously, no one would suggest that students should take A levels where they are not likely to succeed. However, current practice fails to recognise that many B students at GCSE level can and do go on to do well at A level and, with the right teaching and encouragement, have access to better careers.

The situation is not uniform across subjects and students: generally, students feel they get more encouragement from teachers to continue with maths than they do with physics; and boys are seen to receive more encouragement than girls.

Added to all this is the negative impact of teaching outside of specialism. One in every three secondary state school physics teachers lacks relevant post-A-level qualifications.[31] A quarter of chemistry teachers are similarly underqualified. We did not find research that gave a clear answer on the impact of perceived teacher quality on student subject choice. Nonetheless it seems plausible that when teachers are perceived to be less good at a subject, students may be less inclined to join their classes, especially if they are already worried about their own ability to succeed.

David's story

David wanted to continue studying maths after GCSE. However, having scored Bs in GCSE maths and science, he decided not to: "I thought I would struggle for two years and hate it." He did not see STEM-related careers as rewarding, and perceived little encouragement from his school to take maths and physics: "The school shows the percentage of grades to the public during taster days; they indicate maths and physics are difficult and not for everyone." The school careers adviser was similarly unsupportive, saying David could take maths at A level but she would not advise it because she felt he would struggle.

Source: A.T. Kearney interviews with 17- to 18-year-old non-STEM students, 2015

[29] Answer to the survey question: Who is the most important person to talk with about your decisions about what to do after GCSE?

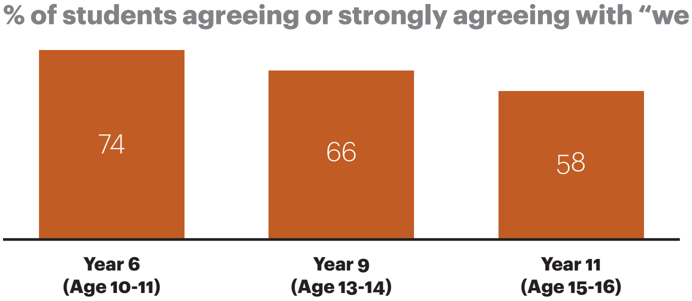
[30] Archer et al., *Science capital: A conceptual, methodological and empirical argument for extending Bourdieusian notions of capital beyond the arts*, 2015

[31] DFE, *School Workforce in England*, 2013

Diminishing interest and enjoyment

The fourth driver to emerge from the root cause analysis of participation in STEM is interest in and enjoyment of the subjects themselves. Although children leaving primary school express a high level of interest in science (74 per cent), this decreases progressively as the focus on exams increases (see figure 9). By the time they are studying for GCSEs, interest has dropped to 58 per cent.

Figure 9
Students' interest in science diminishes



Source: *ASPIRES1* and *2* studies, King's College London

Part of the problem is that students struggle to see the point of what they are being taught. They see lessons becoming less practical and more theoretical as they progress through school. A student remarked: "It's a yes/no answer. Not fun! Not interesting!" Another said: "You learn the basics of maths from primary school. I think that's enough for you unless you want to become an engineer."

This drop in interest is also linked to the widespread lack of knowledge on career relevance as discussed earlier. Students, already put off by what they see as an overemphasis on theory, lack the motivation that could come from seeing a direct connection between what they are learning and its practical application in the workplace. As one commented: "I can't ever see anyone using some things we learned, like vectors: why would anyone teach it?"

Such a disconnect between lessons and the world of work is at odds with the recommendations in Sir John Holman's 2014 report for the Gatsby Foundation, which stressed how important it is for students to experience not just school-based "push" but also employer-based "pull" to identify and gravitate towards the right careers.[32] This is an area where businesses can support teachers—with many companies active already—to help students see the reality of science beyond the classroom.

Lack of appeal to females

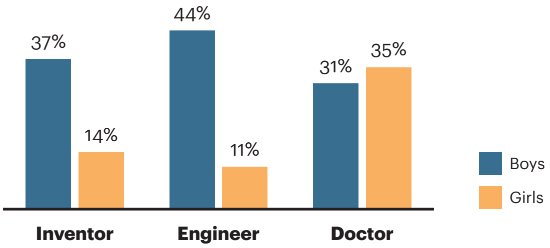
One solution to the STEM shortfall in the UK would be to increase the participation of girls to the same level as that of boys. But there is little sign of that happening soon: by age 14 only 14 per cent of girls say they would like to be an inventor, compared with 37 per cent for boys; and more than four times as many boys as girls want to be an engineer (see figure 10 on page 18).

[32] Gatsby Foundation, *Good Career Guidance Report*, 2014

Figure 10

Engineering careers do not appeal to young girls

STEM-related career aspirations for 13-14 year olds (year 9)
(% of all students)



Note: STEM is science, technology, engineering and mathematics.
Source: *ASPIRES Young People's Science and Career Aspirations,* King's College London

Girls state the issue is one of image: they don't want to be seen doing "masculine" subjects.[33] In general, even TV and media promote the idea that physics is for men. A popular example is the *Big Bang Theory* TV show, in which physics is about men, and most of their female counterparts are presented as either not at all scientific but popular, or smart and geeky.

Some complicated effects are at play here. For one thing, there appears to be an unconscious bias in homes, schools and society in general, as evidenced by girls' comments about parental advice, and their perception that they are given less encouragement than boys from their teachers. In addition, many STEM careers are currently not perceived as appealing to girls' broader ambitions: 50 per cent of girls consider helping others as important in their future careers (which presumably explains the high interest in medicine shown in figure 10). They need help to see the opportunities STEM gives them to do that.[34]

[33] ASPIRES2, King's College London, survey of 15-16 year olds, 2014

[34] ASPIRES2, King's College London, survey of 15-16 year olds, 2014

Developing Solutions to STEM Dropout

The research and analysis presented in this report show a situation that needs to be confronted. The future of the UK economy requires fundamental change in how students choose their subjects—and thus their future path into higher education and employment—at age 16. As the driver analysis showed, tackling the problem requires multiple responses:

Employers should:

- Boost students' understanding of the value of studying STEM, its relevance and transferability for a broad (and growing) range of careers, and its value compared to some of the other subjects that nominally appear more relevant for a career (for example, media studies)
- Emphasise STEM in their recruitment and influence careers advice to this effect
- Broaden the appeal of science and engineering careers for girls, bearing in mind that their priorities can differ from boys'[35]

Government should:

- Structure science teaching to broaden its appeal beyond students achieving A/A* at GCSE (including challenging the placing of students into ability groups such as double and triple science)
- Improve the quality and quantity of STEM teaching, especially in physics, and ensure teaching methods are relevant and engaging, with emphasis on the practical applications of concepts taught
- Address the inequality of A-level grading so that no one choosing A-level subjects need consider the artificial difficulty or ease of a particular subject

Teachers and parents should:

- Change the message students are getting from "It's hard" to "You can do it", without pushing students with very low aptitude into A-level study
- Shift the focus from getting high grades irrespective of subject to a balanced view of subject content, subject mix and likely exam performance (note that universities already do this, so that this is a question of providing accurate information and advice ahead of A-level choice)

All these points are relevant to addressing a deep-seated problem centred on UK youth. The shortfall in STEM skills is already a major obstacle for the economy and will become only more serious as more and more sectors, and a growing proportion of roles within those sectors, depend on STEM skills. The Your Life campaign, together with the CBI, will target action on multiple points where employers have a role to play. The education sector, Government and parents must also step up their own efforts to provide students with the best possible support, advice and encouragement to make the right choices.

Young individuals make these choices en masse every year. Today they often make an apparently rational response to flawed incentives and misinformation. In future we hope that they will respond to better information and clearer incentives to recognise that maths and science often will prove to be their best path to success.

[35] ASPIRES2, King's College London, survey of 15-16 year olds, 2014

Authors and Contacts

A.T. Kearney has prepared this report for Your Life, a business-led and Government-supported campaign to inspire young adults to study maths and science beyond the age of 16.

The immediate ambition of the three-year campaign is to increase maths and physics participation at A level by 50 per cent. As part of its contribution to the campaign, A.T. Kearney is providing research to help maximise the impact of the campaign's activities.

Your Life is guided and backed by a group of leading companies/major UK employers:

The campaign is supported by the Department for Education.

The CBI has supported Your Life and A.T. Kearney with this research to help inform the policy debate on education and, in particular, to explore where business can offer support. Across the UK, the CBI speaks on behalf of 190,000 businesses of all sizes and sectors which together employ nearly 7 million people, or about one-third of the private sector-employed workforce. For business, education is a priority issue and the aim of the CBI's education policy work is that everyone should be equipped with the skills and knowledge needed for them, for business and for the UK economy to succeed.

A.T. Kearney would like to express our special thanks to King's College London ASPIRES, led by Professor Archer, and University College London UPMAP, led by Professor Reiss, for so generously sharing their survey data and insights for this report. The report would not have been possible without them.

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We prepared this report at the request of Your Life and in cooperation with academic partners, corporate partners including the CBI, and Government bodies including the Department for Education. Nonetheless the report is independent and represents only the views of the authors. It is intended as a contribution to an important public debate. A.T. Kearney accepts no responsibility for any other use made of the report.

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Appendix 1: Summary of Methodology

As the research partner for the Your Life campaign, A.T.Kearney proposed using the concept of a STEM Decision Funnel to inform and focus the campaign's activities on crucial dropout points during the school career.

In our initial literature review on the topic, we identified two key studies—ASPIRES and UPMAP—that had amalgamated a wealth of primary data from surveying and interviewing students throughout their time from leaving primary to finishing secondary school.

The academics leading these studies were Professor Michael Reiss from UCL and Professor Louise Archer from King's College London. Both agreed to support A.T. Kearney's research in three crucial ways: 1) granting access to their existing research and publications; 2) engaging in working sessions to discuss and capture their expert perspectives beyond the existing research; 3) granting access to their primary data, to enable full exploitation of the wealth of material compiled.

Overview of ASPIRES (1 and 2) and UPMAP projects

Both these programmes have been funded by the Economic and Social Research Council and were launched in the early 2000s as part of the Targeted Research Initiative on Science and Mathematics Education. The programme funded five research projects in total.

ASPIRES1 explored science aspirations among 10-14 year olds. The research combined qualitative data in the form of 83 longitudinal interviews with quantitative data captured in the form of three surveys. The interviews and surveys took place in three stages, starting in primary school with a group of 10-11 year olds (9,319 survey respondents), continued in secondary school with the students aged 12-13 (5,600 survey respondents) and finished when they were aged 13-14 (4,600 survey respondents).

Each questionnaire had a similar structure covering demographic data, hobbies and interests, attitudes towards science lessons, self-confidence in science, parental attitudes, science activities in and out of school, and career aspirations.

ASPIRES2 extends the work undertaken in ASPIRES1 to 15-18 year olds, similarly combining quantitative surveys and qualitative interviews. In 2014, 13,445 15-16 year olds responded to the questionnaire; the intention is to also survey a minimum of 7,000 17-18 year olds. To ensure continuity from ASPIRES1 and valid year-on-year comparisons, the questions are similar but extended to cover intention to participate in STEM at A level. This quantitative data is being complemented with about 70 student interviews and 60 parent interviews, continuing the longitudinal work from ASPIRES1. Despite the study being ongoing with very little published to date, Professor Archer agreed to give A.T. Kearney access to the results for 15-16 year olds.

The UPMAP (Understanding Participation rates in post-16 Maths And Physics) project was focused on identifying the drivers of participation in maths and physics. The study had three strands: Strand 1, quantitative research in secondary schools among young adults aged 12-15; Strand 2, qualitative interviews in 12 of the schools covered by the quantitative research; Strand 3, qualitative interviews of 51 first-year undergraduates.

In total, 23,000 students completed the questionnaires in Strand 1 of UPMAP. The UPMAP questionnaire has a narrower focus than ASPIRES as it concentrates on potential drivers of participation. However, it drills more deeply into those potential drivers: in addition to detailed questions on attitudes towards physics and maths teachers and classes, and parents' encouragement and support, this questionnaire includes a conceptual test against which the students were rated, and they were also asked to rate how they thought they had performed on the test.

Both ASPIRES and UPMAP analysed the absolute answers of the survey responses. They also used multilevel modelling to identify independent variables that influence aspirations, participation and other factors. Multilevel models are an extension of normal Ordinary Least Squares models but take account of the inherent structure of the data: in this case, that the data is hierarchical in nature with students embedded within schools.

Various constructs were developed from the questionnaire answers by grouping similar questions. For example, self-confidence in maths in UPMAP was assessed based on the responses to the following statements: 1) When I am doing maths, I always know what I am doing; 2) I do well in maths tests; 3) I am good at maths; 4) I do not need help with maths; 5) Thinking about a maths lesson, rate how you feel you compared with others in your group. The constructs developed in this way are then correlated with students' participation to identify the key drivers.

The table below summarises the key drivers of participation for maths and physics identified by UPMAP, and their correlations (Pearson's product) with intention to participate. A correlation of 1 indicates perfect correlation, and 0 shows no correlation.

Four factors drive STEM participation

Key drivers of STEM participation	Correlations (Pearson's product)	
	Maths	Physics
Career relevance	0.33	0.53
Ability to do well	0.50	0.50
Adult encouragement	0.50	0.39
Interest and enjoyment	0.48	0.39

Note: STEM is science, technology, engineering, and mathematics.
Source: *UPMAP* study, UCL Institute of Education

Having previously focused on the nature and level of student aspirations and "family science capital" with their surveys of older students, King's College London is currently also drilling (in ASPIRES2) into drivers of participation. The emerging results are broadly aligned with UPMAP's.

Additional primary research

UPMAP and ASPIRES have focused mainly on forward-looking surveys and interviews, or retrospective accounts from students at university. To complete the picture with a retrospective point of view within schools, A.T. Kearney undertook 30 qualitative interviews of 17- to 18-year-old students who had not chosen STEM, despite attaining at least a B in a number of STEM subjects.

The interviews took place on a 1:1 basis in person or by telephone in three cities: London, Birmingham and Manchester. The students were sourced by an agency specialising in focus groups and were selected to be representative of the socioeconomic and ethnic mix of each city.

The focus of the interviews was to understand the drivers of A-level decisions and who the key influencers were in that process. Their A-level decisions were still very fresh in their mind, but in many cases this was combined with an appreciation of the impact it was having on their university applications. This added perspective brought to life the drivers identified by the surveys and the academic research. Distressingly, we found that many of these students already regret their decisions.

Clarification of scope

Throughout this report, we make reference for the sake of simplicity to A-level studies, which have been the primary basis of our analysis. A number of UK schools have moved to the International Baccalaureate system for the final two years and of course the Scottish education system has a very different exam system for the final years of school (Highers), with evidence suggesting higher STEM uptake.

The ASPIRES and UPMAP studies both included a wide range of schools. UPMAP was UK-wide while ASPIRES focused only on England.

Appendix 2: Overview of Existing/Recent Initiatives to Promote STEM in the UK

In addition to the Your Life campaign, A.T. Kearney has identified a wide range of programmes aimed at promoting STEM uptake, ranging from subject specific (Further Mathematics Support Programme) to profession driven (Tomorrow's Engineers) to those supporting gender diversity (for example Women in Science and Engineering). This list is not exhaustive.

National programmes	Main activities
Campaign for Science & Engineering (CaSE)	Campaign to raise the political profile of science and engineering by working with a wide range of stakeholders, publishing analyses and briefings, and commenting on the topic in the media
Connecting STEM Teachers	Royal Academy of Engineering programme focused on providing local support for STEM teachers to develop the knowledge to illustrate the role of engineering in society and how learning STEM is applied in the real world
CREativity in Science and Technology (CREST) Awards	UK award scheme run by the British Science Association that enables students to build their skills and demonstrate personal achievement in project work
Engineer a Better World	Institution of Engineering and Technology campaign to inspire the next generation of engineers and technicians by encouraging young people and their parents to think differently about careers in engineering
Further Mathematics Support Programme (FMSP)	Area coordinators work with schools to support and promote the study of A-level maths and further maths (tuition for students and training for teachers)
Generation Education	Teach First and Barclay's programme aimed at supporting the recruitment of 533 STEM teachers to work in schools that serve disadvantaged communities across the UK
Project Enthuse	Enthuse Awards to help fund participation in STEM professional development courses
ScienceGrrl	Social networking celebrating and supporting women in science
STEMNET	Three national programmes to inspire young people to study STEM: STEM Ambassadors, STEM Club Programme, and Schools STEM Advisory Network
Stimulating Physics Network	Resources and support for teachers and schools to enhance physics teaching (hands-on physics workshops, mentoring, and targeted-support packages)
The Big Bang	Fair aimed at showcasing the range of opportunities with STEM qualifications
The National STEM Centre	The Centre in York houses the United Kingdom's largest collection of STEM teaching and learning resources
The Triple Science Support Programme	Provides information for schools developing or delivering triple science (school-to-school learning, raising attainment, and teaching specific topics)
Tomorrow's Engineers	Initiatives to help schools incorporate engineering into the current curriculum (industry visits, workshops, STEM ambassador partnerships and career information)
Women in Engineering, Science and Technology (WEST)	Small bursaries to give practical support to women and girls working and learning in STEM-related fields
WISE	Inspires girls and women to study and build careers in STEM through consultancy advice for employers, training, publications and courses
Women in Science, Engineering and Technology (WiSET)	Resources, tools and activities available to those who are seeking to widen access to STEM

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