OPPORTUNITY OR ABILITY?
Key Stage 4 science and mathematics participation and attainment in England 2010
Acknowledgements

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Executive Summary

The UK must ensure it has an adequate supply of people working in science, engineering and technology roles to meet the needs of industry and the wider business community. The key first step to achieving this is to ensure that sufficient numbers of pupils are participating in and achieving good GCSEs or equivalent qualifications in science and mathematics at the age of 16.

However, this report by E4E shows that a significant proportion of young people in England are not attaining good enough grades in the necessary qualifications to enable progression to science, engineering and technology careers. There is also strong evidence to suggest that many pupils across England are not even being given the chance to achieve their full potential in science subjects.

Given that participation and success in Triple Science GCSEs is an indicator of future attainment in science subjects, our research shows that young people’s potential to progress in Science, Engineering and Technology is currently heavily determined by opportunity rather than ability.

This report presents the results of an analysis of the entry and attainment of pupils in mathematics and science subjects at the end of key stage 4 in 2010 in England. It provides a snapshot of the potential pool from which the economy can draw its Science, Engineering and Technology future workforce.

Alongside the national analysis, the results show significant variation in participation and attainment across the regions of England.

We find that:

- Almost one in five pupils (18% of the cohort) was not entered for two science qualifications.
- Only half of pupils achieve A*-C grades in two or more science GCSEs or equivalent qualifications and in mathematics GCSE.
- National averages obscure significant variations across England, with a clear tendency towards higher participation and achievement in the ‘Science South’.
- The analysis by region and participation by school type and school size suggests that pupils’ entry and attainment in Triple Science is often not based solely on the ability of pupils but on the opportunities offered by schools.

The study does not consider the underlying factors contributing to variation in participation and attainment such as pupil characteristics; gender, ethnicity and socio-economic status. However, the findings show there are many areas across the country where there is significant industrial presence, yet high proportions of pupils are not being given the opportunity to achieve their full potential in sciences because they are not being offered triple science qualifications and too few are achieving the minimum requirements for progression in science, engineering or technology.

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Issues and Recommendations

The issue of attainment in science and mathematics in our schools is one which is both national and local. The levels of attainment presented here are not good enough if we are to rebalance the economy in favour of productive and manufacturing industries and compete in a knowledge-led, global marketplace in Science, Engineering and Technology. This issue should be of particular concern for those regions where there is low entry and attainment of pupils in science and mathematics and yet want to attract inward investment from international science and engineering businesses.

Industry needs skilled people to perform its functions. Without these people, it cannot operate and this has an impact on the local economy. This is a local issue as much as an issue for the national economy. Local politicians, local businesses and schools must work together to improve the situation.

Recommendations

To Government

The Government must put in place incentives to increase the number of pupils being entered for Triple Science while also removing potential barriers to greater participation. For example, the English Baccalaureate may act as a disincentive for some schools to pursue Triple Science as opting for Double Science would free up curriculum time for other subjects while still meeting the accountability measure. Careful monitoring is required in order to ensure that the English Baccalaureate does not reduce the engineering and manufacturing skills needed to rebalance the UK economy.

Small schools have fewer participants in triple sciences. Government should monitor participation in triple sciences as the number of Academies and Free schools increases and take appropriate action if participation in triple science begins to decrease as a consequence of the introduction of these new, smaller, schools.

The Government has done much to improve accessibility of data for the education system in England. However, further efforts should be made to make it easier for schools and policy makers to compare participation and attainment in specific subjects and in combinations of subjects locally, regionally and against national statistics.

To Parliamentarians

The regional and sub-regional variation in participation and attainment in science and mathematics is not only a national issue for the economy, but is also a local issue for MPs. They should be clear that industry will not invest in constituencies where there is no potential workforce skilled in science, engineering and technology to meet its requirements. MPs must act as the local champions for increasing the knowledge and skills of young people in science, engineering and technology. They must work closely with local schools and local industry to improve provision and participation, and where there are shortcomings, they must hold schools to account.

To Industry

Young people need to know why science and mathematics are important subjects for their future. When businesses make closer links with schools, role models and ambassadors must take the opportunity to explain to young people how high attainment in science and mathematics will enhance their career prospects and earning potential.

To Head Teachers

Young people are easily engaged and motivated by the application of science and mathematics. It is in the interest of schools to take advantage of industry support to bring these subjects to life in the classroom. We ask head teachers to make greater use of industry involvement to increase engagement and drive attainment in mathematics and science subjects and to re-examine policies on participation in triple sciences to increase the proportion of pupils taking individual sciences.

The importance of engineering skills to the Economy

There has been a growing concern from business and industry for a number of years that while a workforce skilled in Science, Technology, Engineering and Mathematics (STEM) is becoming more important for the UK economy, there is an increasing gap in the supply of people with these skills. The CBI, in its 2012 study, found that 42% of member companies are struggling to find employees with STEM knowledge and skills.

There are increasing pressures on the UK to ensure the health, wealth and security of the nation. This includes ensuring sufficient energy supply in the future, meeting carbon reduction targets, developing road and rail infrastructure and introduction of high speed broadband. Engineering skills are also highly valued in other sectors, not just those directly or indirectly involved in engineering. Analysis of the latest research from the UK Commission for Employment and Skills’ undertaken by the Royal Academy of Engineering suggests that there will be a demand for around 1.2 million workers in science, engineering and technology roles in the next ten years, of which approximately 450,000 will be in technician level roles.

2 Learning to grow. Education and skills survey 2012. CBI. www.cbi.org.uk
How can this requirement be met? The answer lies in the significant proportion of the UK population of young people and adults who currently do not consider careers in science, engineering and technology or pursue the facilitating subjects which lead to those careers. Increasing the number of pupils who participate and attain good results4 in science and mathematics at the end of key stage 4, the first formal assessment for qualifications, is a first step to increasing the potential supply of a science, engineering and technology workforce.

Approach to this research

This study draws on the National Pupil Database5 (NPD) of student attainment held by the Department for Education (DfE). The analysis is based on 2010 data, the most recent available at the time of the study. Government policies to promoting subjects over the last year may well have an impact on 2011 results. Recent data from the DfE for shows that entries for Triple Science year may well have an impact on 2011 results. Recent Government policies to promoting subjects over the last year may well have an impact on 2011 results. Recent data from the DfE for shows that entries for Triple Science increased by 4% from 2010 to 2011, in keeping with increases for the last five years6.

Progression in Science, Engineering and Technology

Progression in science, engineering and technology will nearly always require a thorough grounding in mathematics. For this report this is considered to be a QCF level 2 qualification in mathematics such as A*-C grade at GCSE.

The picture for science qualifications is less clear and requirements are likely to vary across science, engineering and technology sectors and the progression path being taken by the individual7. Progression to level 3 STEM qualifications may be achieved through studying GCSEs in Core and Additional science (termed Double Science in this report) or through taking individual Physics, Chemistry and Biology qualifications (termed Triple Science), or through Vocational Science (or engineering) qualifications at level 2.

There is a hierarchy of qualification combinations in science and mathematics that can be achieved at the end of Key Stage 4. In descending order, these combinations of achievements show the potential for progression to a level or equivalent level 3 qualifications. These can be seen in Table 1 and graded 1 (highest) to 8 (lowest) in terms of potential for progression. The data in this report is presented in this report is based on these combinations8.

Results of the Study

The analysis of the national pupil database is presented in three sections; first, the national participation and attainment is provided, followed by a regional analysis.

<table>
<thead>
<tr>
<th>Combination of qualifications</th>
<th>Ability to progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achieved A*-C Grade in Triple Science GCSes (individual Physics, Chemistry and Biology GCSEs) and A*-C grade in Mathematics GCSE.</td>
<td>1 (Highest)</td>
</tr>
<tr>
<td>Achieved A*-C grade in Double science (Core-science GCSE and Additional-science GCSE or Applied-science GCSE) and A*-C grade 2 in Mathematics GCSE.</td>
<td>2</td>
</tr>
<tr>
<td>Achieved level 2 (equivalent to A*-C grade) in a vocational science or engineering qualification and A*-C grade in Mathematics GCSE.</td>
<td>3</td>
</tr>
</tbody>
</table>

Likely minimum level of qualifications for immediate progression to further study

<table>
<thead>
<tr>
<th>Combination of qualifications</th>
<th>Ability to progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achieved A*-C grade in one science GCSE and A*-C grade in Mathematics GCSE.</td>
<td>4</td>
</tr>
<tr>
<td>Achieved A*-C grade in Mathematics GCSE but did not achieve a A*-C grade in science GCSE or equivalent qualification at level 2.</td>
<td>5</td>
</tr>
<tr>
<td>Achieved A*-C grade in two or more science GCSEs but did not achieve A*-C grade in Mathematics GCSE.</td>
<td>6</td>
</tr>
<tr>
<td>A*–G in one science GCSE and no A*-C grade in Mathematics GCSE</td>
<td>7</td>
</tr>
<tr>
<td>No entry for any science qualification and No A*-C grade in mathematics</td>
<td>8</td>
</tr>
</tbody>
</table>

4 We consider a good result to be A*-C at GCSE or Level 2 in an equivalent vocational qualification
5 GCSE results in England are often quoted from Joint Council for Qualification (JCQ) statistics. JCQ data however, includes a substantial number of qualifications achieved outside of schools. Also, JCQ provides figures on individual qualifications, not on, for example, combinations of GCSEs.
7 There may be circumstances when one Level 2 science qualification may be sufficient to gain entry to a range of engineering and technology Advanced Apprenticeships which will have subsequent progression opportunities.
8 In the data analysis, these groups are exclusive, i.e. a pupil can only appear in one group.
9 Triple science also includes a small proportion (less than 1%) of pupils who were entered for physics GCSE and another science but not as Triple Science.
of the data and finally participation in triple science is compared for mixed and single sex schools in the state-
maintained and independent sectors.

National Participation and Attainment in Science and Mathematics

The analysis first examines national data for England on the numbers of pupils being entered for the various combinations of science and mathematics qualifications and their attainment in those subjects. Table 2 presents this data on both participation and attainment.

The data presented in Figures 1 and 2 reveals that:

- 82% of the cohort was entered for the minimum requirement (two or more science qualifications at the end of key stage 4). This means that almost one in five young people were entered for fewer than the minimum required number of science qualifications to immediately progress to further study or a career in science, engineering or technology.
- 1 in 12 pupils (8%) were not entered for any science GCSE.
- Only half the pupils achieved A*-C grade in a combination of the minimum science GCSEs (or equivalent qualifications) whilst also gaining A*-C in mathematics GCSE.
- 18% of pupils were entered for Triple Science (individual Physics, Chemistry and Biology) GCSEs. The vast majority of this group went on to achieve A*-C in triple science as well as A*-C in mathematics GCSE.
- 39% of pupils did not achieve A*-C in GCSE Mathematics.

### Table 2: Participation and attainment of pupils in science and mathematics subjects at Key Stage 4 in schools across England in 2009/10

<table>
<thead>
<tr>
<th>Science subjects and qualification groups</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
<th>Grade 4</th>
<th>Grade 5</th>
<th>Grade 6</th>
<th>Grade 7</th>
<th>Grade 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entered Triple Science GCSE</td>
<td>112,500</td>
<td>101,500</td>
<td>6,500</td>
<td>1,500</td>
<td>1,500</td>
<td>2,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entered Double Science GCSEs</td>
<td>341,500</td>
<td>185,000</td>
<td>5%</td>
<td>3%</td>
<td>3%</td>
<td>13%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entered BTEC or OCR Science or BTEC Engineering equivalent to 2 or more GCSEs</td>
<td>62,500</td>
<td>23,500</td>
<td>4%</td>
<td>39,000</td>
<td>6%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entered 1 Science GCSEs or equivalent qualification</td>
<td>67,000</td>
<td>12,000</td>
<td>2%</td>
<td>49,000</td>
<td>8%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entered no Science GCSEs or equivalent qualifications</td>
<td>50,000</td>
<td>6,000</td>
<td>1%</td>
<td>44,000</td>
<td>7%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Cohort</td>
<td>633,500</td>
<td>101,500</td>
<td>191,500</td>
<td>23,500</td>
<td>43,000</td>
<td>35,000</td>
<td>67,000</td>
<td>136,000</td>
</tr>
<tr>
<td>% of cohort</td>
<td>16%</td>
<td>30%</td>
<td>4%</td>
<td>7%</td>
<td>5%</td>
<td>11%</td>
<td>21%</td>
<td>7%</td>
</tr>
</tbody>
</table>
Regional Participation and Attainment in Science and Mathematics at the end of key stage 4 across regions of England

The second stage of the analysis examines regional variation in participation and attainment in the combinations of science and mathematics. The analysis is undertaken across sub-regions of England and at Local Authority level. Local Authorities are used as a useful narrow geographical boundary descriptor, but because of the growth in the Academies and Free Schools programme, there is no longer a simple link between accountability of schools within a Local Authority boundary and the education policies of the Local Authority itself.

Participation in Science qualifications at the end of key stage 4 across regions of England

Figure 3 shows the participation in two or more science qualifications (including vocational qualifications equivalent to 2 GCSEs) at key stage 4 across the 41 sub-regions of England. The regions are divided into quintiles with the highest participating regions in dark green and the lowest participating regions in red. Figure 4 shows the same data by Local Authority, again divided into quintiles.

There was significant regional variation in entry and attainment in science and mathematics GCSEs. Across the regions of England sub-divided into 41 smaller sub-regions there is a clear tendency towards a 'Science South'.

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FIGURE 3: Proportion of pupils entered for at least 2 science qualifications at key stage 4 across the 41 sub-regions of England in 2010.
FIGURE 4: Proportion of pupils entered for at least 2 science qualifications at key stage 4 across the 152 Local Authorities in England in 2010. The Boroughs of Greater London are shown inset.
The study shows that:

- The sub-regions of England with the highest number of entries to Triple Science were around the South West and the M4 corridor. There is a 16% variation in proportion of pupils entered for Triple Science across England. The highest was Bournemouth, Dorset and Poole with 27.7%. The lowest, North and North-East Lincolnshire with 11.7%.

- The national average for proportion of pupils not entered for any science qualification was 8%. The sub-regions with the lowest participation were Lincolnshire and Rutland – (at 23%) and Merseyside (at 17%).

- Looking deeper at the Local Authority level, there is an even greater (36%) variation in entry to Triple Science, ranging from 39.5% of the cohort in Sutton, Greater London to 3.5% in Knowsley, Merseyside. Encouragingly, localised excellence can however be found across all of England.

- In four Local Authorities, over a quarter of pupils were not entered for any science qualification.

Attainment in Science and Mathematics qualifications at the end of key stage 4 across regions of England

Attainment in the combinations of science and maths was also examined. Figure 5 shows the variation of attainment in two or more science qualifications and maths GCSE at grades A*–C by sub-regions of England. The sub-regions are divided into quintiles with the highest performing sub-regions in dark green and the areas with lowest attainment in red. Figure 6 presents the attainment data by Local Authority, again divided into quintiles.

The key findings from the attainment data are:

- Higher proportions of pupils attained science and mathematics GCSEs with A*–C grades in the south of England, particularly in the South West.

- The sub-regions with the lowest proportions of students achieving A*–C grades in two sciences and mathematics GCSEs were North and North-East Lincolnshire (32%) and Merseyside (37%).

- Trafford in Greater Manchester had the highest participation and attainment in science and mathematics of all Local Authorities in England with 67% of pupils achieving A*–C in at least two science subjects and A*–C in mathematics GCSE.

- Blackpool was the poorest performing Local Authority in England for combinations of science and mathematics. Only 31% of pupils achieved two or more science GCSEs combined with mathematics GCSE at grades A*–C.

Participation and attainment in State schools and Independent schools

The study has also examined comparisons between state-maintained schools and independent schools. In the 2010 cohort, 7.5% (47,500 pupils) attended schools in the independent sector. The research also examined differences in participation in Triple Science between mixed sex and single-sex schools and the impact of school size on participation in Triple Science.
FIGURE 5: Proportion of pupils who achieved A*-C grade in two science GCSEs (or equivalent vocational qualifications) and A*-C grade in mathematics GCSE at Key Stage 4 across the 41 sub-regions of England in 2010

- 53–69%
- 50–53%
- 48–50%
- 45.5–48%
- 42–45%
FIGURE 6: Proportion of pupils who attained A*–C grade in two science GCSEs (or equivalent vocational qualifications) and A*–C grade in mathematics GCSE at Key Stage 4 across the Local Authorities of England in 2010. The Boroughs of Greater London are shown inset.
Entry to Triple Science by school type

The data in Table 3 shows the number of mixed-sex and single-sex schools for girls and boys in England. The Table also shows the proportion of these schools which enter their pupils for Triple Science GCSEs.

The low proportion of schools in the independent sector which enter pupils for Triple Science may be explained by the size of the cohort in each school. To better understand this, it is useful to examine participation in Triple Science by size of school, shown in Table 4 below.

The data shows that the vast majority of schools with fewer than 50 pupils in the Key Stage 4 cohort did not enter any pupils for Triple Science. This is likely to be due to the lack of specialist teachers in such small schools. A significant proportion of larger schools enter pupils for triple science, but these tend to be small proportions of pupils within the schools. For mid-sized schools with 50–99 pupils a significant proportion of them enter over half their pupils. These results again infer a pattern of schools streaming pupils with the ‘top set’ being entered for triple science.

Since 2010 there have been further increases in the proportion of pupils taking Triple Science qualifications rising to approximately 20% of the cohort attain A*-C in physics, chemistry and biology and this is welcome.

Research by the Department for Education suggests that pupils participating and achieving in triple science are more likely to achieve high grades in level 3 qualifications in science and engineering subjects.

- 44% of all schools in both state-maintained and independent sectors did not enter any pupils for Triple Science GCSEs.
- School size was a critical factor. 87% of schools with fewer than 50 in the Key Stage 4 cohort did not enter any pupils for Triple Science. This is almost 1400 secondary schools.
- Girls-only schools had a much higher rate entry to Triple Science, but independent schools had fewer (52%) than girls-only state maintained schools (67%).
- Similarly, boys-only state maintained schools had a higher entry to triple science (43%) than did boys-only independent schools (30%).

### Table 3: Proportion of pupils entered for Physics GCSE by end of Key Stage 4 by type of school and gender of school for England 2009/10

<table>
<thead>
<tr>
<th>School type</th>
<th>Gender of School</th>
<th>Number of schools</th>
<th>Percentage of schools entering pupils for Triple Science</th>
<th>Number of schools entering pupils for Triple Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintained School</td>
<td>Mixed sex</td>
<td>3550</td>
<td>56%</td>
<td>1998</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>249</td>
<td>67%</td>
<td>166</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>320</td>
<td>43%</td>
<td>137</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>4119</td>
<td>Average 56%</td>
<td>2301</td>
</tr>
<tr>
<td>Independent School</td>
<td>Mixed sex</td>
<td>532</td>
<td>56%</td>
<td>297</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>283</td>
<td>52%</td>
<td>147</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>172</td>
<td>30%</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>987</td>
<td>Average 50%</td>
<td>495</td>
</tr>
</tbody>
</table>

### Table 4: Proportion of pupils entered for Triple Science GCSE by end of Key Stage 4 by size of school for England 2009/10

<table>
<thead>
<tr>
<th>Size of School year group at Key Stage 4</th>
<th>Not entering pupils for Triple Science</th>
<th>Proportion (of the total cohort) of pupils entered for Triple Science GCSE between 1% and 20%</th>
<th>between 21% and 50%</th>
<th>greater than 50%</th>
<th>Total number of schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fewer than 10 pupils</td>
<td>95%</td>
<td>1%</td>
<td>2%</td>
<td>2%</td>
<td>639</td>
</tr>
<tr>
<td>between 10 and 49 pupils</td>
<td>79%</td>
<td>5%</td>
<td>10%</td>
<td>6%</td>
<td>995</td>
</tr>
<tr>
<td>between 50 and 99 pupils</td>
<td>38%</td>
<td>12%</td>
<td>26%</td>
<td>25%</td>
<td>426</td>
</tr>
<tr>
<td>between 100 and 199 pupils</td>
<td>29%</td>
<td>37%</td>
<td>24%</td>
<td>10%</td>
<td>1851</td>
</tr>
<tr>
<td>greater than 200 pupils</td>
<td>17%</td>
<td>47%</td>
<td>33%</td>
<td>2%</td>
<td>1195</td>
</tr>
<tr>
<td>Total</td>
<td>45%</td>
<td>27%</td>
<td>21%</td>
<td>8%</td>
<td>5106</td>
</tr>
</tbody>
</table>

10 GCSE and equivalent results in England. Statistical First Release SFR02/2012 Department for Education www.education.gov.uk
About E4E

Education for Engineering (E4E) is the body through which the engineering profession offers coordinated advice on education & skills policy to UK Government and the devolved Assemblies. It deals with all aspects of learning that underpin engineering. It is hosted by The Royal Academy of Engineering with membership drawn from the professional engineering community including all 36 Professional Engineering Institutions, Engineering Council and Engineering UK.

A full list of E4E member organisations can be found at www.educationforengineering.org.uk

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