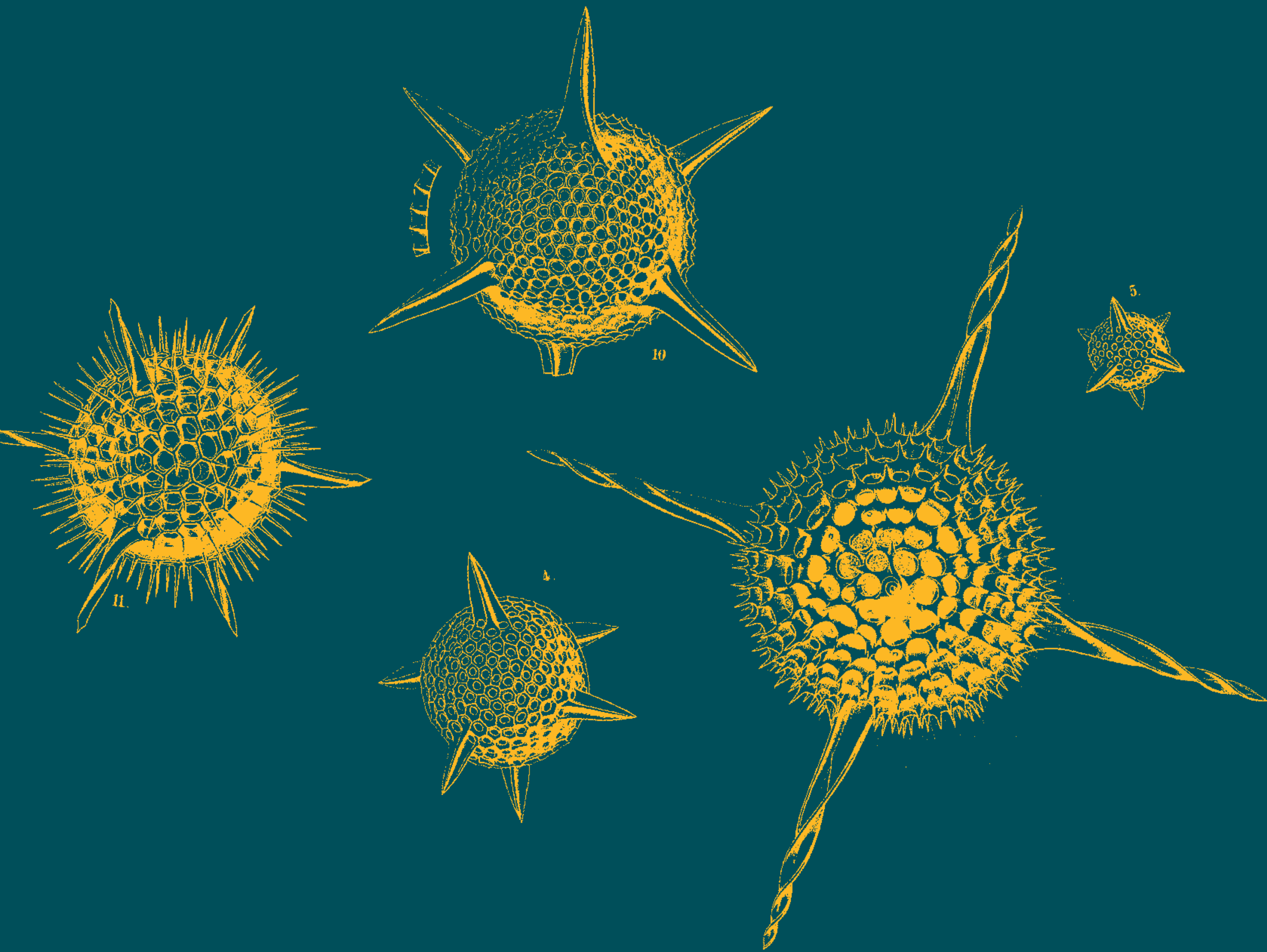
# Preparing for the transfer from school and college science and mathematics education to UK STEM higher education

A 'state of the nation' report



EXCELLENCE IN SCIENCE

THE ROYAL SOCIETY

Cover image: Species of *Hexastylus radiolaria*, a type of plankton, magnified up to 400×, from *Report on the scientific results of the voyage of H.M.S. Challenger*, by Sir C. Wyville Thomson, 1880. From the Royal Society Archive.

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Issued: February 2011 DES2096

ISBN: 978-0-85403-872-5

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# A 'state of the nation' report on preparing for the transfer from school and college science and mathematics education to UK STEM higher education

## Contents

# Foreword

This fourth and final Royal Society 'state of the nation' report considers the 'pool' of the UK's 16–19 year old students taking mainstream science and mathematics combinations suitable for entry to higher education. It makes three major points about these students.

- Firstly, the size of this 'pool' is critical to the success of any policies to produce more UK science and technology undergraduates to meet the globally competitive ambitions of a knowledge-based economy. England, Wales and Northern Ireland should aim to emulate the high levels of student participation in science and mathematics evident in Scotland. A perpetual cycle of too few of these students feeding through to becoming specialist teachers in schools and colleges needs to be broken.
- Secondly, the quality of this 'pool' needs to be further improved by ensuring that these specialist teachers are provided with subject-specific continuing professional development, that the curriculum they teach is rigorous, engaging and inspiring, and that the schooling structure within which this happens is conducive to the needs of science and mathematics as subjects.
- Thirdly, the potential progression routes for students into higher education must remain as open and transparent as possible aided by relevant and accessible careers information, advice and guidance.

'The UK has great scientific strengths, which underpin our society, culture and economy: we must build on these and continue to aspire to be the best country in the world in which to do science.'

This was a key message from the Society's major policy report of a year ago, *The scientific century: securing our future prosperity*. The Coalition Government has recognised these strengths by largely protecting the overall science budget, though issues remain about the importance of mechanisms for ensuring improved innovation. There are further concerns about the cultural value of science, which need more investigation, preferably in conjunction with the arts and humanities.

While this report does not pretend to solve these concerns or focus on the important area of vocational routes to employment, it does attempt to strengthen further the link between mainstream 5–19 science and mathematics education and higher education. It is only by working together coherently that interested parties in both arenas will collectively defend their case for a high quality education that can give everyone with potential the opportunity to progress, whatever their initial life circumstances. Ultimately, a minority of these will become the next generation of excellent UK scientists and technologists that we so badly need.

Paul Nurse

Paul Nurse
President of the Royal Society

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# Summary guide to the report

The aim of this fourth and final 'state of the nation' report is to provide a unique insight into young people's pre-university participation in science and/or mathematics in order to determine the characteristics of the student pool available to undertake STEM (science, technology, engineering and mathematics) first degree courses in the United Kingdom.[1] A summary document of the key messages, 'Increasing the size of the pool', is published alongside this report (Royal Society 2011*a*).

The current landscape of mainstream science and mathematics education for students generally aged 16 and over in schools and colleges in England, Wales, Northern Ireland and Scotland is described in Chapter 2, as well as the process by which these students gain entry into higher education to study UK STEM degree courses.

Data from each of the UK nations regarding the combinations of science and/or mathematics subjects individuals took in post-16 school-leaving examinations (GCE and VCE A-levels and Scottish Highers/Advanced Highers) in the years 2004/05, 2006/07 and 2008/09[2] were analysed in detail. The results provide an insight into the size of the 'pool' of students within each UK nation that is (i) taking science and/or mathematics A-levels or equivalent mainstream combinations; and (ii) the major fraction of this pool that is qualified for entry into STEM first degree courses. Further analysis in terms of gender, institution type and attainment provides a more detailed picture of the changing post-16 science and mathematics qualifications landscape across the UK. An analysis of data at the level of individual nations is included as a supplementary section at the end of this report.

The data were subsequently subjected to a cross-nation comparative analysis, to provide a UK-wide perspective on pre-university participation in science and mathematics. Chapter 3 showcases the variation between nations in the popularity of core sciences and mathematics subjects; provides an estimate of the total size of the pool of 16–18 year old students taking science and mathematics across the UK in recent years; and analyses the provision of physics and mathematics across the UK.

Key messages arising from Chapter 3 are as follows:

- In terms of subjects studied post-16, the biological sciences are universally of greatest popularity across all the Home Nations.
- Across England, Wales and Northern Ireland, there has been an increasing trend for more students taking core sciences to also take mathematics. In Scotland, this trend appears to be better established and is even more pronounced.
- Across the UK in 2009, approximately 17% of the UK's eligible 16–18 year old population took core sciences with or without mathematics in potential preparation for STEM studies at university.
- Across the UK in 2009, nearly two-thirds of students who took at least the minimum required number of core sciences and mathematics subjects expected to gain entry to undergraduate UK STEM higher education courses gained A–C grades needed in these subjects.
- A significant and increasing number of institutions in England, Wales and Northern Ireland do not enter any candidates in A-level physics or mathematics.

Finally, Chapter 4 concludes the report by examining the limiting factors that influence the size and quality of the pool of 16–19 year olds studying science and mathematics and the conversion of these students into STEM undergraduates. With insufficient numbers of STEM graduates for the needs of both higher education and employment, a seemingly self-perpetuating cycle has been established, with too few scientists and mathematicians being produced to help inspire and educate the next generations.

From the evidence presented in this report, and drawing from the other reports in the 'state of the nation' series, it is evident that breaking this cycle requires three key issues to be addressed in order of priority:

1. The **size** of the 'pool' in terms of the numbers and proportion of 16–19 year olds studying mainstream science and mathematics qualifications needs to increase in England, Wales and Northern Ireland towards the level of participation seen in Scotland (see figure 4.1). This will require more specialist science and mathematics teachers to be recruited and retained throughout all phases of 5–19 science and mathematics education within the UK;
2. To help improve the **quality** of the 'pool' of these 16–19 year olds will require professional development for the specialists who teach them and a better understanding of how schooling structures and curricula impact on their learning within science and mathematics.
3. The careers information, advice and guidance available to this 'pool' of 16–19 year olds must enable them to make subject choices that will allow smooth **progression** to STEM higher education courses, wherever they are located in the UK.

The report makes 11 specific recommendations to policy-makers on actions to be taken.

1 This includes candidates who took core sciences with/without mathematics as well as candidates who took mathematics but who did not take core sciences.

2 These years were chosen for analysis as representing a range of data covering a fairly stable period in terms of post-16 qualifications reform, and incorporating the most recent data available.

## Recommendation 1

The UK Government and Devolved Administrations must do all they can to maximise the number of mathematics, chemistry and physics specialist teachers available for employment in secondary schools and colleges.[3] This demands working closely with employers, the STEM community and educational institutions to address weaknesses in the UK's educational systems.

## Recommendation 2

The increasing diversity of A-level and equivalent qualifications provision (particularly in England) needs to be reviewed, and its impact on the numbers of students taking science and mathematics post-16 evaluated. Awarding organisations should make available detailed data on the participation, attainment and progression of students taking their specifications in science and mathematics.

## Recommendation 3

In undertaking reforms to A-level qualifications in England, the Department for Education should consider modifying their structure to enable students to study a wider range and increased number of subjects than is usually the case now.

## Recommendation 4

Scottish Intermediates have proven effective in helping maximise the number of students progressing to Scottish Highers. The Scottish Government should ensure that in reforming its qualification system to suit the new 'Curriculum for Excellence', Intermediates are replaced by a similar and equally successful option.

## Recommendation 5

Science and mathematics teachers should undertake subject-specific continuing professional development (CPD) as part of their overall CPD entitlement. Funding should be maintained for the National Science Learning Centre, the National Centre for Excellence in the Teaching of Mathematics and the Scottish Schools Equipment Research Centre, to allow these bodies to continue to support effective subject-specific CPD for science and mathematics teachers.

## Recommendation 6

The Department for Education should investigate the diversity of schooling structures in England to establish which of these is generally best suited to educating students, and optimising performance and progression in science and mathematics.

3 As our first 'state of the nation' report revealed (Royal Society 2007), there are no universally accepted definitions for a 'specialist' science or mathematics teacher across the four Home Nations, and no reliable up-to-date counts exist.

## Recommendation 7

Science and mathematics curricula need to be inspiring and engaging for both boys and girls, whilst retaining rigorous development of subject-specific knowledge and skills. Governments should work closely with experts from learned societies, the higher education sector and other key stakeholders to develop appropriate subject curricula.

## Recommendation 8

The unique pupil number (UPN), or equivalent, should follow school and college students into and through higher education to make it easier to track student progression. Linking these records to details of STEM initiatives that young people may have experienced could provide an efficient mechanism for measuring their longer-term impact.

## Recommendation 9

Further investigation is needed into understanding motivations for post-16 students' continuing with science and mathematics at university. This could include pursuing the following approaches, with a view to taking appropriate action:

(i) Role models: identifying whether the lack of female physics teachers affects girls' perceptions of physics.

(ii) Educational neuroscience: this emerging field of research is enhancing understanding of neurological processes involved in learning as well as factors that influence motivation to learn.[4] There is scope here for collaboration between neuroscientists, cognitive psychologists and educational researchers aimed at developing a shared and more complete understanding of the factors underlying subject preferences among girls and boys.

## Recommendation 10

In England, the Department for Business, Innovation and Skills needs to ensure that the new careers service to be launched in September 2011 is adequately equipped to provide high quality and easily accessible information, advice and guidance (IAG) on STEM careers to school and college students. This should include links to STEM-careers-related websites, eg *Future Morph* and *Maths Careers*.

## Recommendation 11

The UK Government and the Devolved Administrations should make better use of the data they are collecting on 5–19 science and mathematics education in England, Wales, Northern Ireland and Scotland. They should conduct regular monitoring of the combinations of subjects and qualifications students are taking, gaining understanding of progression from their prior participation and attainment, in order to determine with greater confidence actions to improve the performance of the education systems they are responsible for.

4 Royal Society (2011*b*).

# 1 Introduction

## 1.1 The importance of this study

This final study in the Royal Society's 'state of the nation' series has focused on entry to and attainment in the key academic qualifications in England, Wales, Northern Ireland and Scotland that allow access to courses at university science, technology, engineering and mathematics (STEM) faculties and departments. The report looks in detail at the numbers of students taking mainstream post-16 science and mathematics public examinations in UK schools and colleges. These qualifications are also the ones which ultimately build up the key scientific, technical and mathematical skills urgently required by 'UK plc' in these tough economic times. As the Prime Minister, David Cameron, said to the Confederation of British Industry (CBI) on 25 October 2010:

'All over the world, governments are identifying dynamic sectors in their economy and working strategically to strengthen them. . . . We have made the strategic decision to get behind these strengths. You saw the evidence of that in our Spending Review. Yes, money is incredibly tight. But we protected the science budget in cash terms.'[5]

In terms of the specific focus of this study, a recent SCORE (Science Community Representing Education) report (SCORE 2010) identified the top five A-level science and mathematics subject combinations required by universities for further study in STEM areas, while recent ACME (Advisory Committee on Mathematics Education) work on Level 3 mathematics in 2016 (ACME 2010) outlined possible qualifications pathways in mathematics. Finally, work by the Royal Academy of Engineering for the Department for Business, Innovation and Skills (BIS) on the myriad STEM qualifications available in Further Education (FE) has highlighted the complexity of the post-16 landscape (BIS/Royal Academy of Engineering 2010).

This 'state of the nation' report examines the combinations of mainstream school and college qualifications considered ideal for successful transfer to higher education (HE) STEM and, ultimately, continuation through to a range of key careers including: scientific and technical research and employment; the teaching of STEM subjects in primary, secondary and tertiary education; and other jobs that require the higher level scientific and mathematical skills to help produce the UK's future wealth.[6]

5 See http://www.cbi.org.uk/pdf/20101025-cbi-pm-conference-speech.pdf. The CBI is a key advocate of the need for UK employees to be provided with the right STEM skills.

6 The three previous reports in the series, as well as the final chapter of a major Royal Society report on the contribution of science to the UK economy and society, have provided the policy base for arguments in this report about the importance of 5–19 science and mathematics education in producing the 'pool' of students that will go on to become future scientists, engineers and technologists (Royal Society 2007, 2008*b*, 2010*a,b*).

## 1.2 Aims of this report

Identifying patterns in GCE A-level (that is, A2) and Scottish Higher and Advanced Higher subject combinations taken by a million or so students across the UK in the years 2005, 2007 and 2009 is a complicated exercise. The aim was not only to report the available data and analysis, but to use it to help inform policy, and ultimately, practice. As noted in previous reports, the governance of education is a matter for each of the four nations of the UK to decide individually and curricula and assessment procedures have diverged increasingly.

The study sought answers to the following specific questions as defined by the Working Group:

a) What proportion of students in a particular annual cohort take science and/or mathematics A-levels/ Scottish equivalents, and does this change very much over time?

b) What are the characteristics of students who take science and mathematics A-levels and their equivalents, eg gender, ethnicity, origin in terms of school type? Are patterns distinguishable over time? What factors may be responsible for producing the observed trends?

c) What combinations of science and mathematics subjects have students taken, what are their relative popularities, and do these change much over time?

Analysis was confined to identifying the size and qualities of the pool of students accepted onto STEM higher education courses. Originally, this was to be based on knowledge of university STEM first degree course entry requirements. But initial work in this area confirmed both the complexity of the current UK HE landscape and the uncertainty about future policy directions that will have an impact on the STEM 'artery'.[7] Instead it was decided to recommend that further work is undertaken in this area by the Royal Society in partnership with others, once the policy environment has become clearer as part of the Government and HE response to the Browne Inquiry into the funding of the higher education system.

Vocational qualifications have not been included in the analysis, except for Advanced Vocational Certificates in Education (AVCEs) which were introduced in 2000 to permit an alternative, more applied route to Higher Education. These have replaced Advanced General National Vocational Qualifications (AGNVQs) and are commonly referred to as vocational A-levels. Vocational pathways have key roles to play in terms of providing a

7 The 2009 report of the Northern Ireland STEM Review used the term STEM 'artery' instead of the more traditional 'pipeline'. (See http://www.deni.gov.uk/report_of_the_stem_2009_review.pdf)

workforce that possesses the necessary scientific and mathematical skills to undertake the technical roles the UK needs to support its research and development.[8] Such courses should not be overlooked as routes for students to study science and mathematics beyond the age of 16, and to potentially allow entry to higher education. However, as the most common routes into HE involve A-levels and, in Scotland, Scottish Highers (Royal Society 2006*b*), and because detailed data are only available for these qualifications, further analysis of other types of qualifications—both vocational and academic—is outside the scope of this report. A discussion of these alternative routes will be resumed in the final chapter.

### *Notes on the data*

In the following chapters, the following abbreviations are often used in discussing subject combinations:

B: biological sciences (or biology alone).

C: chemistry.

M: mathematics.

P: physics.

Together, B, C and P represent what are termed in this report the 'core sciences'.

In Scotland, no exact equivalent to the composite 'Other sciences' exists. In addition, 'H' will be used to denote human biology in Scotland, which is much more prevalent than elsewhere in the UK.

It is also important to note that:

(i) Where the sample size is too small (< 5), data have been suppressed. This is in accordance with the national authorities' procedures governing protection of the confidentiality of individuals' personal data.

(ii) The term 'combination' is normally used to describe an aggregate of more than one core science or mathematics subject. However, for convenience, a single core science or mathematics subject is also considered as a 'combination' in its own right. Where possible, descriptive terms such as 'alone' or 'specific' are used to distinguish between a singular subject and combinations including that subject. For instance, chemistry (alone) means chemistry as a singular 'combination', and not combinations including chemistry. Similarly, a phrase such as 'the specific combination CP' relates to that particular combination, rather than all combinations including chemistry and physics.

(iii) Although data on the numbers of students taking mathematics as a standalone subject are included, this report focuses particularly on those students who have taken GCE A-level combinations including mathematics and core sciences. These are normally indicated by the notation 'X(M)', where 'X' is one or more of biology, chemistry or physics. However, the use of parentheses has been suspended for certain diagrams (eg in Chapter 3), for the sake of clarity.

(iv) Data on A-levels in this report refer to those completing A2 examinations.

### *A note on additional data contained in the electronic appendix*

An electronic appendix contains details of the methodology used to obtain and filter the data, and supplementary tables and figures cited in the printed main report and accompanying supplementary evidence. The naming convention used in the electronic appendix mirrors that of the supplementary evidence in the main report. Material referred to in the supplementary evidence carries the prefix 'E' (for England), 'W' (for Wales), 'NI' (for Northern Ireland) and 'S' (for Scotland). In the electronic appendix these nation identifiers are themselves prefixed with an 'A' (eg Table AE.1, Figure AW.2).

8 In September 2010 the Coalition Government commissioned an independent review of vocational qualifications by Professor Alison Wolf at King's College London. The Royal Society is engaging fully with this process as part of the SCORE partnership. (See http://www.score-education.org/news/consultation-responses)

# 2 The context of mainstream 16–19 science and mathematics education in the UK and the transfer to higher education

This chapter outlines the context of science and mathematics education in schools and colleges in the UK that is relevant to students' entry to STEM (science, technology, engineering and mathematics) higher education (HE). Schools, colleges and higher education institutions (HEIs) face key challenges in aligning their practices to ensure a smooth transition from one sector of the education system to another. Students are facing an increasingly complex education landscape in science and mathematics through which they have to navigate.

## 2.1 Science and mathematics education: through 5–19 and beyond

The education systems in the UK nations need sufficient flexibility to allow all pupils to follow pathways that are relevant to them and enable them to reach their full potential. The programmes linked with these pathways need to be of sufficient quality to adequately prepare students for (i) further/higher study in these subjects; (ii) employment which requires mathematical and/or scientific knowledge and skills; as well as (iii) preparing them for living and working in a society that is greatly influenced by advances in science and technology. Associated with such curricula should be examination systems that validly and reliably assess young people's knowledge and skills in these subject areas.

During primary and early secondary education, pupils are innately curious about the world around them, and receptive to learning. The education system should support this stage in children's development with access to science and mathematics teachers with sufficient subject expertise. It should ensure that children's experiences of science and mathematics are not affected by the pressure of testing, or through inadequate arrangements when transferring from primary to secondary education (Royal Society 2010*b,c*).

Once embarked on their secondary education, young people are faced with a complex system of qualifications and learning experiences, creating difficult choices for them—and the teachers, parents and careers' officers who might advise them—as was discussed in the Royal Society's 'state of the nation' report on 14–19 science and mathematics education (Royal Society 2008*b*). A fundamental difficulty lies in the creation of single qualification systems in the nations, providing different yet flexible pathways for learners, which meet a range of educational aims. When considering science and mathematics education, these different aims might include:

- scientific and mathematical literacy that students need in order to play a full part as active and informed citizens in society, where science and technology play a key role in shaping everybody's lives;
- specialist scientific and mathematical skills and knowledge for those who might enter technical roles;
- specialist scientific and mathematical skills and knowledge for those looking to pursue academic courses to higher levels.

Such aims are not mutually exclusive, but whether a single system could ever adequately address them all is contentious.

In terms of higher education, although student numbers grew considerably during the 1990s and early 2000s, the increase in STEM degree applicants did not keep pace (Royal Society 2006*a*). In 2004, the Government and HEFCE responded to some of the issues facing STEM subjects, including the mismatch between demand for STEM graduates and supply of students entering STEM HE courses, and identified them as being strategically important and vulnerable subjects (SIVS),[9] requiring extra support from Government and other programmes.

## 2.2 The current post-16 landscape

During the past three years, the Royal Society has produced a comprehensive overview of education system reform and current policies in respect of 5–19 science and mathematics in the four Home Nations (Royal Society 2008*b*, 2010*b*,*c*). With the education system in continual flux, there is a need for universities to take account of the changing 14–19 landscape in developing their STEM course provision (Royal Society 2006*a*). There is currently a variety of pathways—depending on the school or college attended—that are available to students even before they are faced with the complex process of admission to higher education. Young people's choices at the end of compulsory schooling (currently at age 16), in terms of qualification types and subjects, have implications for their degree options at HE level. Viewed from an HE perspective, the qualifications and subjects taken by pupils determine the pool of students available to undertake STEM degrees at HE.

Tables 2.1 and 2.2 provide an overview of qualifications in the UK, and the levels at which they can be obtained. Students aged 16–19 typically study qualifications at Level 3 (England, Wales, Northern Ireland), or Levels 6/7 (Scotland).

9 See http://www.hefce.ac.uk/aboutus/sis/, accessed 13 October 2010.

*Table 2.1. Qualifications available in England, Wales and Northern Ireland, and how they correspond to levels in the National Qualifications Framework (NQF).* [(a)]

| NQF level | NQF qualifications | Vocational/applied qualifications | Higher education qualifications |
|---|---|---|---|
| 8 | | | – Doctoral degree |
| 7 | | – BTEC Advanced Professional Diplomas, Certificates and Awards | – Masters degree<br>– Postgraduate diploma/certificate |
| 6 | | | – Bachelors degree (with or without Honours)<br>– Graduate diploma/certificate |
| 5 | | – Higher National Diplomas<br>– NVQ Level 5<br>– BTEC Professional Diplomas, Certificates and Awards | – Diploma of Higher Education<br>– Foundation degrees |
| 4 | | – Higher National Certificates<br>– NVQ Level 4<br>– BTEC Professional Diplomas, Certificates and Awards | – Certificate of Higher Education |
| 3 | – A-levels<br>– International Baccalaureate Diploma Programme<br>– Cambridge Pre-U | – NVQ Level 3<br>– BTEC Awards, Certificates, and Diplomas Level 3<br>– BTEC Nationals<br>– OCR Nationals<br>– 14–19 Diploma (Advanced) | |
| 2 | – GCSE Grades A*–C | – NVQ Level 2<br>– BTEC Awards, Certificates, and Diplomas Level 2<br>– OCR Nationals<br>– 14–19 Diploma (Higher)<br>– Functional Skills Level 2 | |
| 1 | – GCSE Grades D–G | – NVQ Level 1<br>– BTEC Awards, Certificates, and Diplomas Level 1<br>– OCR Nationals<br>– 14–19 Diploma (Foundation)<br>– Foundation Learning Tier pathways<br>– Functional Skills Level 1 | |
| Entry | | – Foundation Learning Tier pathways at entry level<br>– Functional Skills entry level | |

(a) This table is a simplified version of those provided on the *Directgov* website.[10]

### 2.2.1 Post-16 institutions across the UK

Students in the UK can attend a variety of institutions for their post-16 education, depending on the nation in which they reside. In England, post-16 education providers include comprehensive schools, specialist schools, grammar schools, and academies/city technology colleges (which are independent from state control, yet state-funded), as well as the independent sector. Post-16 students can also study at sixth form and further education (FE) colleges. In Wales, there is a choice between either maintained or independent schools, with 25% of

10 See http://www.direct.gov.uk/en/EducationAndLearning/QualificationsExplained/DG_10039017, accessed 22 November 2010.

*Table 2.2. Qualifications available in Scotland, and how they correspond to levels in the Scottish Credit and Qualifications Framework (SCQF).*[(a)]

| SCQF level | Scottish Qualifications Authority (SQA) qualifications | Scottish Vocational Qualifications | Higher education qualifications |
|---|---|---|---|
| 12 | | | – Doctoral degree |
| 11 | | – SVQ5 | – Masters degree<br>– Postgraduate diploma/certificate |
| 10 | | | – Honours degree<br>– Graduate diploma/certificate |
| 9 | | – SVQ4 | – Bachelors/ordinary degree<br>– Graduate diploma/certificate |
| 8 | – Higher National Diploma | | – Diploma of Higher Education |
| 7 | – Advanced Higher<br>– Scottish Baccalaureate<br>– Higher National Certificate | – SVQ3 | – Certificate of Higher Education |
| 6 | – Higher | | |
| 5 | – Intermediate 2<br>– Credit Standard Grade | – SVQ2 | |
| 4 | – Intermediate 1<br>– General Standard Grade<br>– National Certificate | – SVQ1 | |
| 3 | – Access 3<br>– Foundation Standard Grade | | |
| 2 | – Access 2 | | |
| 1 | – Access 1 | | |

(a) This table is a simplified version of the one provided by the SCQF.[12]

maintained secondary schools providing at least half of their lessons in the Welsh medium,[11] and post-16 students also have the option of attending FE colleges. Post-16 students in Northern Ireland may study in selective (grammar), in non-selective secondary schools, or in FE colleges. In Scotland, state schools are not selective, and only around 6% of secondary pupils are educated in the independent sector. A similar proportion of post-16 students is educated in Scotland's FE colleges.

### 2.2.2 Specific qualifications issues in England

Prior to 2004, there was a large variety and complexity of qualifications available for 14–19 year olds in England. Reforms proposed by the Tomlinson Report (Tomlinson 2004), some of which were later rejected by the Government, would have led to an overarching Diploma in England, which could be obtained at different levels. This would have allowed greater flexibility and a mixing of different kinds of academic and vocational awards (including GCSEs, A-levels and BTECs, for example) to meet the requirements of the learners and of the intended further or higher education institution. However, instead of implementing the full Tomlinson Report proposal, four pathways were created within the National Qualification Framework (NQF), utilising both newly created qualifications and those which were already available, with a view to giving greater opportunity and choice to 14–19 year olds who have different abilities, aspirations and degrees of engagement in education. These pathways are: GCSEs and A-levels; the 14–19 Diplomas related to occupational sectors; Apprenticeships and National Vocational Qualifications (NVQs); and the Foundation Learning tier.

### 2.2.3 Specific qualifications issues in Wales

Although there are many similarities with the English system—and qualifications in Wales are part of the same

11 See http://wales.gov.uk/docs/dcells/publications/100420welshmediumstrategyen.pdf, accessed 13 October 2010.
12 See http://www.scqf.org.uk/TheFramework/InteractiveFramework.aspx, accessed 22 November 2010.

NQF as in England—since Devolution in 1999, the education system in Wales has undergone some divergence from that in England. A significant difference in post-16 education in Wales was brought about by the introduction of the Welsh Baccalaureate in 2007, following its pilot in 2003. Now offered by over 200 schools and colleges,[13] the Welsh Baccalaureate is designed to encompass GCSEs, AS-levels and A-levels, as well as NVQs and BTECs. To be awarded the Baccalaureate at Advanced level, students have to take a compulsory core, which includes key skills and an individual investigation, and then will typically study two A-level subjects.

### 2.2.4 Specific qualifications issues in Northern Ireland

The 14–19 qualifications framework is broadly similar to that in England and Wales. All selective and the majority of non-selective schools offer A-levels, whether general (academic) or applied. The FE colleges and some schools will offer vocation-related qualifications such as BTEC National Diplomas or Certificates. In respect of the core sciences and mathematics, relatively few students follow A-levels in FE colleges, reflecting, perhaps, an increasing focus in this sector on economically focused, professional, technical and vocational courses, including pre-university programmes.

### 2.2.5 Shared mainstream post-16 qualifications in England, Wales and Northern Ireland

#### *2.2.5.1 GCE A-levels*

The most common route into higher education in England, Wales and Northern Ireland is that of General Certificate of Education (GCE) A-levels (Royal Society 2006*b*). Prior to the Dearing review of 16–19 qualifications in 1996, students studied A-levels over two years, and/or one-year Advanced Supplementary (AS-level) courses. Reforms introduced in September 2000 (known as 'Curriculum 2000') aimed to widen the breadth of study in terms of A-level subjects. A-levels were split into AS (Advanced Subsidiary) and A2 modules. Students now typically take four or more AS-levels in Year 12 and continue some of these subjects at A2 level in Year 13. Successful completion of modules at both AS and A2 level in a subject is required for a full A-level to be awarded. However, students can achieve an AS-level qualification by passing just the AS-level modules. The Government's recently published White Paper includes plans to reform A-levels, with a view to making them more rigorous (DfE 2010*a*). Any prospective return to a synoptic approach would need to be monitored for potential effects on the uptake of science and mathematics at A-level.

There is a large range of potential combinations within scientific and mathematical subjects at A-level, although students' options will be limited by the institution which they attend. In addition to the core sciences of biology, chemistry and physics, students can take A-levels in subjects including environmental science, psychology, geology and electronics, as well as broader qualifications such as perspectives on science and science for public understanding. In mathematics, students might choose to study mathematics, further mathematics, pure mathematics or statistics at A-level, and use of mathematics at AS-level. While Advanced Extension Awards (designed to stretch the most able students) have been dropped in all other subjects, they are expected to remain in mathematics until at least 2013.

The percentage of students attaining A grades at A-level has continued to rise (eg, in England, from 22.7% in 2005 (DfES 2006), to 26.8% in 2010 (DfE 2010*b*)).[14] New A-level specifications introduced in 2008 were designed to stretch and challenge the most able pupils at A2 level, who would subsequently be awarded an A* grade if they scored over 80% across the whole A-level and over 90% in their A2 modules. The provisional results for 2010 showed that 8.1% of students gained the A* grade when analysed across all subjects; 17.2% in mathematics, 29.9% in further mathematics, 10.3% in physics, 9.3% in chemistry and 8.0% in biological sciences (JCQ 2010).

#### *2.2.5.2 Applied A-levels*

As part of the Curriculum 2000 reforms, VCE (Vocational Certificate of Education) A-levels were introduced, replacing the Advanced General National Vocational Qualifications (GNVQs). In 2005, VCE A-levels were reformed once more in order to be incorporated within the GCE AS/A2 level system. Students are now able to study Applied GCE A-levels in ten subjects, including applied science and engineering. Applied A-levels are due to be withdrawn in England by 2013 (DCSF 2008*a*).

### 2.2.6 Mainstream post-16 qualifications in Scotland

The education system in Scotland follows very different pathways to those in the other three nations. The main academic route post-16 comprises Highers and Advanced Highers, corresponding to Levels 6–7 of the Scottish Credit and Qualifications Framework (SCQF) (table 2.2). Students can enter HE after taking Highers at age 17, as many Scottish degrees are four years in length; they can instead, however, opt to remain a year longer at school and take Advanced Highers, potentially allowing entry into the second year of a degree course. Very few students enter higher education after one year of Highers, with most

13 See http://www.assemblywales.org/10-064.pdf, accessed 13 October 2010.

14 This percentage includes those candidates awarded the A* grade, first awarded in 2009/10.

choosing to stay on either to take Advanced Highers or to take additional or upgrade previous Highers. Students intending to enter HE generally study five subjects at Higher level, and two at Advanced Higher level (Supplementary evidence, table S.2). Highers and Advanced Highers may be taken in the separate core sciences (including human biology, which features much more prominently in Scotland than elsewhere in the UK) and mathematics, and Highers can also be taken in subjects covering the applied sciences, such as environmental science or biotechnology.

With the introduction of the Curriculum for Excellence, Standard Grade and Intermediate (table 2.2) qualifications are being replaced by new National 4 and 5 qualifications, which are due for implementation from 2013–14.

The Scottish Baccalaureate in Science was introduced in 2009, and comprises two science courses (or one science and one technology course) plus mathematics or applied mathematics, together with an interdisciplinary project. Two courses have to be taken at Advanced Higher level and one at Higher level. There has been a relatively low initial take-up for this award, with some schools not offering it at all. However, the award is aimed at highest-achieving students and the latest indications suggest that uptake is growing as the qualification becomes more widely available and embedded.[15]

### 2.2.7 Awarding organisations

Additional choice and complexity in the education system are engendered by the presence of a number of qualification awarding organisations. When A-levels were first established, they were awarded mainly by University Examining Boards, under the control of the HEIs working in cooperation with schools and colleges, and independent of Government. The historical justification for this was to prepare and select a very small proportion of young people for HE. However HEIs are no longer in charge of the content, specifications and standards of A-levels, which are instead determined by Government agencies in the form of the Qualifications and Curriculum Development Agency (QCDA, due to be abolished by the current Government in September 2011) and Ofqual.

Ofqual regulates a number of different awarding organisations, which offer both academic and vocational qualifications. Schools and colleges not only have to choose which subjects and types of qualifications to teach, they also have to buy in to specific versions of qualifications that are offered by the awarding organisations. Therefore, students with an A-level in biology, for example, may enter HE with different subject knowledge and skills depending on which awarding organisation's course they took at school or college. Concerns have been expressed over the relationship between the market forces that impact on awarding organisations, and overall qualification standards.[16]

### 2.2.8 Projects that support transition into STEM higher education

During the last Government, HEIs were encouraged to seek wider participation in HE from students with non-traditional backgrounds. One strand of the National HE STEM Programme for England and Wales is related to widening participation at HE by working with the school and FE sectors.[17] The recent Government response to the Browne Review of Higher Education Funding and Student Finance in England, which was required to take the goal of widening participation into account, agreed with the recommendation that public funding should be preferentially awarded to those institutions that recruit and retain students from disadvantaged backgrounds (BIS 2010*a*; Browne 2010). The report noted, however, that the performance indicators on access produced by HESA did not take sufficient account of institutions' admissions requirements. It is not yet known whether and how BIS may address this issue, but clarification may be detailed in the forthcoming Higher Education White Paper.[18]

Various projects are in place throughout the UK to assist the transition between school or college and HE, by aiming to raise aspirations among schools, social groups and geographical areas that are currently underrepresented in this sector. One such programme is Aimhigher, an English initiative funded by HEFCE and BIS until 2011. Participants in the programme are able to attend master classes and summer schools that take place in HEIs, as well as benefiting from mentoring. The Step-Up programme in Northern Ireland, which has attracted national and international recognition, aims to raise pupils' aspirations, expectations and academic performance. In this initiative, HE, local industry, government agencies and participating secondary schools have formed collaborative partnerships to promote interest and engagement among pupils taking A-level applied science. As a result, many have progressed to HE. Other projects are involved in helping those students already *en route* to HE, such as the STAR (Student Transition and Retention) Project led by the University of Ulster. This focuses on the identification and dissemination of good practice in activities that help students acquire the information they need before starting their course, as well as adapting to the changes in academic and social practices at HE. Many other HEIs are engaged in similar projects.

15 Gerald Donnelly (Education Analytical Services, Scottish Government), personal communication, 19 January 2011.

16 See http://acme-uk.org/downloaddoc.asp?id=190, accessed 13 October 2010.

17 In order to address the supply side of HE physics, chemistry, mathematics and engineering, HEFCE funds the HE STEM project based at the University of Birmingham, which is the next stage of the individual SIVS subject pilots ('Stimulating Physics', 'Chemistry for our Future', 'More Maths Grads' and the 'London Engineering Project'). DfE currently funds the schools oriented part of 'Stimulating Physics' run by the Institute of Physics, though currently there is no commitment from Government to continue funding beyond March 2011.

18 See http://www.bis.gov.uk/news/speeches/david-willetts-statement-on-HE-funding-and-student-finance, accessed 17 November 2010.

The formation of partnerships between educational establishments, employers and HE (in various combinations) is a key feature of STEM transition projects. For example, establishing partnerships between institutions offering post-16 courses allows funding to be shared and a common timetable set up, so that a particular provider could focus upon specific subjects (eg physics or engineering), thereby ensuring the critical mass of specialist teachers, the best possible science facilities, and a high quality IAG (Information, Advice and Guidance) service. The transfer of post-16 funding from the Learning and Skills Council to local authorities in April 2010,[19] supported by the Young People's Learning Agency, would fund partnerships accordingly. The Welsh Assembly Government is strongly promoting partnerships between post-16 providers, and the Chief Education Officer recently urged each Governing Body to appoint one governor to have special responsibility for 'partnership' working. Similarly, in Northern Ireland collaboration between schools and FE colleges is being developed through the establishment of Area Learning Communities (ALCs).

### 2.2.9 Careers information, advice and guidance (IAG)

A crucial aspect of the transition process from school or college to HE is the need for an IAG service that is well-informed and impartial (Royal Society 2006*a*). Worryingly, 90% of careers advisers have no scientific background (Royal Society 2004), and a recent evaluation of the STEM Careers Education, Information, Advice and Guidance (CEIAG) programme, conducted in Northern Ireland schools, identified strengths in the approaches taken, but also the need for continued improvement (ETI 2010). The UCAS course search website aims to provide comprehensive information on entry requirements for all available HE courses, yet it is not meeting the needs of students looking to search through the thousands of STEM courses on offer (SCORE 2009).

## 2.3 Higher education

Higher education funding, teaching and research support infrastructure in the UK is complex and linked to specific national and regional economic and employment needs. Given that England is home to four-fifths of all UK Higher Education Institutions (HEIs) and hosts 82% of the UK undergraduate population, inevitably most of the focus in this section of the report will be on England.

### 2.3.1 The flows into and out of UK STEM higher education

Higher education institutions aim to provide degree courses that meet the needs of employers and students. One of the challenges faced by HEIs is to fill their places with those students who are most suitable for the STEM courses that they offer. HEIs operate in a dynamic market—they compete for students—and must be able to respond to year-on-year changes in the number of available places and applicants chasing those places. The size of the market—the number of places available—is determined by the funding councils in the four nations, based on the overall level of Government funding available for higher education. Balancing recruitment is vital, as there are financial repercussions for HEIs if they either do not fill their places, or if they overshoot their quotas. With emphasis on prestige and league-table rankings amongst HEIs, the additional importance to these institutions of selecting the highest quality students cannot be underestimated.

In 2009, UK HEIs accepted over 90,000 undergraduate students on degree courses in medicine and dentistry, subjects allied to medicine, biological sciences, veterinary science, agriculture and related subjects, physical sciences, mathematical sciences, computer science and engineering and technology. Given continuation of past trends in employment patterns, and using a model incorporating longer-term prospects for the economy, results suggest that apart from medicine, the demand for most STEM subjects is likely to grow faster than for other disciplines over the coming decade (Wilson 2009).

### 2.3.2 General requirements for entry to STEM university degrees

Although HEIs receive funding from the Government, they operate as independent institutions, having the freedom to develop their own range of degree courses and titles, and set their own entry requirements. However applications to HEIs pass through the UCAS (Universities and Colleges Admissions Service) system, and all qualifications—including vocational and applied ones—are awarded a UCAS tariff points score.[20] In theory this allows HEIs to define entry requirements in terms of UCAS tariff points, and the equivalence between A-levels and other qualifications is then accounted for. Using tariff points, however, does not allow HEIs to specify the level of attainment needed in specific subjects. Many HEIs therefore continue to make offers based on A-level grades and subjects, and use this as a basis to determine equivalent requirements for those applicants offering non A-level qualifications, whether academic or vocational.

Concerns over the mismatch between what students offer in terms of subject knowledge and what HEIs expect were set out in *A degree of concern* (Royal Society 2006*a*). Applicants are increasingly likely to offer a greater breadth of subjects, but having only one A-level/Higher in a science subject is generally regarded as a poor preparation for studying science at HE. Despite the wide choice of

19 This reform was part of the Apprenticeships, Skills, Children and Learning Act 2009.

20 See http://www.ucas.com/students/ucas_tariff/, accessed 13 October 2010. UCAS is reviewing the whole tariff points system at the request of Government and HEIs.

science-related subjects that can be taken by 16–19 year olds, HEIs consider only a minority of subject combinations to be really relevant for studying STEM subjects at degree level. Indeed, the importance of A-levels/Highers in mathematics, chemistry, physics and biology in providing access for students to a wide range of science degrees has been already emphasized (SCORE 2009).

### 2.3.3 The process of selection and admission

Admissions processes should be consistent with the recommendations of the Schwartz report (Schwartz 2004), and the Quality Assurance Agency (QAA) code of practice (QAA 2006), both of which aim to ensure admissions processes are fair and transparent. The extent to which all HEIs have achieved this goal is uncertain, and the sector is still being called on to make improvements (SCORE 2010).

HE admissions tutors have to discriminate between applicants in order to help them select the best students for their course, based on information supplied by the applicant and their school or college. The relevance of the subjects offered by applicants to STEM degree courses generally carries a lot of weight, as do students' predicted or actual attainment in their qualifications. Grades achieved in previous qualifications, such as GCSEs, AS-levels or Highers, are considered by some HEIs, but not all. Additional information—the educational context in which the qualifications were achieved—can also be taken into account, such as the deprivation index of the neighbourhood in which the applicant's school is located, or whether the school achieves below the national average at the level of GCSEs or Highers. The extent to which contextual factors are taken into account varies widely across the HE sector.

HE admissions tutors' opinions are divided on the use and benefit of interviews, hence not all the institutions include them as part of the admissions process. The other increasingly popular mechanism available to HEIs to help discriminate between applicants is university admissions tests. According to SPA (Supporting Professionalism in Admissions), 21% of UK universities and colleges (up from 16% in 2009) used one or more of 84 identified admissions tests in 2010 (SPA 2009).

If applicants satisfy the admissions requirements of their chosen HEI, they will receive an offer based on their predicted attainment and in the case of A-levels/Highers, conditional on achieving specific grades in specific subjects. Due to the dynamic nature of the admissions process, students may be accepted with lower grades if, when A-level and Highers results are announced in August, the HEI has unfilled places on its courses. However, if they miss both their first and second (insurance) choice places, gaining another place through the clearing process can be difficult. Across all degree schemes, about 75% of applicants in 2006 and 2007 were able to get a place at an HEI, although not always at their first choice of university (Ertl *et al.* 2008). In 2010, only 70% of applicants were accepted onto an HE course.[21]

## 2.4 Conclusion

The complexity of options available to learners—at school, college, and when looking to enter HE—creates severe challenges in trying to ensure all young people get the best opportunity to study science and mathematics to the level appropriate for them. Despite the many pathways that students have the opportunity to follow from the age of 14 onwards, the most common route to HE in the UK is through taking A-levels or Scottish Highers, and HEIs generally rate other qualifications in terms of their equivalence to A-levels. Therefore, analysis was carried out on the pool of students who undertake A-levels and Scottish Highers/Advanced Highers in core sciences and mathematics. This creates a picture of the combinations of science and mathematics subjects that 16–19 year olds choose to study, with implications for how this might broaden or narrow their options for progression to first-degree-level courses in STEM-related subjects.

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21 See http://www.ucas.ac.uk/about_us/media_enquiries/media_releases/2010/211010, accessed 28 October 2010.

# 3 Analysis of mainstream science and mathematics subject combinations taken by students in the UK during 2005–2009

## 3.1 Introduction

The Supplementary evidence to this report (Chapter 5) provides fresh insight into the size of the 'pool' of students within each UK nation that is (i) taking science and/or mathematics A-levels or equivalent mainstream combinations; and (ii) the major fraction of this pool that is qualified for entry into STEM first degree courses.

The following account brings together key comparative data on these trends in order to acquire a more holistic, ie UK-wide, perspective on pre-university participation in science and mathematics. Such information provides a useful indication of the predominant contribution that each of the Home Nations' education systems makes in respect of supplying the UK with STEM undergraduates.

The following cross-nation comparisons are made:

(i) variation in the popularity of core sciences and mathematics subjects in respect of cohort size and population;

(ii) variation in the popularity of core sciences;

(iii) variation in the popularity of core sciences and mathematics combinations; and

(iv) patterns of uptake of core sciences subjects with mathematics.

These cross-comparisons provide the background for estimating the total size of the pool of 16–18 year old students across the UK in recent years, based on participation rates in core sciences and/or mathematics. These estimates are refined further by a consideration of patterns of attainment.

Finally, the chapter concludes with an analysis of the provision of physics and mathematics (the most vulnerable of the strategically important science subjects), and a novel attempt to understand what may lie behind the patterns observed.

### 3.1.1 The justification for conducting cross-UK comparisons

As Chapter 2 indicated, just as GCE A-levels provide the main route into higher education for students in England, Wales and Northern Ireland, so it is that Scottish Highers provide the main route into higher education studies for students educated in Scotland. Even so, comparisons between the two need to be handled with caution, for two reasons: (i) the totally distinct nature and separateness of the Scottish qualifications system; and (ii) the fact that while A-levels are mostly taken by 17 year olds (corresponding to the age of most candidates at the start of the academic year in which they take their final examinations), by the same token, Scottish Highers and Advanced Highers tend to be taken by 16- and 17-year-olds.

## 3.2 Variation in the popularity of core sciences and mathematics among 16–18 students

The data suggest that England and Wales have consistently the lowest rates of participation in science and mathematics A-levels—and their closest equivalents in Scotland—among all the Home Nations. To exemplify this, table 3.1 provides

*Table 3.1. Mainstream pre-university core sciences qualifications candidature as a function of cohort size across the United Kingdom (2005, 2007, 2009).*[a]

| | England | Wales | Northern Ireland | | Scotland[b] |
|---|---|---|---|---|---|
| Total size of A-level cohort | 283,798 | 15,087 | 11,805 | Total size of Highers[b] cohort | 36,654 |
| Total numbers of students taking core sciences A-levels | 78,540 | 4,008 | 4,412 | Total numbers of students taking core sciences Highers | 18,233 |
| Percentage of cohort taking core sciences A-levels | 27.7%<br>(28.6%)[c]<br>(28.9%)[d] | 26.6%<br>(27.5%)[c]<br>(32.2%)[d] | 37.4%<br>(38.2%)[c]<br>(37.6%)[d] | Percentage of cohort taking core sciences Highers | 49.7%<br>(50.1%)[c]<br>(49.4%)[d] |

*Sources of data:* DCSF, Welsh Assembly Government, DENI, Scottish Government.

(a) A proportion of these individuals also took mathematics.

(b) The figures presented here include candidates taking combinations of Highers and/or Intermediates and/or Advanced Highers.

(c) Equivalent percentage for 2007.

(d) Equivalent percentage for 2005.

combined data on the equivalent participation rates in England, Wales and Northern Ireland in 2009, and juxtaposes these with equivalent data for Scotland. Data for 2005 and 2007 demonstrate the level of consistency over recent years.

Notably, a much higher proportion of the A-level cohort in Northern Ireland has consistently taken sciences and/or mathematics compared to the equivalent cohorts in England and Wales, with more than a third of individuals within the cohort taking examinations for these qualifications. Over the three years measured, it is also possible to see that there has been a dramatic decrease in the proportion of the A-level cohort in Wales taking these subjects while, in contrast, the equivalent situation for Scotland suggests stability at an altogether higher level.

By comparison, very nearly half of all individuals taking Highers in Scotland took core sciences in 2005, 2007 and 2009. Overall, the most recent data confirm the finding of the Society's second 'state of the nation' report, that post-16 participation in core sciences in Scotland is higher than anywhere else in the UK (Royal Society 2008*a*).

If, alternatively, a comparison is made between those who took core sciences (with/without mathematics) and those who took mathematics (but no core sciences), the picture presented in table 3.2 emerges. Table 3.2 provides the most flattering indication of participation in the core sciences and mathematics, and it serves to confirm that participation in these subjects is considerably higher among students in Scotland compared to post-16 students elsewhere in the UK. Further, while participation rates in core sciences and/or mathematics in England and Northern Ireland (overall) grew in recent years, they decreased in Wales.

## 3.3 Variation in the popularity of core sciences combinations across England, Wales, Northern Ireland and Scotland (2009)

Some substantial differences are notable in the numbers of students taking core sciences in England, Wales and Northern Ireland. Here the focus is on understanding whether this variation is also evident when looking at the proportional weighting of these combinations, using the most recent data collected for this study.

Figure 3.1 provides graphical representations of the popularity of core sciences subjects and subject combinations in each of the Home Nations, based on information in tables E.13, W.9, NI.9 and S.6 in the Supplementary evidence: the height of each letter corresponds to its proportional popularity.

Comparison of these figures shows that biological sciences (B) was comparatively more popular in Northern Ireland than in England and Wales, and that chemistry (C), physics (P) and the specific combination chemistry and physics (CP) were comparatively much more popular in England and Wales in 2009. The combination biological sciences and chemistry (BC) comes second to biological sciences alone (B) in popularity in each of these nations.

The importance of Higher human biology in Scotland, which has attracted increasing levels of participation since the mid-1990s, sets it apart from the other Home Nations, in which GCE A-level human biology is taken by so few individuals that the national educational authorities in England, Wales and Northern Ireland produce composite data for biological sciences (combining data on biology and human biology). However, this should not be allowed to hide the fact that the relative importance of biological sciences and the specific combinations, biological sciences and chemistry (BC), biological sciences, chemistry and physics (BCP) and chemistry and physics (CP) is similar to

*Table 3.2. Mainstream pre-university core sciences and/or mathematics qualifications candidature as a function of cohort size across the United Kingdom (2005, 2007, 2009).*

| | England | Wales | Northern Ireland | | Scotland[a] |
|---|---|---|---|---|---|
| Total size of A-level cohort | 283,798 | 15,087 | 11,805 | Total size of Highers[b] cohort | 36,654 |
| Total numbers of students taking core sciences and/or mathematics A-levels | 105,216 | 5,144 | 5,233 | Total numbers of students taking core sciences and/or mathematics Highers | 22,138 |
| Percentage of cohort taking core sciences A-levels | 37.1% (36.6%)[b] (35.8%)[c] | 34.1% (34.5%)[b] (38.2%)[c] | 44.3% (45.1%)[b] (43.1%)[c] | Percentage of cohort taking core sciences Highers | 60.1% (61.2%)[b] (60.7%)[c] |

*Sources of data*: DCSF, Welsh Assembly Government, DENI, Scottish Government.

(a) The figures presented here include candidates taking combinations of Highers and/or Advanced Highers.

(b) Equivalent percentage for 2007.

(c) Equivalent percentage for 2005.

*Figure 3.1. The popularity of GCE A-level and Higher core sciences combinations across the United Kingdom (2009).*[a]


*Sources:* DCSF, Welsh Assembly Government, DENI, Scottish Government.

(a) These diagrams have been produced using Wordle™.

(b) This diagram combines data for biology and human biology.

that elsewhere in the UK, but that the combination chemistry and physics (CP) and physics (P) on its own are comparatively more dominant.

Key message 1. The biological sciences are universally of greatest popularity across all the Home Nations, though the preference is especially marked in Northern Ireland. A more even balance of core sciences combinations is observable in Scotland, compared with the rest of the UK.

## 3.4 Variation in the popularity of core sciences and mathematics combinations across England, Wales, Northern Ireland and Scotland

The data on core sciences are disaggregated further in table 3.3 to show the popularity of these subject combinations with mathematics. It is important to do this due to the pervasive importance of mathematics to science, for instance its function in analysing and modelling solutions to some of the greatest challenges humanity faces, such as global warming, and its concomitant value in studying science in higher education.

Figure 3.2 provides graphical representations of the information in table 3.3, the height of each letter corresponding to its proportional popularity. These figures show that levels of GCE A-level candidature were broadly similar across England, Wales and Northern Ireland. The combination physics and mathematics (P(M)) comes next to biological sciences in relative and comparative popularity among all three nations, with the combinations biological sciences, chemistry and mathematics (BC(M)) and biological sciences and chemistry (BC) being of similar importance. Nonetheless, the markedly greater preference for biological sciences to be taken as a singular subject in Northern Ireland is striking, as is the relative greater popularity in Northern Ireland of the combinations B(M) and BCP(M). Moreover, P and C (as single subjects) and the combinations C(M) and CP(M) were comparatively less popular in Northern Ireland compared with England and Wales. Certain combinations, notably BP(M), CP and BP proved universally least popular.

Notwithstanding those individuals who chose to take mathematics on its own or in combination with arts and/or modern foreign languages and/or social sciences subjects, the patterns of candidature for 2009 illustrated in figure 3.2 suggest that mathematics has become a popular companion choice for students taking core sciences GCE A-levels.

By contrast, in Scotland a very different picture emerges. Here the proportions of students taking combinations of core sciences with mathematics appear to be much more balanced than elsewhere in the UK. Consonant with the data in table 3.3, combinations involving physics/biological sciences and mathematics and appear to be comparatively more popular (in particular P(M), BCP(M), B(M) and CP(M)) in Scotland, with much smaller proportions pursuing the biological sciences solely than are seen elsewhere in the UK. (Figures A3.1 and A3.2 present the Scottish picture with combinations involving biology and human biology aggregated and disaggregated.)

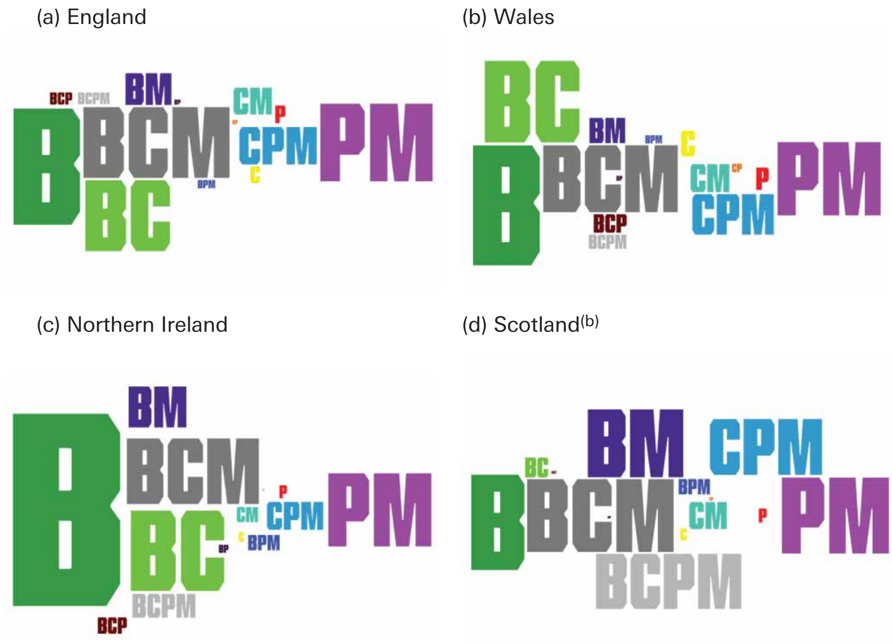
*Table 3.3. Numbers of 16–18 year old students taking GCE A-level core sciences with or without GCE A-level mathematics in 2009 (England, Wales and Northern Ireland) compared with equivalent data for Scottish Highers (2009).*

| Core sciences combinations with/without mathematics | England | | Wales | | Northern Ireland | | Scotland[a] | |
|---|---|---|---|---|---|---|---|---|
| B | 17,990 | 22.9% | 894 | 22.3% | 1,454 | 33.0% | 3,279 | 17.6% |
| P(M) | 12,018 | 15.3% | 546 | 13.6% | 552 | 12.5% | 2,663 | 14.3% |
| BC | 10,976 | 14.0% | 608 | 15.2% | 607 | 13.8% | 662 | 3.5% |
| BC(M) | 10,947 | 13.9% | 499 | 12.5% | 496 | 11.2% | 2,505 | 13.4% |
| CP(M) | 5,800 | 7.4% | 302 | 7.5% | 211 | 4.8% | 1,956 | 10.5% |
| B(M) | 4,909 | 6.3% | 189 | 4.7% | 310 | 7.0% | 2,329 | 12.5% |
| C(M) | 4,154 | 5.3% | 208 | 5.2% | 115 | 2.6% | 1,593 | 8.5% |
| P | 2,722 | 3.5% | 166 | 4.1% | 99 | 2.2% | 495 | 2.7% |
| C | 2,627 | 3.3% | 192 | 4.8% | 74 | 1.7% | 415 | 2.2% |
| BCP | 1,877 | 2.4% | 138 | 3.4% | 123 | 2.8% | 95 | 0.5% |
| BCP(M) | 1,801 | 2.3% | 106 | 2.6% | 180 | 4.1% | 1,935 | 10.4% |
| BP(M) | 1,280 | 1.6% | 61 | 1.5% | 117 | 2.7% | 535 | 2.9% |
| BP | 779 | 1.0% | 37 | 0.9% | 61 | 1.4% | 89 | 0.5% |
| CP | 660 | 0.8% | 62 | 1.5% | 13 | 0.3% | 122 | 0.7% |
| Total | 78,540 | 100.0% | 4,008 | 100.0% | 4,412 | 100.0% | 18,673 | 100.0% |

*Sources*: DCSF, Welsh Assembly Government, DENI, Scottish Government.

(a) Data for Scotland combine figures for biology and human biology.

*Figure 3.2. The popularity of GCE A-level and Higher core sciences combinations (with or without mathematics) across the United Kingdom (2009).*[a]




*Sources:* DCSF, Welsh Assembly Government, DENI, Scottish Government.
(a) These diagrams have been produced using Wordle™.
(b) This diagram combines data for biology and human biology.

The next section explores the extent to which such patterns are observable over time, and what the significance of this may be.

Key message 2. The most striking difference between the situation in Scotland and that elsewhere in the UK is that the proportions of students taking core sciences combinations with mathematics considerably exceed the proportions taking core sciences combinations without mathematics.

## 3.5 Patterns of uptake of core sciences subjects with mathematics

The evidence presented in the Supplementary evidence clearly suggests that while the proportions of 16–18 year old students in England, Wales, Northern Ireland taking core sciences GCE A-levels, and those taking Highers in Scotland, have remained fairly static, increasing numbers of these students are also opting to take mathematics.

Figure 3.3 compares data on the numbers of such students across England, Wales, Northern Ireland and Scotland taking biological sciences. The blue-shaded columns indicate the proportions of these students who took biological sciences either alone or in combination with other core science subjects (ie chemistry and/or physics), while the pink columns show the proportions taking biological sciences in combination with mathematics and/or other core sciences. Figures 3.4 and 3.5 illustrate the equivalent comparisons for chemistry and physics.

The results are striking and, so far as England, Wales and Northern Ireland are concerned, strikingly similar. They show in these nations that decreases in the proportions (and numbers) of individuals taking a single core science or core-sciences-only combinations have in some sense been compensated by growth in the proportions (and numbers) of students taking combinations of core sciences and mathematics. This is especially apparent in considering biological sciences (figure 3.3) and physics (figure 3.5), but in the case of both chemistry, and more especially physics, the total numbers/proportions of students taking combinations of these subjects together with mathematics and other core sciences have outstripped the numbers/proportions that take single core sciences and/or core sciences combinations alone. Moreover, regardless of whether the popularity of core sciences combinations has decreased or increased, the overall extent to which their popularity has waxed or waned has been similar across each of the nations.

The situation in Scotland is similar, but different in key ways. As with the other nations, combinations involving core sciences and mathematics are more popular, have been increasing in popularity and come to exceed the proportions taking core sciences combinations without mathematics. However, unlike the other Home Nations, where the proportion of students taking combinations involving the biological sciences and mathematics has grown in 2009 to a third of all biological sciences candidates, the equivalent proportion in Scotland had reached almost two-thirds by the same time. Indeed, the most striking difference between the situation in Scotland and that elsewhere in the UK is that the proportions of students taking core sciences combinations with mathematics considerably exceed the proportions taking core sciences combinations without mathematics.

Figures 3.3–3.5 seem to capture a transitional moment in England, Wales and Northern Ireland. Increasing numbers of students are eschewing GCE A-level combinations of core sciences alone, and embracing mathematics in their suite of GCE A-level choices. But while the popularity of core sciences and mathematics combinations in these nations has come to exceed the popularity of combinations that do not involve mathematics, in Scotland this has always been the case.

The increasing trend across England, Wales and Northern Ireland for students to combine mathematics with core sciences is tremendously encouraging, and the continuing same trend in Scotland is equally to be welcomed. But the former, especially, is perplexing. Why, one may ask, is this happening?

While there are indeed multiple and confusing sources of such information, and variation in individual university STEM course entry requirements, the patterns of candidature observed suggest that one particularly powerful message is being received: namely that those who aspire to study for a higher education STEM qualification need to take mathematics in addition to science subjects. Whether this message stems from the fact that entry into higher education STEM courses is increasingly competitive due to grade inflation or the fact that universities have been increasing the stringency of their (perceived) entry requirements (presumably in response to this) merits investigation.

Nonetheless, it is inescapable that Scotland is somehow ahead of the game, and that students there have a clearer understanding of the requirements for entry into STEM higher education than their peers in the other UK nations.

Section 3.7 explores another possibility, the changing prevalence with which physics (the least popular core science subject) and mathematics are offered in these nations. First, in § 3.6, we consider variation in attainment among students taking A-level and Higher core sciences combinations.

Key message 3. Across England, Wales and Northern Ireland, there has been an increasing trend for more students taking core sciences to also take mathematics. In Scotland, this trend appears to be better established and is even more pronounced.

## 3.6 The size of the UK's pool of potential STEM first degree undergraduates

Table 3.4 attempts to capture the totality of potential STEM undergraduate students among 16–18 year olds taking core sciences and/or mathematics GCE A-levels and Scottish Highers in 2009 (the most recent year for which

*Figure 3.3. Breakdown of biological sciences A-level/Higher candidature among students taking core sciences combinations across England, Wales, Northern Ireland and Scotland (2005, 2007, 2009).*

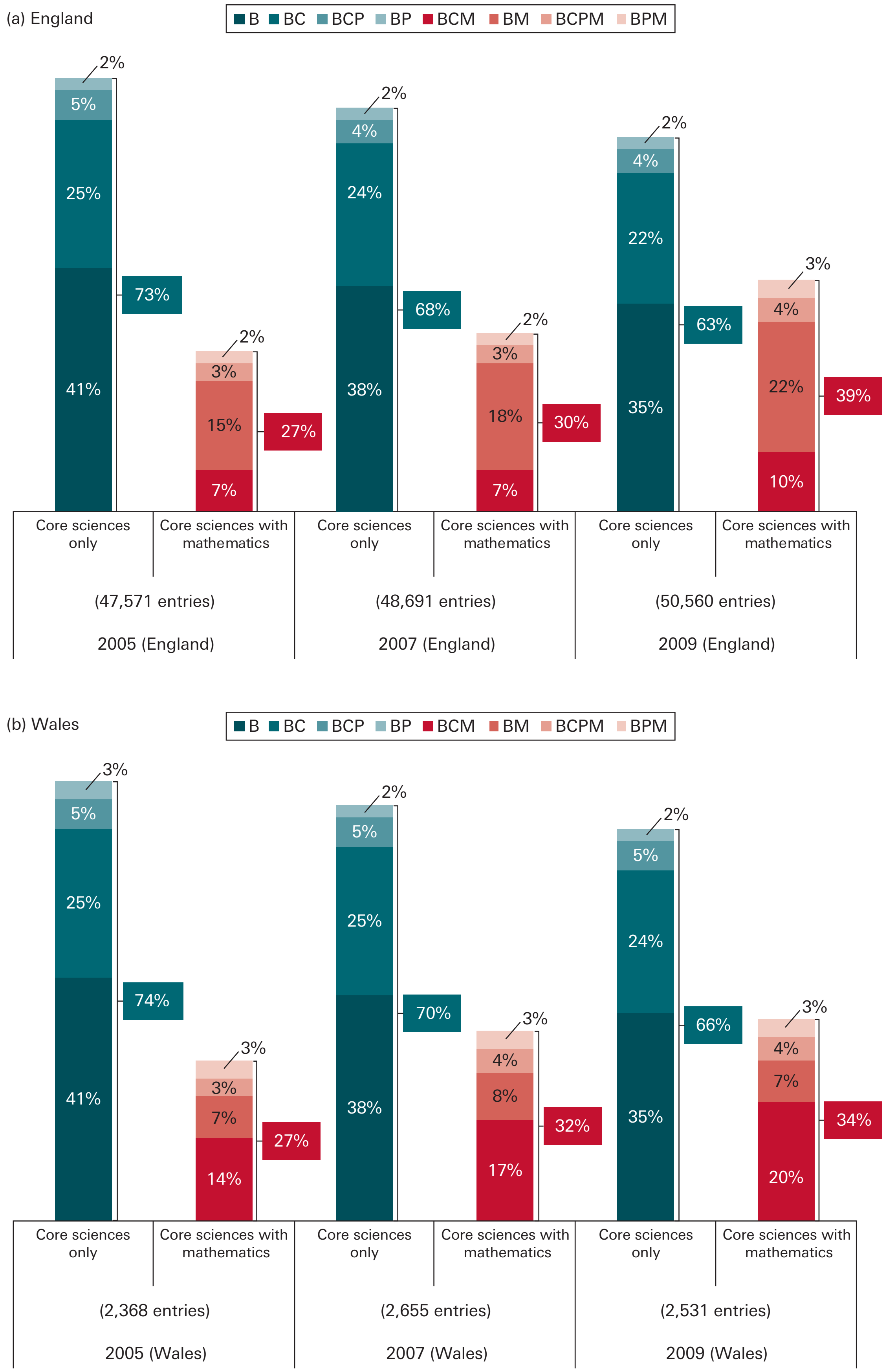
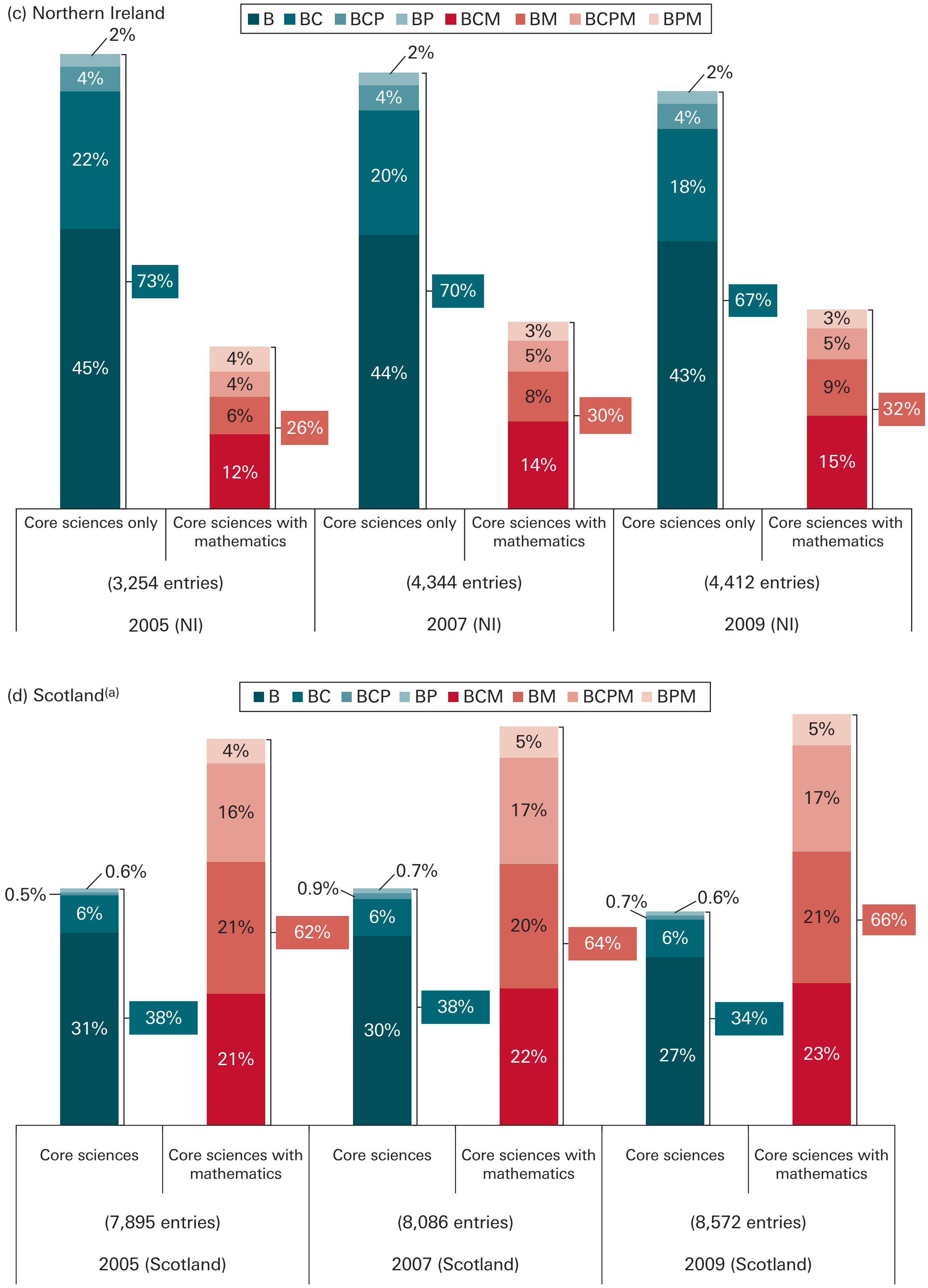


*Figure 3.3 (Continued)*



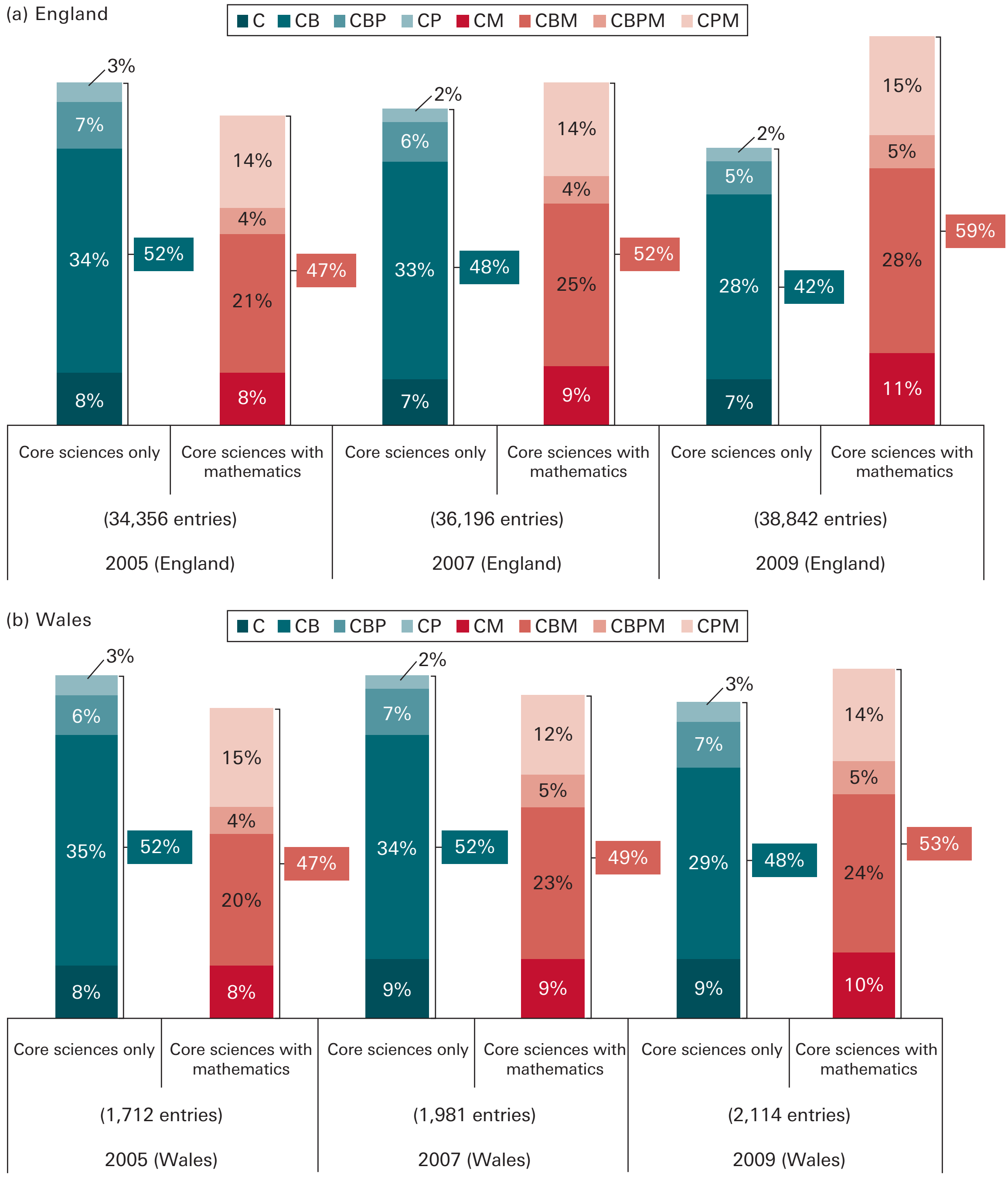

*Sources:* DCSF, Welsh Assembly Government, DENI, Scottish Government.

(a) For Scottish Highers, data for biology and human biology have been combined.

data were surveyed). Although (i) GCE A-levels and Scottish Highers are not exactly equivalent and (ii) they are each generally taken by students of different ages, both are nonetheless considered the essential currency for entry into UK higher education. This argument forms the basis for the following comparison.

Accordingly, table 3.4 suggests that there were 137,731 such students in 2009. However, this total neither takes account of the comparatively small numbers of students (across England, Wales and Northern Ireland) taking statistics (standalone) nor the numbers taking the following combinations: (i) other sciences and core

*Figure 3.4. Breakdown of chemistry A-level/Higher candidature among students taking core sciences combinations across England, Wales, Northern Ireland and Scotland[(a)] (2005, 2007, 2009).*



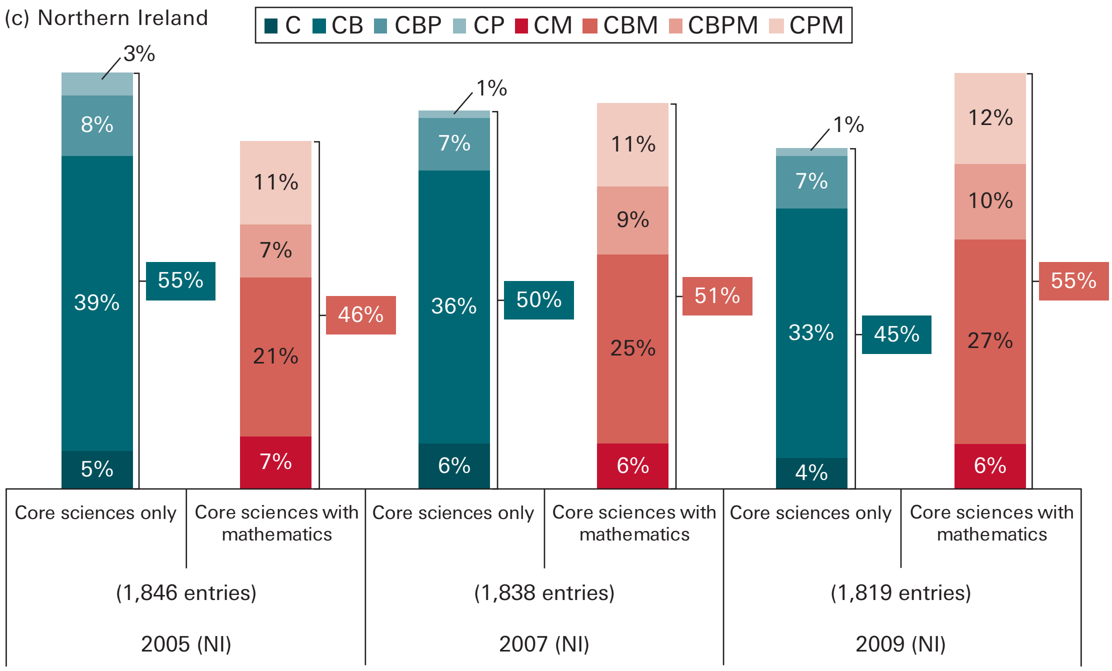

sciences; (ii) other sciences and statistics; (iii) other sciences and mathematics; and (iv) core sciences and statistics. Further it must be pointed out that this estimate does not take account of attainment (see § 3.6.1), nor does it consider the expected minimum entry requirements into first degree STEM courses. It also ignores the additional impact of Scottish Intermediate II and Advanced Higher qualifications, AS-levels, vocational A-levels (and combinations of these with core sciences and/or mathematics, albeit that these are few and far between), all of which may enhance a candidate's prospects of entering a course of STEM higher education, plus those home-domiciled 16–18 students taking other routes into STEM higher education (such as the International Baccalaureate and BTEC Nationals), which are considered further in Chapter 4.[22]

Despite these caveats, this figure of 137,731 students does provide a good indication of the quantity involved. Table 3.4 shows that when compared with relevant population-based data, it may be established that somewhere in the region of 17% of the UK's eligible

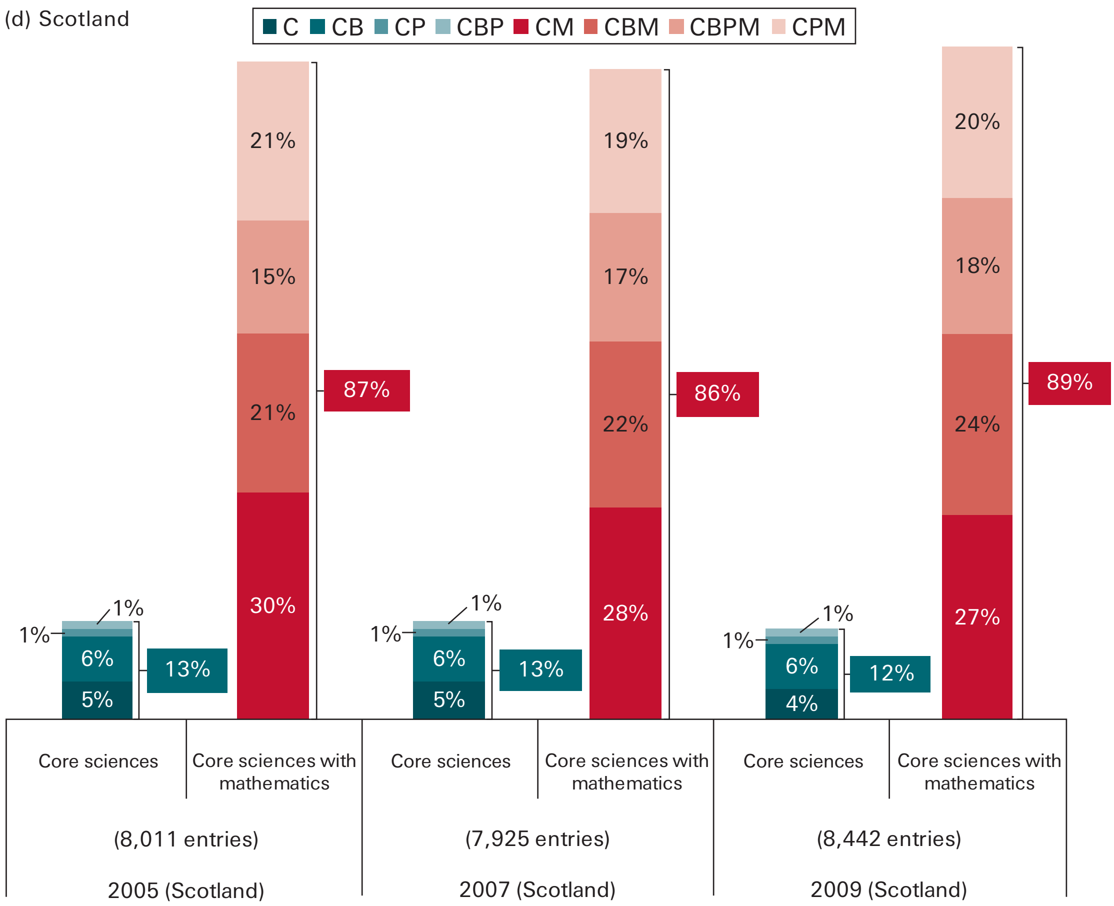
22 It is important to note that the Cambridge Pre-U was introduced into teaching in September 2008, and first assessed in June 2010, thereby increasing the choice of qualifications open to post-16 students.

*Figure 3.4 (Continued)*

(c) Northern Ireland




(d) Scotland



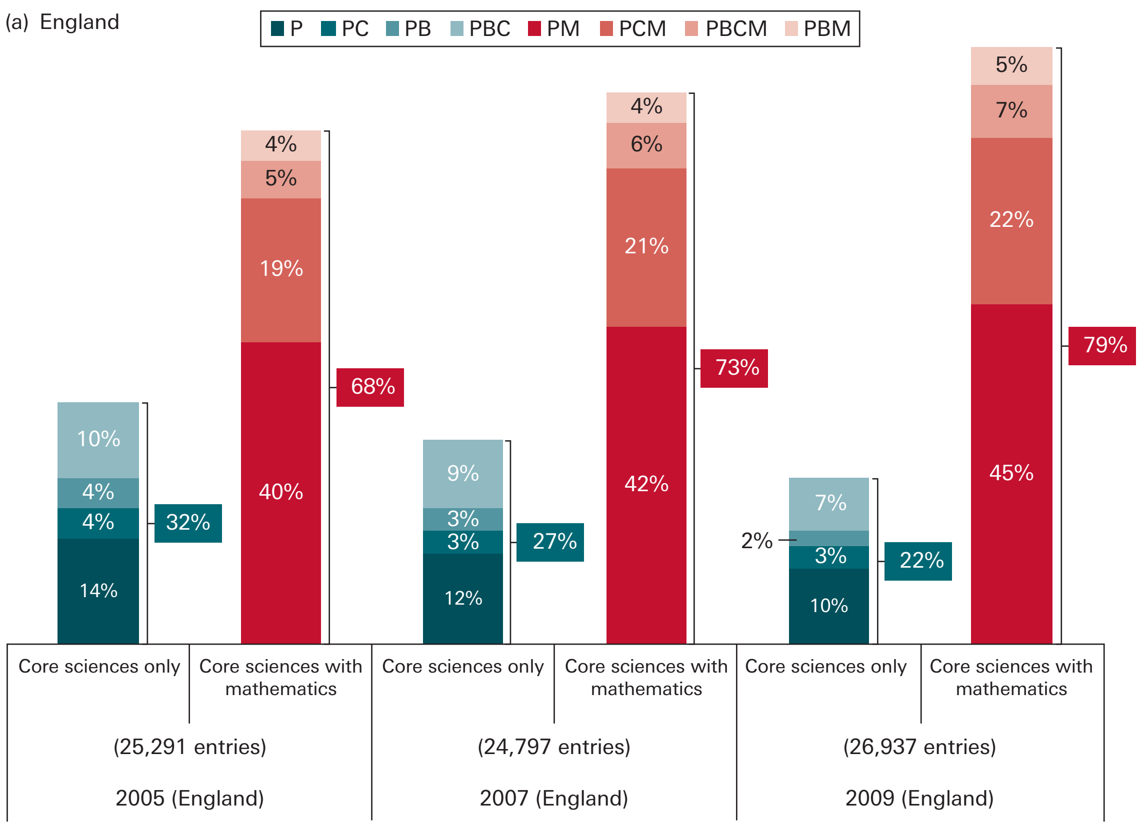

*Sources:* DCSF, Welsh Assembly Government, DENI, Scottish Government.

(a) For Scottish Highers, data for biology and human biology have been combined.

16–18 year old population took core sciences with or without mathematics that may have prepared them for STEM studies at university. It should be noted that most students in England, Wales and Northern Ireland are aged 17 at the start of the academic year in which they take their final GCE A-level examinations, while equivalently students taking Scottish Highers tend to be aged 16.

Key message 4. Less than one-fifth of eligible 17 year olds in England, Wales and Northern Ireland and 16 year olds in

*Figure 3.5. Breakdown of physics A-level/Higher candidature among students taking core sciences combinations across England, Wales, Northern Ireland and Scotland[a] (2005, 2007, 2009).*



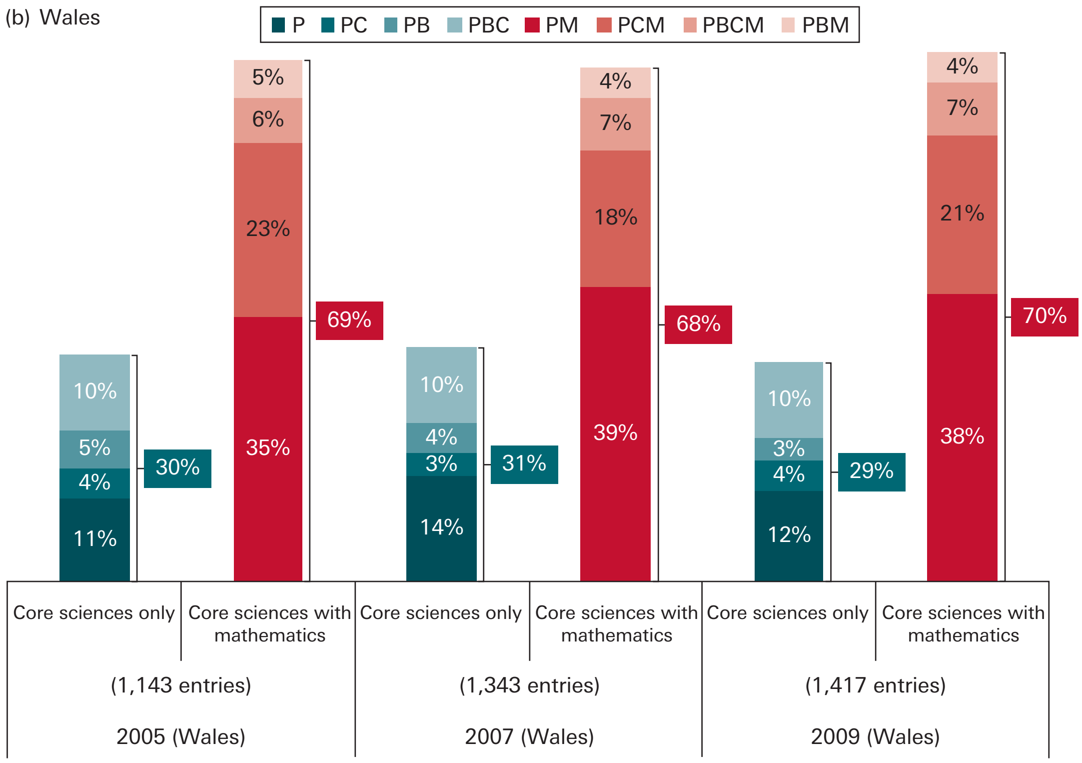
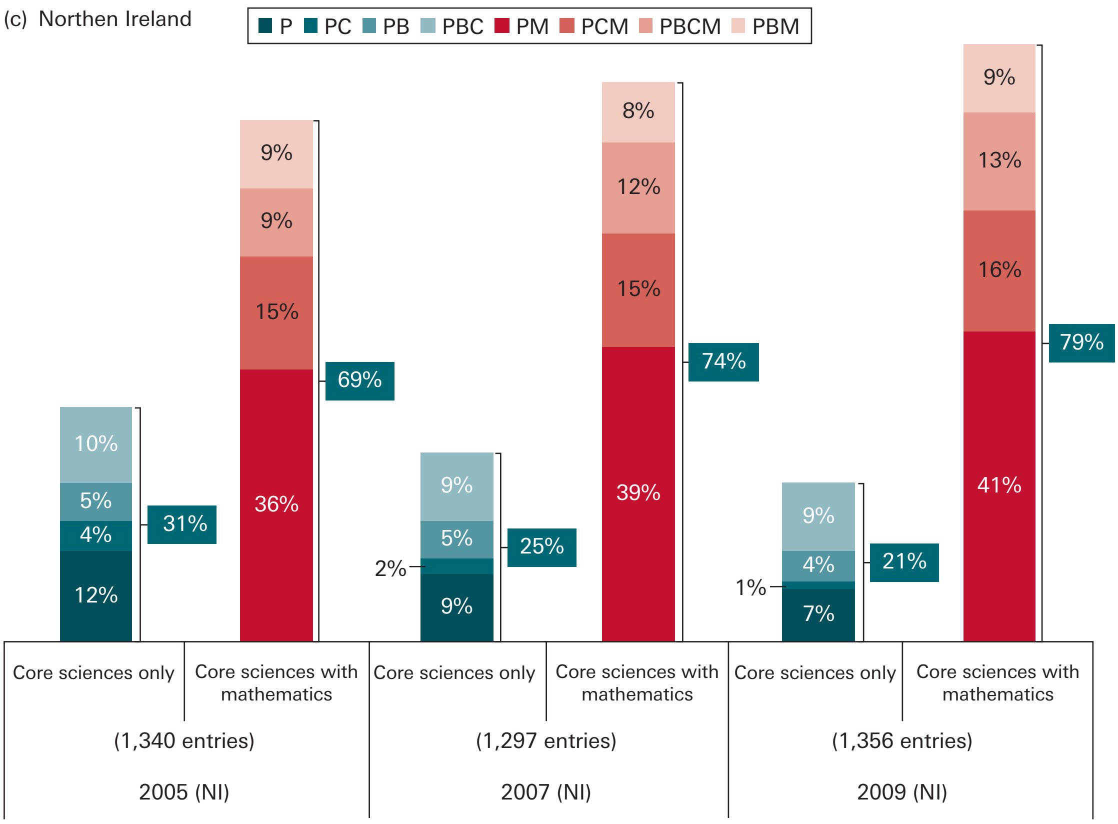
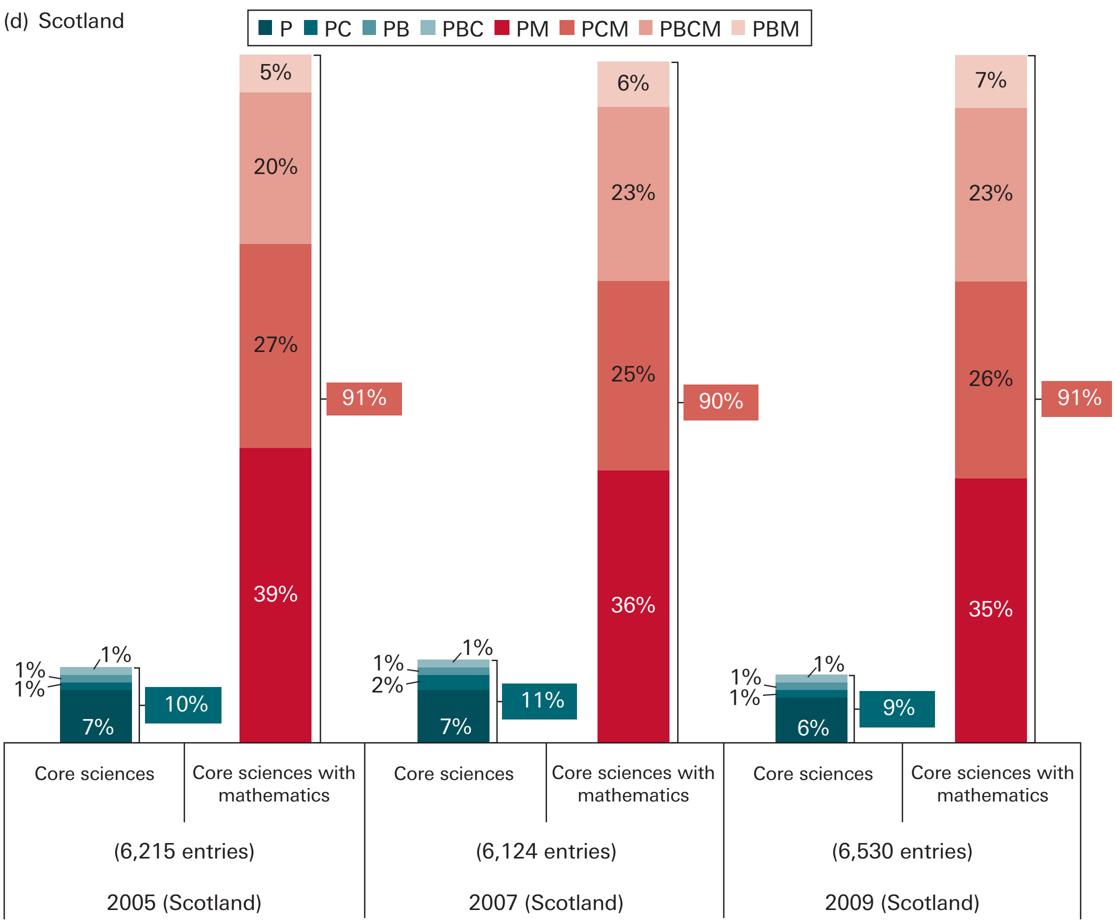



*Figure 3.5 (Continued)*




*Sources:* DCSF, Welsh Assembly Government, DENI, Scottish Government.

(a) For Scottish Highers, data for biology and human biology have been combined.

*Table 3.4. Cross-UK table showing total numbers of students taking combinations of core sciences A-levels or Scottish Highers (with or without mathematics) and those who in addition take mathematics alone (or in combination with other subjects) compared to the size of the potentially eligible population (2009).*

| | England | Wales | Northern Ireland | Scotland (Highers only)[a] | Grand total |
|---|---|---|---|---|---|
| All students taking core sciences and/or mathematics | 105,216 | 5,144 | 5,233 | 22,138 | **137,731 (A)** |
| Number of 17 year olds[b] | 666,927 | 40,396 | 25,463 | – | **732,786** |
| Number of 16 year olds | | | | 63,669 | **63,669** |
| | | | | Total potentially eligible population | **796,455 (B)** |
| Proportion of the potentially eligible population taking core sciences and/or mathematics | | | | =((A)/(B)) x 100 | **17.3%** |

(a) Scotland data also includes human biology subject combinations with other core sciences with and without mathematics.

(b) Data received from the ONS.

Scotland take post-16 mainstream higher education preparatory courses in core sciences with or without mathematics.

### 3.6.1 Variation in patterns of attainment in GCE A-level/Higher core sciences combinations with or without mathematics

In order to gain a better size of the true pool of potential talent that is most likely to be qualified for entry to STEM higher education, table 3.5 illustrates the proportions of 16–18 year olds taking at least the modal number of A-levels/Highers and attaining good grades in at least two core sciences with/without/(or) mathematics, according to what is generally recognised as being the acceptable requirements for entry onto most STEM higher education first degree courses (SCORE 2009*b*).

Table 3.5 indicates that of these students, those in Northern Ireland outperform their peers in England and Wales, with greater proportions attaining all A grades, A/B grades and A–C grades, and rather fewer failing to obtain these grades in any or all of their core sciences and/or mathematics examinations. However, based on these analogous university requirements, it appears that greater proportions of Scottish students are attaining A–C grades in two core sciences and mathematics, albeit that smaller proportions gain straight A grades compared to students elsewhere in the UK.

Table 3.6 takes the analysis a step further by establishing the numbers of students that these proportions represent, based on the total numbers of students in each year's cohort that took core sciences and/or mathematics.

Taking from table 3.6 the figures for 2009 and comparing them with the total numbers of students who took core sciences and/or mathematics that year (cf. table 3.4), it is possible to calculate that of a UK total of 137,731 candidates, around 102,325 (74%) obtained the A–C grades that would generally be required for entry into UK STEM higher education first degree courses. This total does not take account of their attainment in other subjects, and is based on an understanding of basic entry requirements gained from SCORE and the Scottish Government (SCORE 2009). Equally, depending on a variety of factors, a proportion of the (approximately) 35,406 individuals who attained 'other' grades would also be able to gain a place on a STEM HE course.

Key message 5. Across the UK in 2009, almost three-quarters of the students who took at least the minimum required number of core sciences and mathematics subjects for entry to undergraduate UK STEM higher education courses gained A–C grades needed in these subjects.

## 3.7 Variation in the provision of physics and mathematics in schools and colleges

In order to understand the factors underlying the pattern of core sciences entries observed, this section investigates the distribution of GCE A-level physics (the least popular and strategically most vulnerable core science) and mathematics (because of the increasing tendency for this to be taken with core sciences) entries across the different types of educational institutions found in England, Wales, Northern Ireland and Scotland.

This approach does not provide clear-cut answers, but it is reasonable to expect that, size apart, the decrease (or increase) in entrants to these subjects would correlate with a corresponding reduction or increase in the numbers of institutions producing physics or mathematics candidates, and that this would potentially be a key limiting factor to proliferation of numbers taking these subjects.

However, it is no less important to consider supplementary or alternative explanations for the subject provision seen. Many of these issues were discussed in the Society's

*Table 3.5. Proportions of students in England, Wales and Northern Ireland taking three or more GCE A-levels and gaining grades A–C in two or more core sciences with/without mathematics subjects compared with students in Scotland taking five or more Highers and gaining grades A–C in two or more core sciences and mathematics (2005, 2007, 2009).*

| | 2005 | | | | 2007 | | | | 2009 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | England | Wales | NI | Scotland | England | Wales | NI | Scotland | England | Wales | NI | Scotland |
| All A | 23.7% | 24.8% | 30.7% | 24.5% | 26.3% | 23.7% | 33.1% | 26.1% | 27.5% | 26.2% | 33.4% | 25.2% |
| A–B | 48.3% | 49.3% | 57.2% | 51.0% | 51.1% | 49.1% | 59.7% | 53.8% | 52.5% | 52.4% | 60.7% | 53.6% |
| A–C | 69.1% | 71.1% | 77.3% | 80.7% | 71.6% | 71.5% | 79.6% | 81.9% | 72.5% | 74.4% | 80.6% | 81.3% |
| Other[(a)] | 30.9% | 28.9% | 22.7% | 19.3% | 28.4% | 28.5% | 20.4% | 18.1% | 27.5% | 25.6% | 19.4% | 18.7% |
| **Grand total** | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

*Sources*: DCSF, Welsh Assembly Government, DENI, Scottish Government.

(a) Other denotes candidates who were not awarded a grade A, B or C in all their science or mathematics A-levels/Highers.

*Table 3.6. Numbers of 16–18 year old students in England, Wales and Northern Ireland taking three or more GCE A-levels and gaining grades A–C in two or more core sciences and/or mathematics subjects compared with students in Scotland taking five or more Highers and gaining grades A–C in two or more core sciences and mathematics (2005, 2007, 2009).*

| | 2005 | | | | 2007 | | | | 2009 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | England | Wales | NI | Scotland | England | Wales | NI | Scotland | England | Wales | NI | Scotland |
| All A | 21,367 | 1,028 | 1,536 | 5,242 | 24,911 | 1,194 | 1,701 | 5,285 | 28,934 | 1,348 | 1,748 | 5,579 |
| A–B | 43,545 | 2,043 | 2,861 | 12,239 | 48,401 | 2,474 | 3,069 | 10,894 | 55,238 | 2,695 | 3,176 | 11,866 |
| A–C | 62,298 | 2,946 | 3,867 | 17,267 | 67,819 | 3,608 | 4,091 | 16,584 | 76,282 | 3,827 | 4,218 | 17,998 |
| Other[(a)] | 27,858 | 1,198 | 1,135 | 4,129 | 26,900 | 1,436 | 1,049 | 3,665 | 28,934 | 1,317 | 1,015 | 4,140 |
| Total numbers taking core sciences and/or mathematics | 90,156 | 4,144 | 5,002 | 21,396 | 94,719 | 5,039 | 5,140 | 20,249 | 105,216 | 5,144 | 5,233 | 22,138 |

*Sources*: DCSF, Welsh Assembly Government, DENI, Scottish Government.

(a) Other denotes candidates who were not awarded a grade A, B or C in all their science or mathematics A-levels/Highers.

*Table 3.7. The decline in the provision of physics among independent schools across the UK (2005–09).*

| | Change in the total no. of independent schools | Change in the no. of independent schools sending any physics candidates |
|---|---|---|
| England | +8 | –25 |
| Wales | +1 | –2 |
| Northern Ireland | –1 | 0 |
| Scotland | +2 | +2 |

*Sources*: DCSF, Welsh Assembly Government, DENI, Scottish Government.

second 'state of the nation' report, and some are taken up in Chapter 4. These include:

(i) educational reform;

(ii) socio-economic status;

(iii) student attitudes and motivation;

(iv) local/regional effects;

(v) the influence of school type;

(vi) the numbers, deployment of and access to subject-specialist teachers;

(vii) pupil–teacher ratios;

(viii) changes to curricular and course specifications;

(ix) transferral to alternative qualifications;

(x) constraints on student choice resulting from school governance, prior attainment and resources; and

(xi) the access to and effectiveness of careers information, advice and guidance young people receive.

### 3.7.1 Physics

It may be calculated from tables 3.8–3.11 that, across the UK, physics entries rose overall across institutions during the period measured,[23] by 6% in England and Wales and by 4% in Scotland, though by a negligible amount in Northern Ireland. Universally, overall falls in physics entries were recorded by FE colleges, but there were overall percentage increases in entries in maintained sector schools of 4% (in England) and 6% (in Wales). Entries in physics among independent schools increased 7% in England and 1.5% in Scotland,[24] but they decreased in Wales by more than 1%.

However, against this general pattern of growth, figures 3.6–3.9 show that the *proportions* of institutions providing physics entrants decreased in each of the Home Nations.

23 The comparison with Wales is with 2007 data owing to the lack of information on FE for 2005.
24 Data are combined for Highers and Advanced Highers.

The highest overall proportion of institutions providing physics candidates is to be found in Scotland (90% in 2009), followed by Wales (88% in 2009) and then England (82% in 2009), but in each of these nations, 2% fewer institutions overall offered physics in 2009 than was the case in 2005. The concentration of physics in grammar schools in Northern Ireland (consistently 100% throughout the years studied) contrasts with these being fewer than a third of all other secondary and FE institutions putting up physics entrants, which explains why just 57% of all institutions there provided physics candidates in 2009.

Across the UK, between 2007 and 2009 there was a sharp fall in the number of selective schools not sending physics A-level/Higher/Advanced Higher candidates, with the greatest fall being evident in England (see table 3.7). These falls need to be set against the fact that the total number of these institutions generally increased in this period. What makes this trend especially worrying is that historically the independent sector has been the major provider of physics undergraduates to many of the UK's leading universities (Royal Society 2006*b*).

A more in-depth nation-based examination of entries and apparent teaching provision in physics reveals the following.

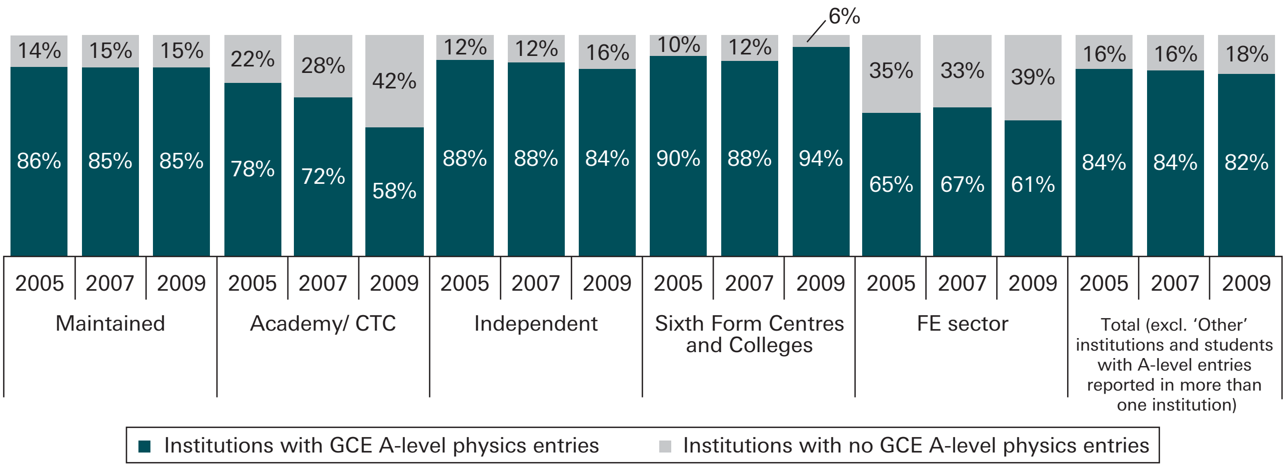
#### *England*

During 2005–09, overall numbers of physics entries increased across all types of institution, with the exception of the FE sector (table 3.8). Table 3.8 also shows, or else it may be calculated from it:

(i) that physics is largely the preserve of the maintained, independent and sixth form college sectors.

(ii) that in 2009, 15% (or 254) of maintained sector schools, 16% (or 92) of independent schools, 39% (or 98) of FE sector colleges, 6% (or 6) of sixth form colleges and 42% (32) of academies/CTCs did not put forward any GCE A-level physics candidates. This means that approximately 492 educational institutions that could conceivably have produced physics candidates failed to do so.

*Figure 3.6. Distribution by institution type of GCE physics A-level entries among 16–18 year old students (England, 2005, 2007, 2009).*[(a)]




*Sources:* DCSF.

(a) Graph provides information about institutions where students entered for GCE A-level courses (year for KS5 cohort of 16–18 year olds; may include exams taken previously within the same institution).

(iii) that against an overall increase in the size of the independent sector by eight institutions between 2005 and 2009 (table 3.7), the proportion of independent schools provisioning physics A-level candidates dropped 20% between 2007 and 2009, with 25 fewer schools (a 37% decline) in 2009 than in 2007 appearing to teach the subject.

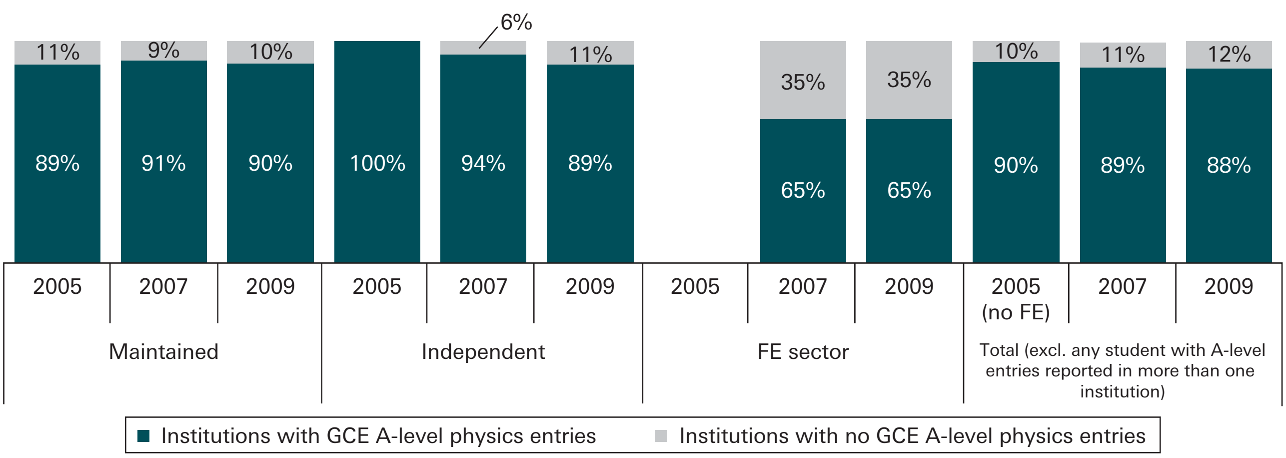
The following key observations may be made by comparing table 3.8 with figure 3.6:

(i) despite the fact that physics entries increased 4%, 7% and 18% across the maintained, independent and sixth form college sectors, the contribution of physics entries reported in the maintained sector stayed constant and there were overall falls in the proportion of entries from within the independent sector and sixth form centres and colleges.

(ii) there was a dramatic fall in the proportion of physics entries from among academies and CTCs, although the actual number of physics entries from academies increased, reflecting the expansion of this sector under the previous Labour Governments.

(iii) the 10% overall fall in physics entries from the FE sector was matched by an overall 4% decrease in the proportion of FE sector colleges contributing physics A-level entries.

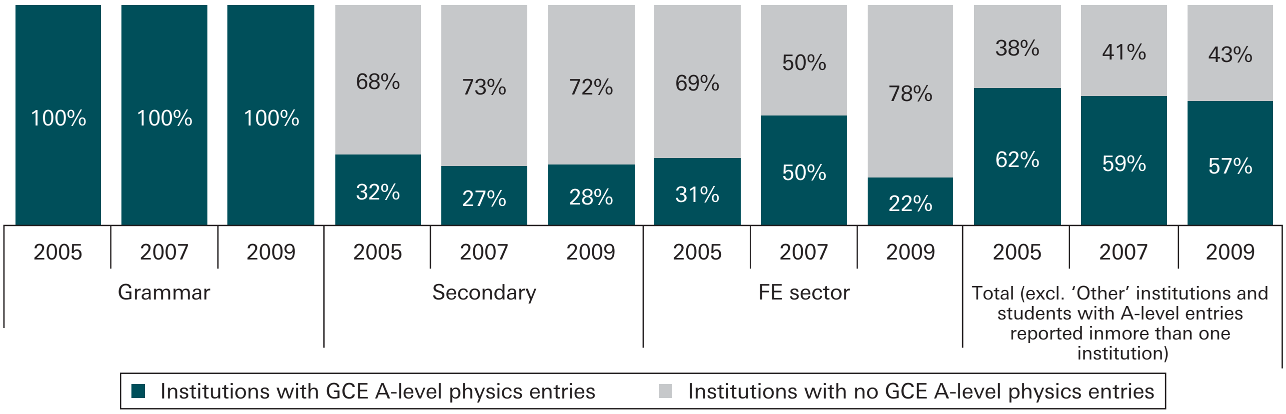
*Figure 3.7. Distribution by institution type of GCE physics A-level entries among 16–18 year old students (Wales, 2005, 2007, 2009).*[(a)]




*Source:* Welsh Assembly Government.

(a) Graph provides information about institutions where students entered for GCE A-level courses (year for KS5 cohort of 16–18 year olds; may include exams taken previously within the same institution).

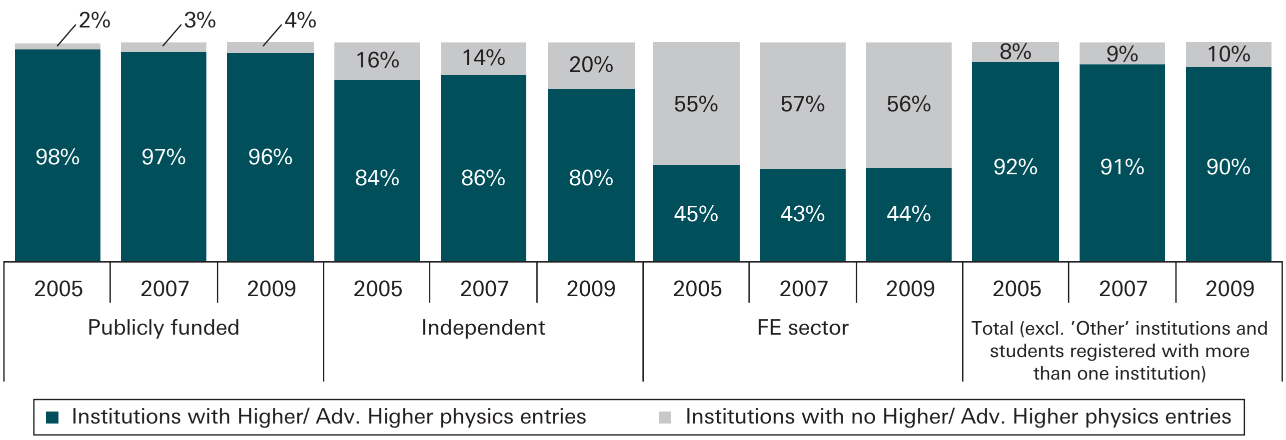
*Figure 3.8. Distribution by institution type of GCE physics A-level entries among 16–18 year old students (Northern Ireland, 2005, 2007, 2009).*[(a)]




*Source:* DENI.

(a) Graph provides information about institutions where students entered for GCE A-level courses (year for KS5 cohort of 16–18 year olds; may include exams taken previously within the same institution).

*Figure 3.9. Distribution by institution type of Higher and Advanced Higher physics entries among 16–18 year old students (Scotland, 2005, 2007, 2009).*[(a)]




*Source:* Scottish Government.

(a) Graph provides information about institutions where leavers entered for Higher and Advanced Higher courses.

While the third of these observations seems to stand to reason and correlates with the diminishing number of FE institutions entering GCE A-level candidates, the first two observations appear counter-intuitive. A plausible interpretation for these is that there is provision for greater capacity within those academies, maintained, independent and sixth form institutions that do offer (and probably have consistently offered) physics. It would appear that, so far, these have been able to cope with the increasing demand, presumably because they employ specialist physics teachers and have sufficient physical resources available to cope; but if this is the case, it is very difficult to know how many more entrants they would be capable of delivering without undertaking a more forensic analysis. The decrease in the proportions of colleges offering physics may also reflect the economic pressures they are under not to offer classes for small numbers of students, a matter of recent debate.[25]

The number of independent schools entering GCE A-level candidates has risen. The plausibility of this explanation comes from the fact that entries to physics in maintained schools have increased while the number of maintained schools entering students for GCE A-levels has decreased. Further, the considerable fall in provision of physics within academies could well be because provision of physics at A-level has not kept pace with the expansion of this sector,

25 See letter of 14 July 2010 from the Advisory Committee on Mathematics Education to the Minister of State for Schools (http://www.acme-uk.org/downloaddoc.asp?id=226, accessed 1 November 2010).

which trebled in size over this time, thereby creating additional pressure on those few academies that do provide physics entrants.

Notably, the results of a recent modelling exercise by the Institute of Physics estimated that there are approximately 500 state schools in England, including both 11–16 and 11–18 schools, that send people to do A-levels, but that do not send any on to study A-level physics.[26]

It seems highly likely that the increases of late in physics entries will soon reach a ceiling that will be impossible to break through unless and until more institutions (or larger institutions, perhaps created through mergers or cross-institutional agreements) offer A-level physics. Unfortunately, the chronic shortage of physics specialists in the workforce, reported in our first 'state of the nation' report, will inevitably act as a major hindrance to reversing this situation. The effects of this for UK STEM higher education and the economy are self-evident.

Table 3.8 provides summary information on the numbers of physics entries across England, derived from information within (or underpinning) the Supplementary evidence for England. It shows that during 2005–09, there was a slight overall increase in the numbers of students taking A-level physics in each nation, but that numbers have fluctuated within this period.

Figures 3.6–3.12 attempt to:

(i) shed some light on these patterns; and

(ii) try to establish better the nature of the physical constraints to achieving a higher take-up of these subjects.

### *Wales*

Table 3.9 shows the distribution of physics entries among 16–18 year olds across the range of educational institutions in Wales during 2005, 2007 and 2009. It shows that during this period, overall numbers of physics entries increased modestly, and that, with the exception of the FE sector, these increases occurred across all types of institution. Table 3.10 also shows that physics is largely the preserve of the maintained and independent sectors. In terms of numbers alone, the independent sector is about one-ninth the size of the maintained sector, and has contributed approximately one-eighth of all physics entrants.

Figure 3.7 details the proportionate distribution of physics entries by institution type, which provides a very good indication of teaching provision across educational institutions in Wales.

The following key observations may be made from a comparison of table 3.9 with figure 3.7:

(i) physics entries increased 6% within the maintained sector, albeit that the percentage of such schools providing physics entrants fell during this period.

(ii) physics entries decreased slightly overall in independent schools, and the proportion of these schools producing physics candidates fell from 100% to 89% between 2005 and 2009.

(iii) between 2007 and 2009, physics entries in FE sector colleges fell, and this drop was echoed in the decreasing proportion of these institutions providing physics entrants.

Across Wales, the proportion of institutions entering GCE A-level physics candidates has fallen. Although this still means that 88% or so of Welsh educational institutions appear to offer physics, the decline in the maintained and independent sectors is especially concerning, given that these institutions provide the majority of GCE A-level physics candidates. Based on data for 2009, it is effectively the case that 17 fewer maintained schools and two fewer independent schools than the numbers listed in table 3.9 suggest are presenting physics entrants. Although it is a point of conjecture, it seems reasonable to speculate that these decreases may be due to schools' inability to find new physics specialists to replace retirees, a problem likely to be compounded among schools that are geographically isolated.

These figures indicate that, as in England, recent (if small) gains in physics entries are probably down to capacity being stretched within schools that have traditionally offered physics, and that there is a similar shortage of physics specialists in the teaching workforce in Wales.

### *Northern Ireland*

Table 3.10 shows the distribution of physics entries among 16–18 year olds across the range of educational institutions in Northern Ireland during 2005, 2007 and 2009. In contrast, figure 3.8 details the proportionate distribution of physics entries by institution type, which provides a very good indication of teaching provision in educational institutions across Northern Ireland.

It is notable from figure 3.8 that grammar schools in Northern Ireland have a 100% record in terms of providing GCE A-level physics candidates in recent years, and table 3.10 confirms that despite the disappearance of one of these schools, these institutions have continued to grow their physics cohorts. However, almost three-quarters of non-selective secondary schools in Northern Ireland produce no physics candidates, and just 22% of FE colleges produced any in 2009.

Despite the performance of the grammar schools, Northern Ireland has witnessed a substantial decline in GCE A-level physics provision in recent years. Although no detailed and reliable records appear to exist on the numbers of physics specialists in the Northern Ireland teaching workforce

26 Physics teacher shortage—more than a decade of doubled intake needed. Press release, 20 September 2010. London: Institute of Physics.

*Table 3.8. Comparison of GCE A-level physics entries among 16–18 year old students by institution type and number (England, 2005, 2007, 2009).*

| Institution type | Student entries to GCE A-level physics, by institution type (for all institutions with any GCE A-level entry recorded) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004/5 KS5 cohort with GCE A-level physics entries | | | | | 2006/7 KS5 cohort with GCE A-level physics entries | | | | | 2008/9 KS5 cohort with GCE A-level physics entries | | | | |
| | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions |
| Maintained | 1,492 | 249 | 86% | 14,044 | 1,741 | 1,476 | 258 | 85% | 13,592 | 1734 | 1474 | 254 | 85% | 14,644 | 1,728 |
| Academy/ CTC | 18 | 5 | 78% | 201 | 23 | 23 | 9 | 72% | 217 | 32 | 45 | 32 | 58% | 356 | 77 |
| Independent | 512 | 67 | 88% | 5,583 | 579 | 505 | 70 | 88% | 5,579 | 575 | 495 | 92 | 84% | 5,988 | 587 |
| Sixth Form Centres and Colleges | 103 | 11 | 90% | 3,293 | 114 | 99 | 13 | 88% | 3,546 | 112 | 100 | 6 | 94% | 3,875 | 106 |
| FE sector | 170 | 92 | 65% | 2,035 | 262 | 158 | 77 | 67% | 1,776 | 235 | 155 | 98 | 61% | 1,824 | 253 |
| Total[(a)] | 2,295 | 424 | 84% | 25,156 | 2,719 | 2,261 | 427 | 84% | 24,710 | 2,688 | 2,269 | 482 | 82% | 26,687 | 2,751 |

*Source:* DCSF.

(a) Excludes 'Other' institutions and students registered with more than one institution.

*Table 3.9. Comparison of GCE A-level physics entries among 16–18 year old students by institution type and number[(a)] (Wales, 2005, 2007, 2009).*

| | Student entries to GCE A-level physics, by institution type (for all institutions with any GCE A-level entry recorded) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004/5 GCE A-level physics entries | | | | | 2006/7 GCE A-level physics entries | | | | | 2008/9 GCE A-level physics entries | | | | |
| Institution type | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions | Institutions with Entries | Institutions with no Entries | % institutions with entries | Students entered (*n*) | All institutions | Institutions with Entries | Institutions with no Entries | Institutions with no Entries | Students entered (*n*) | All institutions |
| Maintained | 152 | 18 | 89% | 1,003 | 170 | 153 | 15 | 91% | 989 | 168 | 152 | 17 | 90% | 1,059 | 169 |
| Independent | 18 | | 100% | 141 | 18 | 16 | 8 | 94% | 114 | 17 | 17 | 9 | 89% | 139 | 19 |
| FE sector | – | – | – | – | – | 13 | | 65% | 241 | 20 | 13 | | 65% | 220 | 20 |
| Total[(b)] | 170 | 18 | 90% | 1,144 | 188 | 182 | 23 | 89% | 1,344 | 205 | 182 | 26 | 88% | 1,418 | 208 |

*Source:* Welsh Assembly Government.

(a) The total number of each type of institution takes account of all establishments where students were entered for any VCE/GCE subjects.

(b) Excludes any student registered with more than one institution.

(c) As reported in Chapter 4, no data were provided for the FE sector.

(d) For the FE sector, this comparison relates to data for 2007 and 2009 only (see previous footnote).

(e) This figure results from comparing 2009 with 2007 data.

*Table 3.10. Comparison of GCE A-level physics entries among 16–18 year old students by institution type and number*[(a)] *(Northern Ireland, 2005, 2007, 2009).*

| | Student entries to GCE A-level physics, by institution type (for all institutions with any GCE A-level entry recorded) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004/5 KS5 cohort entering GCE A-level physics entries | | | | | 2006/7 KS5 cohort entering GCE A-level physics entries | | | | | 2008/9 KS5 cohort entering GCE A-level physics entries | | | | |
| Institution type | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions |
| Grammar | 70 | 0 | 100% | 1,200 | 70 | 69 | 0 | 100% | 1,160 | 69 | 69 | 0 | 100% | 1,217 | 69 |
| Secondary | 24 | 50 | 32% | 130 | 74 | 24 | 64 | 27% | 114 | 88 | 26 | 67 | 28% | 121 | 93 |
| FE sector | 4 | 9 | 31% | 23 | 13 | 5 | 5 | 50% | 25 | 10 | 2 | 7 | 22% | 16 | 9 |
| Total[(b)] | 98 | 59 | 62% | 1,353 | 157 | 98 | 69 | 59% | 1,299 | 167 | 97 | 74 | 57% | 1,357 | 171 |

*Source:* DENI.

(a) The total number of each type of institution takes account of all establishments where students were entered for any VCE/GCE subjects.

(b) Excludes 'Other' institutions and students registered with more than one institution.

(c) As reported in Chapter 5, four other institutions in Northern Ireland could not be identified. Between them, these institutions accounted for just 17 GCE A-level core sciences entrants over 2005, 2007 and 2009, and these have had to be excluded owing to the rules governing data suppression. However, this exclusion only affects the grand total for one these years, and is not of great statistical significance.

*Table 3.11. Comparison of physics Higher and Advanced Higher entries among leavers by institution type and number*[a] *(Scotland, 2005, 2007, 2009).*

| Institution type (Higher, Advanced Higher physics), Scotland | School leavers having taken Higher and Advanced Higher physics, by institution type | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004/5 leaver cohort | | | | | 2006/7 leaver cohort | | | | | 2008/9 leaver cohort | | | | |
| | Institutions with Higher/Adv. Higher physics entries | Institutions with no Higher/Adv. Higher physics entries | % institutions with entries | Students taking Higher/Adv. Higher physics (*n*) | All institutions | Institutions with Higher/Adv. Higher physics entries | Institutions with no Higher/Adv. Higher physics entries | % institutions with entries | Students taking Higher/Adv. Higher physics (*n*) | All institutions | Institutions with Higher/Adv. Higher physics entries | Institutions with no Higher/Adv. Higher physics entries | % institutions with entries | Students taking Higher/Adv. Higher physics (*n*) | All institutions |
| Publicly funded | 360 | 8 | 98% | 6,174 | 368 | 360 | 11 | 97% | 6,053 | 371 | 349 | 14 | 96% | 6,473 | 363 |
| Independent | 32 | 6 | 84% | 752 | 38 | 32 | 5 | 86% | 719 | 37 | 32 | 8 | 80% | 763 | 40 |
| FE sector | 17 | 21 | 45% | 152 | 38 | 18 | 24 | 43% | 101 | 42 | 18 | 23 | 44% | 114 | 41 |
| Total[b] | 409 | 35 | 92% | 7,078 | 444 | 410 | 40 | 91% | 6,873 | 450 | 399 | 45 | 90% | 7,350 | 444 |

*Source:* Scottish Government.

(a) This is the number of each type of institution, not the number that produced physics Higher/Advanced Higher entrants.

(b) Excludes 'Other' institutions and students registered with more than one institution.

(Royal Society 2007), the recent Report of the STEM Review must be correct in its suggestion that, in theory, the non-selective secondary schools contain a significant untapped market (DENI/DELNI 2009). The question, though, is whether there are sufficient physics specialists in the workforce to make the most of this talent.

### *Scotland*

Table 3.11 shows the distribution of physics entries among students across the range of educational institutions in Scotland during 2005, 2007 and 2009. In contrast, figure 3.9 details the proportionate distribution of physics entries by institution type, which provides a very good indication of teaching provision in educational institutions across Scotland.

It is notable from figure 3.9 that fewer proportions of all types of institutions have produced physics Highers/ Advanced Highers candidates. Overall, between 2005 and 2009, the number of institutions not entering physics candidates increased from 35 to 45.[27]

Nonetheless, the number of physics entries at Higher and Advanced Higher increased overall across all institution types, except FE centres, with the bulk of this increase coming from the state-funded schools. This is strange given that the number of state-funded schools not producing any physics candidates increased from 8 to 14 during 2005–09. Similarly, despite 4% fewer independent schools sending physics candidates in 2009 than was the case in 2005, it is calculable from table 3.11 that overall entries among independent schools increased 1.5% during this period.

## 3.7.2 Mathematics[28]

This section looks at the provision of mathematics in UK schools and colleges, and focuses in particular on the participation of students taking core sciences with mathematics and further mathematics, the latter being particularly important in England.

Across the UK, mathematics entries increased overall between 2005 and 2009. It is calculable from tables 3.12 and 3.13 that they increased 40% in England, 46% in Wales, 22% in Northern Ireland and 4% in Scotland during this period.[29] With the exception of the FE sector in Wales, Northern Ireland and Scotland, entries increased across all types of educational institution.

However, as figures 3.10–3.13 show (derived from tables 3.12 and 3.13), the proportion of institutions putting up mathematics A-level/Higher/Advanced Higher candidates fell across all the Home Nations, so that by 2009, 8%, 5% and 33% of institutions in England, Wales and Northern Ireland were failing to present any mathematics A-level candidates, as well as 7% of institutions in Scotland.

The following sections seek to understand better this contrasting picture, by considering the situation in each of the Home Nations.

### *England*

From the data in table 3.12*a*, it can be shown that in England, A-level mathematics entries rose 44%, 150%, 32%, 41% and 24% across maintained schools, academies/CTCs, independent schools, sixth form centres and colleges and the FE sector, respectively, between 2005 and 2009. These increases occurred despite falls in the number of maintained schools (–13), sixth form centres and colleges (–8) and FE sector colleges (–9) during this period, which the trebling of the academies/CTCs sector could not overcome as by 2009 this sector accounted for just 3% of all educational institutions in England.

But these increases have also occurred against an apparent fall in teaching provision across maintained and independent schools and academies/CTCs, and increased provision in the FE sector and sixth form centres and colleges (with both increases seeming to owe much to the reduction in size of these sectors). In fact, by 2009, a total of 217 institutions (or 8% of the total) were not putting up a single mathematics A-level candidate: 98 maintained schools, 47 independent schools, 56 FE sector colleges, 14 academies/CTCs and 2 sixth form centres and colleges.

The falls in both the maintained and independent sectors are worrying, particularly the latter given that (i) this sector actually increased in size between 2005 and 2009, and (ii) the fact that in the past it has been responsible for providing more than 70% of acceptances onto undergraduate mathematics and physics first degree courses at the UK's leading universities.

It seems very likely that this decline has resulted from a combination of retirements (given that according to the NFER, some 30% of mathematics teachers in England were aged over 50 in 2005 (Moor *et al.* 2006)),[30] and a decade of under-recruitment of mathematics teachers (see figure 3.14) and vacancy figures from the *Times Educational Supplement* and Eteach.com indicating the demand for mathematics specialists (Royal Society 2007).

The Advisory Committee on Mathematics Education has recently given considerable thought to the need for post-16

27 These are probably small schools in rural/island situations or inner city schools where small numbers of candidates may go to another school for teaching of particular subjects. Professor Jack Jackson (Visiting Professor, University of Strathclyde), personal communication, 30 November 2010.

28 It is important to note that in England, mathematics includes mathematics (98.8% of all entries in 2009), pure mathematics (0.1%), additional mathematics (0.1%) and statistics (1% of all entries in 2009). In Wales, mathematics accounted for 97% of entries in 2009, the rest being made up of pure mathematics and statistics entrants. In Northern Ireland, mathematics accounted for 99.7% of entries in 2009, the remaining 0.3% being comprised of statistics entrants. In Scotland, only one form of mathematics exists at Higher level.

29 Scottish data combine information on Highers and Advanced Highers.

30 Note: this study was based on the maintained sector.

*Table 3.12. Comparison of GCE A-level mathematics entries among 16–18 year old students and provision of mathematics across educational institutions in England, Wales and Northern Ireland (2005, 2007, 2009).*

(a) England

| | Student entries to GCE A-level mathematics, by institution type (for all institutions with any GCE A-level entry recorded) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004/5 KS5 cohort with GCE A-level mathematics entries | | | | | 2006/7 KS5 cohort with GCE A-level mathematics entries | | | | | 2008/9 KS5 cohort with GCE A-level mathematics entries | | | | |
| Institution type | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions |
| Maintained | 1,604 | 137 | 92% | 24,666 | 1,741 | 1,627 | 107 | 94% | 28,864 | 1,734 | 1,630 | 98 | 94% | 35,532 | 1,728 |
| Academy/CTC | 20 | 39 | 87% | 309 | 23 | 28 | 37 | 88% | 381 | 32 | 63 | 14 | 82% | 773 | 77 |
| Independent | 542 | | 94% | 10,731 | 579 | 542 | | 94% | 12,156 | 575 | 540 | 47 | 92% | 14,170 | 587 |
| Sixth Form Centres and Colleges | 104 | 10 | 91% | 8,053 | 114 | 102 | 10 | 91% | 9,210 | 112 | 104 | | 98% | 11,352 | 106 |
| FE sector | 192 | 70 | 73% | 4,118 | 262 | 177 | 58 | 75% | 4,268 | 235 | 197 | 56 | 78% | 5,089 | 253 |
| Total[(a)] | 2,462 | 257 | 91% | 47,877 | 2,719 | 2,476 | 212 | 92% | 54,879 | 2,688 | 2,534 | 217 | 92% | 66,916 | 2,751 |

*Source:* DCSF.

(a) Excludes ‘Other’ institutions and students registered with more than one institution.

*Table 3.12. (Continued)*

(b) Wales

| Institution type | Student entries to GCE A-level mathematics, by institution type (for all institutions with any GCE A-level entry recorded) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004/5 KS5 cohort with GCE A-level mathematics entries | | | | | 2006/7 KS5 cohort with GCE A-level mathematics entries | | | | | 2008/9 KS5 cohort with GCE A-level mathematics entries | | | | |
| | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions |
| Maintained | 168 | X[(b)] | 99% | 1,832 | 170 | 166 | | 99% | 1,945 | 168 | 166 | 6 | 98% | 2,266 | 169 |
| Independent | 18 | X[(b)] | 100% | 249 | 18 | 17 | 6 | 100% | 264 | 17 | 16 | | 84% | 253 | 19 |
| FE sector | — | — | — | — | — | 16 | | 80% | 563 | 20 | 15 | 5 | 75% | 528 | 20 |
| Total[(a)] | 186 | X[(b)] | 99% | 2,079 | 188 | 199 | 6 | 97% | 2,772 | 205 | 197 | 11 | 95% | 3,045 | 208 |

*Source:* Welsh Assembly

(a) excludes any student registered with more than one institution.

(b) Data suppressed.

(c) Northern Ireland

| Institution type | Student entries to GCE A-level Mathematics, by institution type (for all institutions with any GCE A-level entry recorded) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004/5 KS5 cohort with GCE A-level mathematics entries | | | | | 2006/7 KS5 cohort with GCE A-level mathematics entries | | | | | 2008/9 KS5 cohort with GCE A-level mathematics entries | | | | |
| | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions |
| Grammar | 70 | 0 | 100% | 2,036 | 70 | 69 | 0 | 100% | 2,246 | 69 | 69 | 0 | 100% | 2,450 | 69 |
| Secondary | 36 | 38 | 49% | 209 | 74 | 43 | 45 | 49% | 303 | 88 | 43 | 50 | 46% | 313 | 93 |
| FE sector | 6 | 7 | 46% | 47 | 13 | 4 | 6 | 40% | 44 | 10 | 3 | 6 | 33% | 36 | 9 |
| Total[(a)] | 112 | 45 | 71% | 2,292 | 157 | 116 | 51 | 69% | 2,593 | 167 | 115 | 56 | 67% | 2,799 | 171 |

*Source:* DENI.

(a) Excludes 'Other' institutions and students registered with more than one institution.

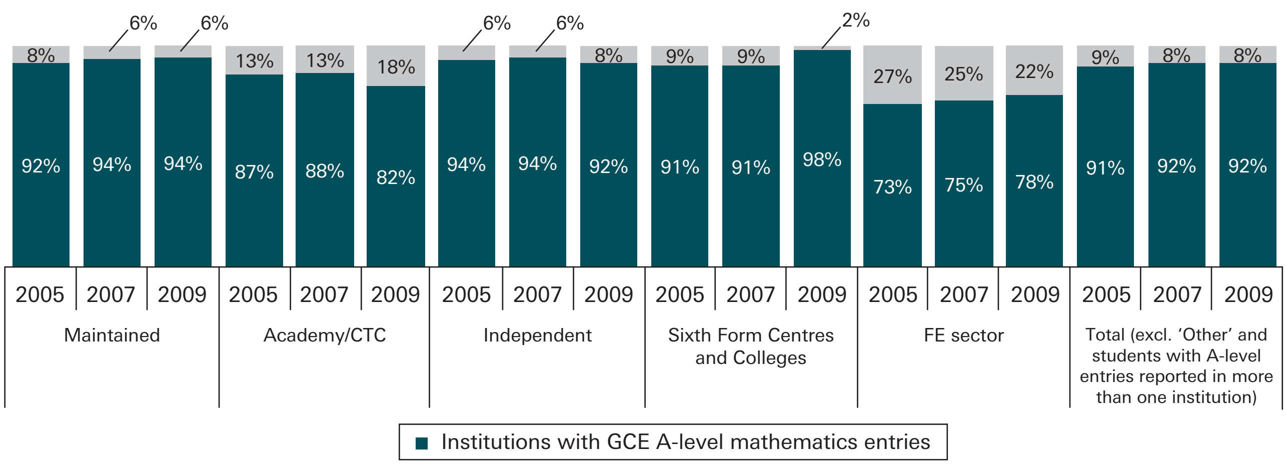
*Table 3.13. Comparison of Higher and Advanced Higher level mathematics entries among leavers in Scotland, and provision of mathematics across educational institutions therein (2005, 2007, 2009).*

| Institution type (Higher, Advanced Higher mathematics), Scotland | School leavers having taken Higher and Advanced Higher Mathematics, by institution type | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004/5 leaver cohort | | | | | 2004/5 leaver cohort | | | | | 2004/5 leaver cohort | | | | |
| | Institutions with Higher/ Adv. Higher mathematics entries | Institutions with no Higher/Adv. Higher mathematics entries | % institutions with entries | Students taking Higher/Adv. Higher mathematics (*n*) | All institutions | Institutions with Higher/ Adv. Higher mathematics entries | Institutions with no Higher/Adv. Higher mathematics entries | % institutions with entries | Students Taking Higher/Adv. Higher mathematics (*n*) | All institutions | Institutions with Higher/ Adv. Higher mathematics entries | Institutions with no Higher/Adv. Higher mathematics entries | % institutions with entries | Students taking Higher/Adv. Higher mathematics (*n*) | All institutions |
| Publicly funded | 365 | 6 | 99% | 13,024 | 368 | 367 | 6 | 99% | 12,486 | 371 | 356 | 7 | 98% | 13,547 | 363 |
| Independent | 35 | | 92% | 1,410 | 38 | 35 | | 95% | 1,406 | 37 | 33 | 7 | 83% | 1,469 | 40 |
| FE sector | 26 | 13 | 67% | 306 | 39 | 26 | 16 | 62% | 249 | 42 | 26 | 15 | 63% | 254 | 41 |
| Total[(a)] | 426 | 19 | 96% | 14,740 | 445 | 428 | 22 | 95% | 14,141 | 450 | 415 | 29 | 93% | 15,270 | 444 |

*Source:* Scottish Government.

(a) Excludes 'Other' institutions and students registered with more than one institution.

*Figure 3.10. Distribution by institution type of GCE A-level mathematics entries among 16–18 year old students (England, 2005, 2007, 2009).*[(a)]




*Source:* DCSF.

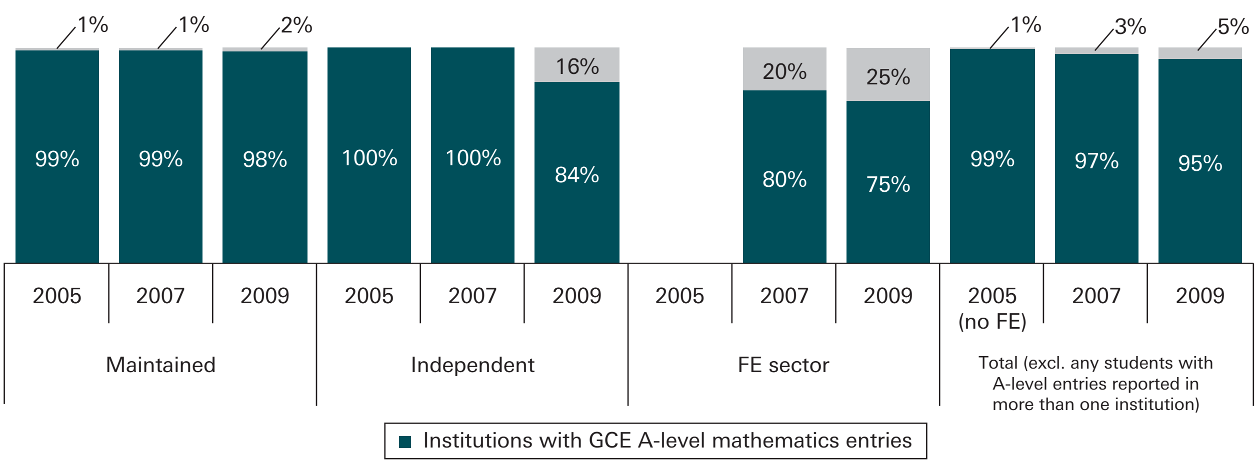
(a) Graph provides information about institutions where students entered for GCE A-level courses (year for KS5 cohort of 16–18 year olds; may include exams taken previously within the same institution).

mathematics provision, and has proposed that given (i) current gaps in this (eg between A-levels and some Diplomas); (ii) the fact that the school leaving age is due to rise to 18; (iii) the relevance of mathematics to many areas of study and its value as a subject of study itself and in research; and (iv) the importance of mathematics to employers, mathematical pathways are required for all students post-16 (ACME 2010). This idea was recently suggested by the CBI, but the recent decline in mathematics provision evidenced in this report indicates that establishing all the necessary pathways will be very difficult. While CPD may be a means to improve the quality and extensiveness of provision among existing teachers, attracting and retaining sufficient numbers of new teachers with the qualifications and the confidence to teach mathematics at A-level represents an immense long-term challenge.

### *Wales*

With reference to table 3.12*b* and figure 3.11 it is possible to see that entries increased overall between 2005 and 2009, but that there has been a recent decrease in institutions producing mathematics A-level candidates,

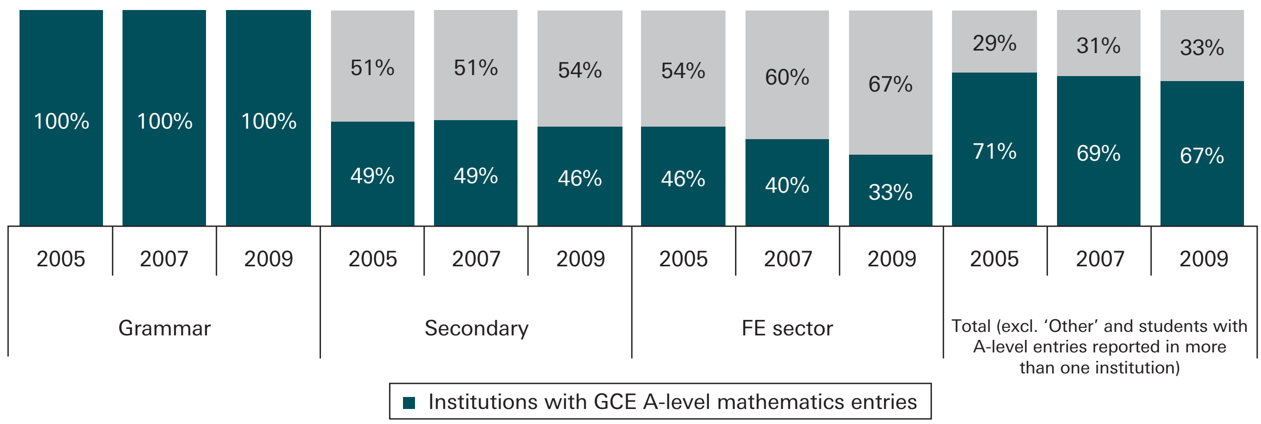
*Figure 3.11. Distribution by institution type of GCE A-level mathematics entries among 16–18 year old students (Wales, 2005, 2007, 2009).*[(a)]




*Source:* Welsh Assembly Government.

(a) Graph provides information about institutions where students entered for GCE A-level courses (year for KS5 cohort of 16–18 year olds; may include exams taken previously within the same institution).

*Figure 3.12. Distribution by institution type of GCE A-level mathematics entries among 16–18 year old students (Northern Ireland, 2005, 2007, 2009).*[a]




*Source:* DENI.

(a) Graph provides information about institutions where students entered for GCE A-level courses (year for KS5 cohort of 16–18 year olds; may include exams taken previously within the same institution).

with 5% (or a total of 11 institutions) not presenting any such candidates in 2009.

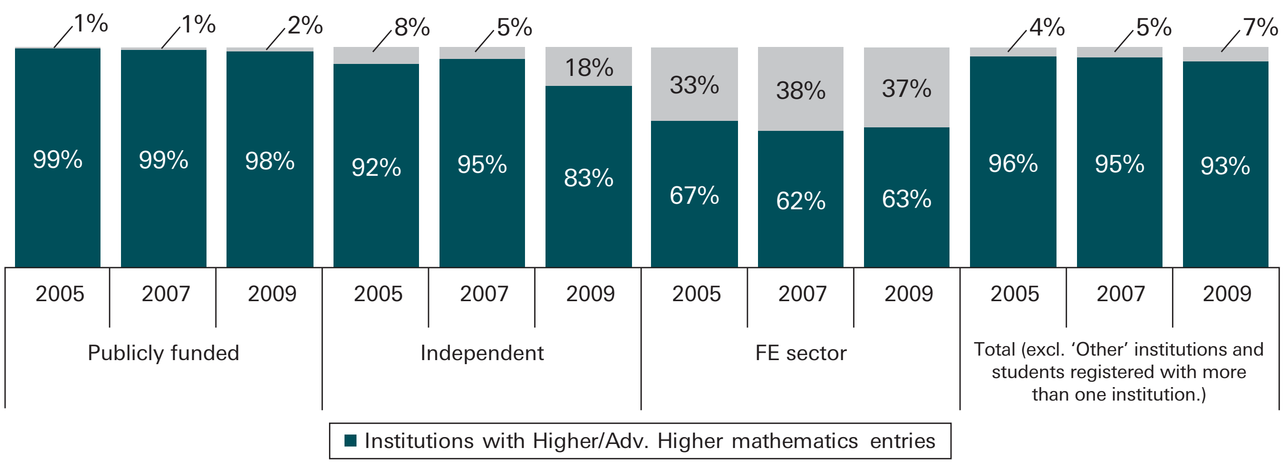
Given the heavy dependence on the maintained sector for providing GCE A-level mathematics candidates, it is concerning to note a small increase in the proportion of maintained schools recorded as entering such candidates. Similarly, there has been a sharp and sudden drop in the independent sector, indicating that only 16 out of 19 independent schools produced mathematics entrants in 2009.

The emergence of this development is worrying and, just as in England, may very well have been caused by a combination of retirements and shortages of mathematics specialist teachers in Wales.

### *Northern Ireland*

As in physics, grammar schools maintained a 100% provision of mathematics A-level in each of the years investigated, and entries increased 20% overall during 2005–09 despite the closure (or merger) of one institution (figure 3.12). Mathematics A-level entries grew 50% in other secondary schools in the same period, in line with a 25% plus growth in the number of institutions within this sector. Only in the FE sector was there a fall in entries, which fell by some 23% (table 3.12*c*).

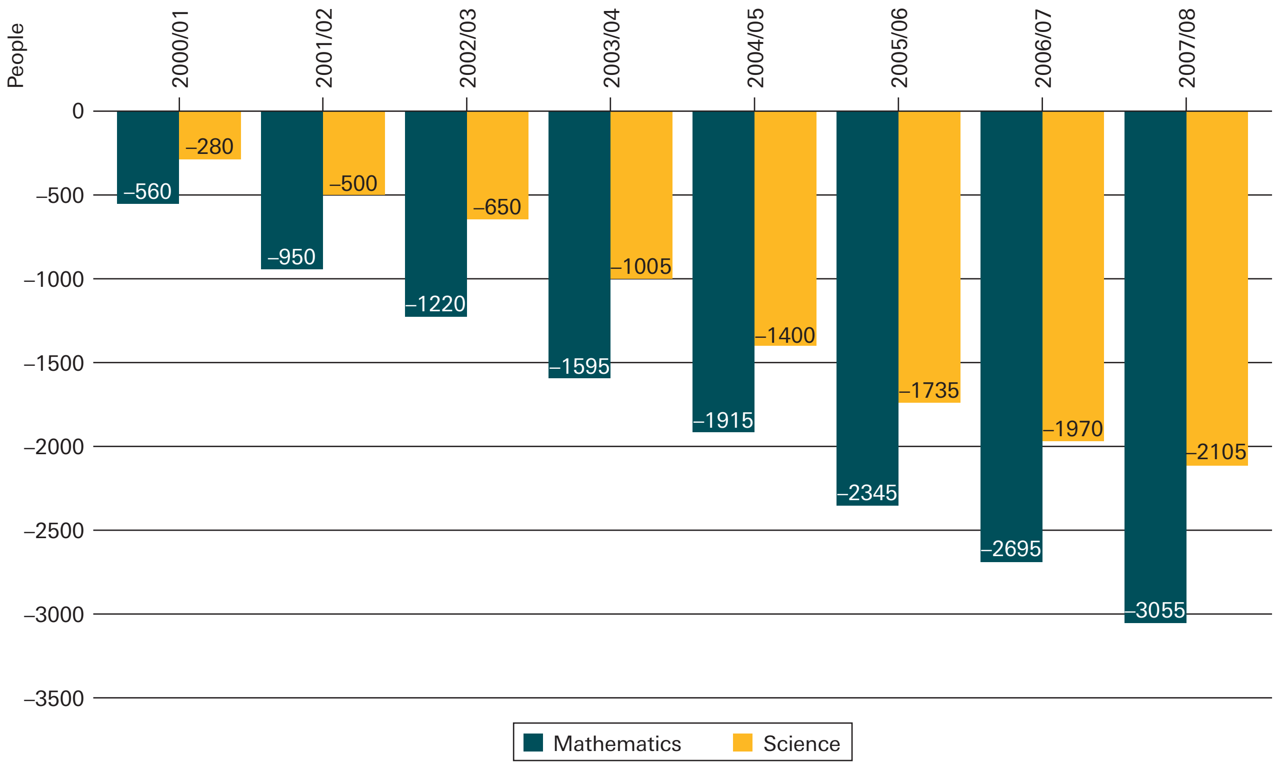
*Figure 3.13. Distribution by institution type of Higher and Advanced Higher mathematics entries among leavers (Scotland, 2005, 2007, 2009).*[a]




*Source:* Scottish Government.

(a) Graph provides information about institutions where leavers entered for Higher and Advanced Higher courses.

*Figure 3.14. Cumulative shortfall in meeting science and mathematics teacher recruitment targets (2000/01–2007/08).*




*Source:* Royal Society (2010*a*).

Although one-third of institutions in Northern Ireland still did not present any mathematics A-level candidates in 2009, the recent growth among other secondary schools is especially encouraging.

## Scotland

Table 3.13 provides details of the numbers and distribution by institution type of students taking mathematics Highers or Advanced Highers, and compares these figures with the total number of students who took these qualifications in 2005, 2007 and 2009.

It shows that the 4% overall increase in entrants during these years was led by increases across both the state-funded and independent sectors. Only in the FE sector was there a decrease, which appears disproportionally large due to the small number of candidates recorded.

Notably, the number of institutions in both the independent and FE sectors increased, but there was a larger overall decrease in the number of state-funded schools during this time. Confusingly, as figure 3.13 shows, the proportion of all types of institutions entering mathematics Higher/Advanced Higher candidates actually fell. Indeed, the proportion of independent schools sending mathematics candidates decreased 10% between 2005 and 2009, equivalent to two fewer independent schools offering mathematics candidates.

These observations, which are similar to those for physics in Scotland, do not appear to have an obvious explanation. Scotland does not suffer from the same lack of specialist mathematics and physics teachers that haunts England and Wales, even in rural areas.[31] The smaller numbers of institutions sending Higher and Advanced Higher candidates in these subjects is hard to account for, although it is notable that three independent schools in Scotland are now offering the International Baccalaureate.[32]

### *3.7.2.1 Further mathematics*

## *England*

With the exception of the academies/CTCs, there has been strong growth reported in further mathematics entries from across all types of educational institutions, with entries increasing overall by 81% during 2005–09 in England. There was a 22% increase in the proportion of maintained schools reporting candidature in further mathematics and in 2009, for the first time, more than half of such schools filed further mathematics applicants (table 3.14; figure 3.15). Between 2005 and 2009, further mathematics

31 Professor Jack Jackson (Department of Curricular Studies, University of Strathclyde), personal communication, 22 May 2008.

32 See http://www.scis.org.uk/assets/files/Qualifications_offered_at_each_mainstream_school_October_2010.pdf, accessed 1 November 2010.

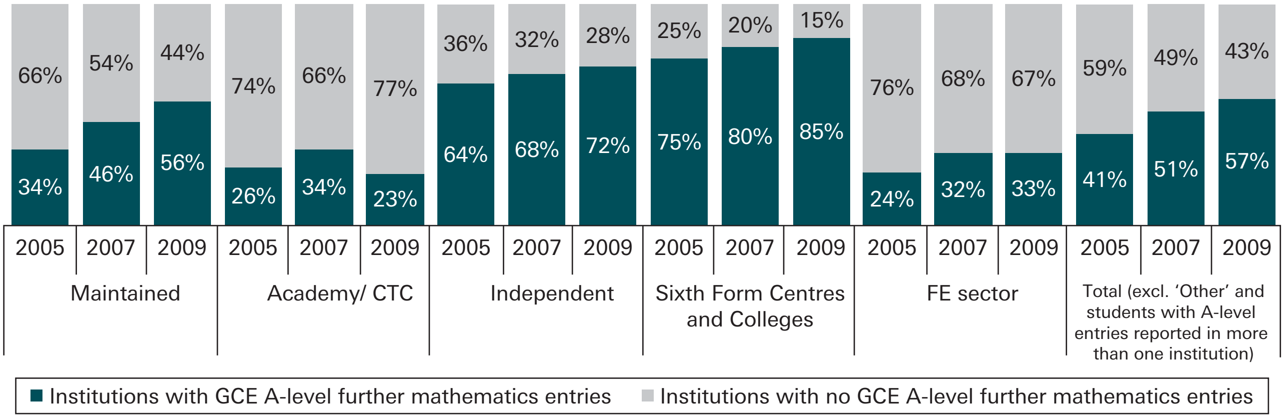
*Table 3.14. Comparison GCE A-level further mathematics entries among 16–18 year old students in England and provision of further mathematics across educational institutions therein (2005, 2007, 2009).*

| | Student entries to GCE A-level further mathematics, by institution type (for all institutions with any GCE A-level entry recorded) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004/5 KS5 cohort with GCE A-level entries | | | | | 2006/7 KS5 cohort with GCE A-level entries | | | | | 2008/9 KS5 cohort with GCE A-level entries | | | | |
| Institution type | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions | Institutions with entries | Institutions with no entries | % institutions with entries | Students entered (*n*) | All institutions |
| Maintained | 600 | 1,141 | 34% | 2,177 | 1,741 | 806 | 928 | 46% | 3,289 | 1,734 | 969 | 759 | 56% | 4,537 | 1,728 |
| Academy/CTC | 6 | 17 | 26% | 17 | 23 | 11 | 21 | 34% | 47 | 32 | 18 | 59 | 23% | 62 | 77 |
| Independent | 370 | 209 | 64% | 1,995 | 579 | 391 | 184 | 68% | 2,472 | 575 | 420 | 167 | 72% | 3,058 | 587 |
| Sixth Form Centres and Colleges | 86 | 28 | 75% | 823 | 114 | 90 | 22 | 80% | 1,087 | 112 | 90 | 16 | 85% | 1,444 | 106 |
| FE sector | 63 | 199 | 24% | 322 | 262 | 76 | 159 | 32% | 462 | 235 | 83 | 170 | 33% | 554 | 253 |
| Total[(a)] | 1,125 | 1,594 | 41% | 5,334 | 2,719 | 1,374 | 1,314 | 51% | 7,357 | 1,580 | 1,580 | 1,171 | 57% | 9,655 | 2,751 |

*Source:* DCSF.

(a) Excludes ‘Other’ institutions and students registered with more than one institution.

*Figure 3.15. Distribution by institution type of GCE A-level further mathematics entries among 16–18 year old students (England, 2005, 2007, 2009).*[(a)]




*Source:* DCSF.

(a) Graph provides information about institutions where students entered for GCE A-level courses (year for KS5 cohort of 16–18 year olds; may include exams taken previously within the same institution).

entrants from independent schools, sixth form colleges and centres and FE sector colleges increased 8%, 10% and 9%, respectively. Overall, across the whole nation, 57% of all educational institutions offered further mathematics candidates in 2009, with as many as 56%, 72% and 85% of maintained schools, independent schools and sixth form centres and colleges.

The apparent decrease in the number of academies/CTCs offering further mathematics is in line with the fall in the provision of mathematics A-level in these institutions, suggesting that, most probably through a shortage of mathematics specialist teachers, it has not been possible for provision of these subjects to keep pace with the expansion of this sector.

However, the overall growth in further mathematics entries is impressive, and this undoubtedly owes much to the efforts of the Further Mathematics Support Programme which, working closely with the National Centre for Excellence in the Teaching of Mathematics, has had something of a transformational impact (Searle 2009).

*Wales and Northern Ireland*

Entry to further mathematics A-level grew substantially in Wales, almost 100% during 2007–09, albeit from a very low base (table 3.15).

As we evidenced in 2008 (Royal Society 2008*b*, p. 100), even fewer people take further mathematics in Northern Ireland, with numbers totalling 120, 140 and 153 in 2005, 2007 and 2009, respectively.

### 3.7.3 Mathematics in combination with the core sciences

*England*

This section investigates the changes in the numbers of students taking combinations of mathematics and/or further mathematics and science.

Table 3.16 provides details of the numbers and distribution of 16–18 year old students taking combinations of core sciences with mathematics and/or

*Table 3.15. Comparison GCE A-level further mathematics entries among 16–18 year old students in Wales and provision of further mathematics across educational institutions therein (2005, 2007, 2009).*

| Year | FE sector[(a)] | Independent | Maintained | All institutions |
|---|---|---|---|---|
| 2005 | – | 33 | 108 | 141 |
| 2007 | 22 | 46 | 89 | 157 |
| 2009 | 132 | 46 | 135 | 313 |

*Source:* Welsh Assembly Government.

(a) No data are available for the FE sector for 2005.

*Table 3.16. Numbers of 16–18 year olds taking core sciences combinations with GCE A-level mathematics and further mathematics across all institution types (England, 2005, 2007, 2009).*

| | Core science(s) | 2005 | 2007 | 2009 |
|---|---|---|---|---|
| Mathematics with... | B | 3,056 | 3,507 | 4,683 |
| | BC | 7,027 | 8,512 | 10,342 |
| | BCP | 1,270 | 1,377 | 1,554 |
| | BP | 946 | 963 | 1,172 |
| | C | 2,478 | 2,771 | 3,474 |
| | CP | 3,568 | 3,598 | 3,886 |
| | P | 8,176 | 7,912 | 8,542 |
| Grand total | | 26,521 | 28,640 | 33,653 |
| Further mathematics with... | B | 89 | 138 | 226 |
| | BC | 300 | 452 | 605 |
| | BCP | 108 | 185 | 247 |
| | BP | 49 | 101 | 108 |
| | C | 367 | 476 | 680 |
| | CP | 1,248 | 1,539 | 1,914 |
| | P | 1,975 | 2,601 | 3,476 |
| Grand total | | 4,136 | 5,492 | 7,256 |
| Total taking mathematics and/or further mathematics with core sciences | | 30,657 | 34,132 | 40,909 |
| Total taking mathematics and further mathematics with or without core sciences | | 48,133 | 55,044 | 67,585 |
| Total taking core sciences without mathematics | | 42,023 | 39,675 | 37,671 |
| Percentage of students taking core sciences with mathematics/further mathematics | | 8.6% | 10.0% | 10.7% |

*Source:* DCSF.

further mathematics and compares these figures with the total number of GCE A-level students who took mathematics and/or further mathematics in 2005, 2007 and 2009.

The substantial increases in numbers of students taking mathematics with core sciences contributed 33% of the overall 35% and 40% increases in numbers recorded as taking, respectively, mathematics and mathematics and further mathematics. Evidently, the maintained and independent sectors and sixth form colleges have provided the bulk of the increases seen.

The Department's data showed that the numbers of 16–18 year old students taking core sciences with mathematics and further mathematics across all institutions in 2005, 2007 and 2009 rose 75%, from 4,136 to 7,256. A more detailed breakdown is also provided in table 3.16, confirming previous indications that core sciences combinations including physics are mainly favoured by those students who take mathematics and further mathematics.

These increases are consonant with the 40% increase in students taking GCE A-level mathematics and further mathematics reported in table 3.15, and they are mirrored in the depiction of further mathematics provision (figure 3.15).

Finally, it is encouraging to report that students taking core sciences with mathematics and/or further mathematics grew to account for 11% of all mathematics and further mathematics A-level candidates in each year investigated. Equally, the proportion of students taking core sciences without mathematics has fallen 10%.

### *Wales*

Table 3.17 provides details of the numbers and distribution of 16–18 year old students taking combinations of core sciences with mathematics and/or further mathematics and

*Table 3.17. Numbers of 16–18 year olds taking core sciences combinations with GCE A-level mathematics and further mathematics across all institution types (Wales, 2005, 2007, 2009).*

<table>
<tr><th></th><th>Core science(s)</th><th>2005[a]</th><th>2007</th><th>2009</th></tr>
<tr><td rowspan="7">Mathematics with...</td><td>B</td><td>166</td><td>196</td><td>176</td></tr>
<tr><td>BC</td><td>334</td><td>444</td><td>482</td></tr>
<tr><td>BCP</td><td>65</td><td>90</td><td>94</td></tr>
<tr><td>BP</td><td>58</td><td>54</td><td>56</td></tr>
<tr><td>C</td><td>124</td><td>166</td><td>175</td></tr>
<tr><td>CP</td><td>227</td><td>213</td><td>241</td></tr>
<tr><td>P</td><td>351</td><td>473</td><td>436</td></tr>
<tr><td colspan="2">Grand total</td><td>1,325</td><td>1,636</td><td>1,660</td></tr>
<tr><td rowspan="7">Further mathematics with. . .</td><td>B</td><td>0</td><td rowspan="2">13</td><td>13</td></tr>
<tr><td>BC</td><td rowspan="3">8</td><td>17</td></tr>
<tr><td>BCP</td><td rowspan="2">5</td><td>12</td></tr>
<tr><td>BP</td><td>5</td></tr>
<tr><td>C</td><td>18</td><td>10</td><td>33</td></tr>
<tr><td>CP</td><td>33</td><td>33</td><td>61</td></tr>
<tr><td>P</td><td>53</td><td>56</td><td>110</td></tr>
<tr><td colspan="2">Grand total</td><td>112</td><td>117</td><td>251</td></tr>
<tr><td colspan="2">Total taking mathematics and/or further mathematics with core sciences</td><td>1,437</td><td>1,753</td><td>1,911</td></tr>
<tr><td colspan="2">Total taking mathematics and further mathematics with or without core sciences</td><td>2,081</td><td>2,772</td><td>2,875</td></tr>
<tr><td colspan="2">Total taking core sciences without mathematics</td><td>2,063</td><td>2,267</td><td>2,097</td></tr>
<tr><td colspan="2">Percentage of students taking core sciences with mathematics/further mathematics</td><td>69.1%</td><td>63.2%</td><td>66.5%</td></tr>
</table>

*Source:* Welsh Assembly Government.

(a) Data for 2005 are incomplete owing to the fact that no information is available for the FE sector for this year.

compares these figures with the total number of GCE A-level students who took mathematics and/or further mathematics in 2005, 2007 and 2009. While the dearth of data from the FE sector for 2005 is constraining, there is a clear overall growth in mathematics and further mathematics entry among those students who are also taking core sciences combinations. As in England, most of these core sciences and mathematics combinations involved physics (table 3.17). However, all the growth has come from the maintained sector, there being decreases reported across both the independent and FE sectors (data not shown).

Students taking science with mathematics and/or further mathematics accounted for over half of all mathematics and/or further mathematics A-level candidates in 2007 and 2009, the years investigated for which complete data exist. In addition, the total number of students not taking mathematics in combination with core sciences fell 7.5%.

### *Northern Ireland*

Table 3.18 provides details of the numbers and distribution of 16–18 year old students taking combinations of core sciences with mathematics and/or further mathematics and compares these figures with the total number of GCE A-level students who took mathematics and/or further mathematics in 2005, 2007 and 2009. There was a clear overall growth in mathematics and further mathematics entry. While the

*Table 3.18. Numbers of 16–18 year olds taking core sciences combinations with GCE A-level mathematics and further mathematics across all institution types (Northern Ireland, 2005, 2007, 2009).*[(a)]

| | Core science(s) | 2005 | 2007 | 2009 |
|---|---|---|---|---|
| Mathematics with... | B | 206 | 262 | 309 |
| | BC | 388 | 457 | 477 |
| | BCP | 120 | 152 | 173 |
| | BP | 116 | 98 | 112 |
| | C | 116 | 98 | 110 |
| | CP | 162 | 164 | 160 |
| | P | 447 | 451 | 504 |
| Grand total | | 1,555 | 1,682 | 1,845 |
| Further mathematics with... | B | 5 | 14 | 20 |
| | BC | 8 | | |
| | BCP | 5 | 9 | 7 |
| | BP | 1 | 6 | 5 |
| | C | 6 | 11 | 5 |
| | CP | 35 | 30 | 51 |
| | P | 46 | 56 | 48 |
| Grand total | | 106 | 126 | 136 |
| Total taking mathematics and/or further mathematics with core sciences | | 1,661 | 1,808 | 1,981 |
| Total taking mathematics and further mathematics with or without core sciences | | 2,292 | 2,593 | 2,799 |
| Total taking core sciences without mathematics | | 2,710 | 2,545 | 2,431 |
| Percentage of students taking core sciences with mathematics/further mathematics | | 72.5% | 69.7% | 70.1% |

*Source:* DENI.

(a) This table does include data from other institutions.

great majority of entries came from grammar schools, the largest proportional increase in candidature came from non-selective secondary schools. As in the other nations, most of those taking core sciences and mathematics combinations took physics, but there was a steady increase, too, in those taking biological sciences combinations with mathematics (table 3.18).

Students taking science with mathematics and further mathematics accounted for over two-thirds of all mathematics and further mathematics A-level candidates in each year investigated, the highest of any of the three nations for which A-levels are the main route into STEM higher education.

*Scotland*

Table 3.19 provides details of the numbers of students taking combinations of core sciences with Higher mathematics and Advanced Higher mathematics and compares these figures with the total number of students who took core sciences and/or mathematics in 2005, 2007 and 2009.

There was a clear overall growth in Higher and Advanced Higher mathematics entry. Just as across the rest of the UK, most of those taking core sciences and mathematics combinations took physics, but a much more even balance of core sciences with mathematics combinations is discernible (table 3.19).

*Table 3.19. Numbers of students taking core sciences combinations with Higher and Advanced Higher mathematics across all institution types (Scotland, 2005, 2007, 2009).*

| | Core science(s) | 2005 | 2007 | 2009 |
|---|---|---|---|---|
| Higher mathematics with... | B[a] | 2,089 | 2,035 | 2,377 |
| | BC | 4,147 | 4,249 | 4,564 |
| | BCP | 1,619 | 1,761 | 1,935 |
| | BP | 395 | 444 | 539 |
| | C | 1,004 | 917 | 945 |
| | CP | 1,950 | 1,740 | 1,956 |
| | P | 2,797 | 2,436 | 2,663 |
| Grand total | | 14,001 | 13,582 | 14,979 |
| Total taking Higher mathematics with/without core sciences | | 15,975 | 15,106 | 16,887 |
| Advanced Higher mathematics with... | B | 77 | 114 | 168 |
| | BC | 108 | 189 | 253 |
| | BCP | 11 | 18 | 20 |
| | BP | 7 | 12 | 29 |
| | C | 278 | 292 | 333 |
| | CP | 198 | 225 | 284 |
| | P | 497 | 513 | 632 |
| Grand total | | 1,176 | 1,363 | 1,719 |
| Total taking Advanced Higher mathematics[b] with/without core sciences | | 2,433 | 2,647 | 3,258 |
| Total taking Higher and/or Advanced Higher mathematics with core sciences | | 15,177 | 14,945 | 16,698 |
| Total taking Higher and/or Advanced Higher mathematics with or without core sciences | | 18,408 | 17,753 | 20,145 |
| Percentage of students taking core sciences with Higher mathematics | | 87.6% | 89.9% | 88.7% |

*Source:* Scottish Government.

(a) This table combines data for Higher biology and human biology. Human biology is not available at Advanced Higher.

(b) This total includes students taking applied mathematics options (295, 273 and 301 in 2005, 2007 and 2009, respectively).

Almost 90% of students taking Higher mathematics also take core sciences, which probably reflects the understanding that to gain a place on a STEM higher education course requires individuals to take at least two science and mathematics Highers. To the extent that these figures are comparable with the situation elsewhere in the UK, it is evident that a greater proportion of the Highers cohort in Scotland is taking combinations appropriate for gaining entry to STEM higher education than is the case with the A-level cohorts elsewhere in the UK.

# 4 Conclusions and recommendations

## 4.1 Initial reflections

The series of Royal Society 'state of the nation' reports, of which this is the final one, has covered the key aspects of 5–19 science and mathematics education in the UK. These reports have looked in depth at aspects of primary, secondary and tertiary science and mathematics education, including participation, attainment, progression and the teaching workforce. They have provided new insight and understanding regarding the strengths, weaknesses and challenges facing each of the Home Nations and the UK as a whole.

In this report, we have begun to address concerns over the quantity, in particular, of students that are prospectively equipped with qualifications to undertake STEM first degrees. By analysing the subject combinations students have taken, we have probed the enormous quantity of information that lies buried within the annual releases of subject entry data. This exercise has not been at all straightforward, and has meant facing similar issues to those encountered in compiling the previous 'state of the nation' reports. In particular, the range, quality and complexity of the data being investigated have created technical issues in obtaining comparable and balanced data across the nations. Nonetheless, although we have just scratched the surface, the richness of the data we have uncovered is impressive, and there are many aspects that merit both further exploration and explanation.

## 4.2 Outcomes of this study

It is clear from the evidence presented in this report that, as a whole, our education systems are failing to maximise the numbers of students who could go on to become STEM undergraduates. It is worrying that in this most exciting and challenging of scientific centuries, only around 10% of all 17 year olds in England and Wales, and some 17% of 17 year olds in Northern Ireland, are taking science and mathematics examinations post-16 (tables E5, W.5, NI.5), and that less than a third of the A-level cohorts in England and Wales takes core sciences combinations (with/without mathematics) (table 3.1; figure 4.1). By contrast, in Scotland some 50% of the Highers cohort takes core sciences combinations with/without mathematics (table 3.1; figure 4.1).

The Royal Society has identified the role science plays in stimulating the UK's economic growth and more specifically the expansion of (and innovation within) the service sector, which now accounts for 80% of UK employment (Royal Society 2009, 2010*a*). Increasingly urgent voices from business leaders are to be heard appealing for more employees with better STEM skills (CBI 2008, 2009, 2010). With insufficient numbers of STEM graduates for the needs of both higher education and employment, a seemingly self-perpetuating cycle has been established, with too few scientists and mathematicians being produced to help inspire and educate the next generations.

From the evidence presented in this report, and drawing on the other reports in the 'state of the nation' series, it is evident that breaking this cycle requires three key issues to be addressed (see figure 4.1):

1. The **size** of the 'pool' in terms of the numbers and proportion of 16–19 year olds studying mainstream science and mathematics qualifications needs to increase in England, Wales and Northern Ireland towards the level of participation seen in Scotland. This will require more specialist science and mathematics teachers to be recruited and retained throughout all phases of 5–19 science and mathematics education within the UK.
2. To help improve the **quality** of the 'pool' of these 16–19 year olds will require professional development for the specialists who teach them and a better understanding of how schooling structures and curricula impact on their learning within science and mathematics.
3. The careers information, advice and guidance available to this 'pool' of 16–19 year olds must enable them to make subject choices that will allow smooth **progression** to STEM higher education courses, wherever they are located in the UK.

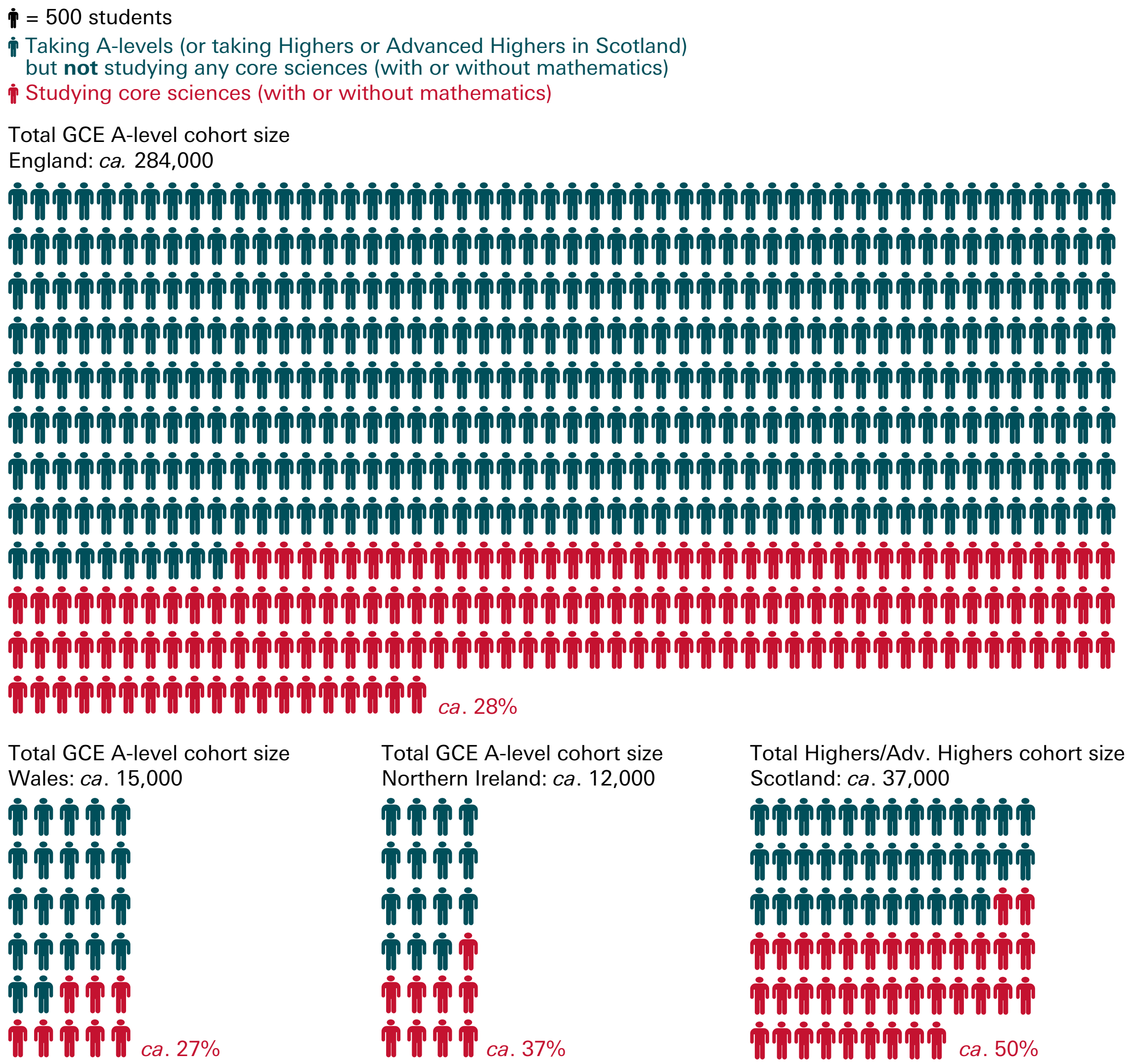
The levels of participation in science and mathematics observed here indicate an underlying cultural indifference towards them across the population as a whole, which needs to be grappled with if attitudes towards these subjects are to become measurably more positive, and if the tremendous investments in initiatives to stimulate young people's interest in these subjects are to have really meaningful returns.

As the following sections show, these are all complex—and largely intertwined—issues. Tackling them successfully will require an open admission of the extent of the problem, and an unparalleled long-term commitment from a variety of interested parties, most notably Government, employers, professional bodies and the teaching profession.

## 4.3 The size of the pool of post-16 students studying mainstream sciences and mathematics

This section looks in more detail at the first issue highlighted above, in order to peel back some of the interrelated layers of this complex problem.

*Figure 4.1. The proportion of the student pool in England, Wales, Northern Ireland and Scotland taking core sciences A-levels or Scottish Highers based on 2008/09 data.*[a] *(cf. table 3.1)*




*Sources:* DCSF, Welsh Assembly Government, DENI, Scottish Government.

(a) Core sciences include biological sciences (biology and human biology), chemistry and physics.

### 4.3.1 Primary science and mathematics

Our third 'state of the nation' report on 5–14 science and mathematics education showed that young people's initial experiences of these subjects during primary and early secondary schooling most probably have an enormous impact on their future attitude towards them and their attainment and progression in them (Royal Society 2010*b*).

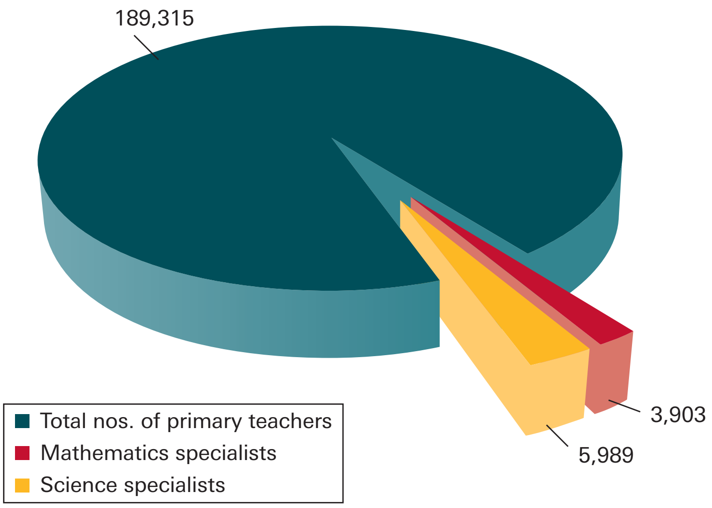
Unfortunately, many children do not enjoy a truly stimulating introduction to these subjects, and it seems highly likely that this is partly because far too few primary school teachers have the background specialist knowledge and skills, and therefore the confidence, required to teach them in ways that will focus and extend children's natural curiosity in the world around them.

These problems are also compounded by uninspiring curricula, and an assessment system that encourages teaching to the test. The result is that many become irrevocably disenchanted and disengaged, leading to fewer students wishing to pursue science beyond the compulsory years of schooling.

Given the most recent and reliable information available on the extent of science and mathematics subject specialism within England's 17,000 primary schools (figure 4.2), we estimate that the numbers of these specialists needs to triple simply to enable all children to be able to access specialists at this level (Royal Society 2010*c*).

Critically, the responsibility for driving up the quality of primary science and improved progression must be shared. The STEM Directories, created and supported by Government and leading organisations within the STEM community, detail the *ca*. 150 schemes across the UK that are geared to enriching or enhancing the primary

*Figure 4.2. Pie-chart showing separately the numbers of in-service primary teachers with specialist degree and initial teacher training qualifications in science and mathematics as a fraction of the total number of registered practising primary teachers in England.*[(a)]




*Source:* GTCE, Royal Society (2010*b,c*).

(a) Data on 'specialists' were obtained from the GTCE in April 2010. Information on the total number of in-service registered primary teachers (199,207) was obtained from the GTCE's most recent *Digest* of statistics for 2008/09.

curriculum. The impact of these initiatives needs to be monitored and geared towards tracking longer-term effects on student's attainment and progression in these subjects rather than evaluating these initiatives on the extent to which they have met their immediate and individual objectives. Moreover, the key learned and professional STEM bodies, and those within business and industry who have been appealing for more STEM graduates, must invest more of their resources into fostering high quality primary education and be prepared to do so long-term.

### 4.3.2 Inadequate numbers of secondary, sixth form and college teachers

Although it appears that there are enough science and mathematics subject specialist secondary teachers in Scotland and Northern Ireland, the shortages of such teachers in England and Wales limit the extent to which these subjects are taught post-16.

Data from this report have shown that there is a significant number of institutions in England, Wales and Northern Ireland that do not enter any candidates in A-level physics or mathematics, and that the overall proportions have been falling. In 2009, 18%, 12% and 43% of all relevant institutions across England, Wales and Northern Ireland[33] failed to present a single physics A-level candidate. There are other explanations for the proportional falls in institutions putting up candidates in these subjects, such as retirement coupled with the inability of schools to find replacement subject specialists, the financial constraints on small colleges or the geographical isolation of certain institutions. But clearly institutions will only be able to offer A-levels/Highers/Advanced Highers in specific subjects if they have sufficient appropriately qualified teaching staff.

In England, the Department for Education has admitted that the targets set by the previous Government for numbers of specialists teaching physics and mathematics will not be met (NAO 2010). The Department created a variety of initiatives (under its previous incarnation, the DCSF) to boost the numbers of these specialists, including, the Science Additional Specialist Programme (SASP), Subject Knowledge Enhancement (SKE) courses, Transition to teaching and Teach First. These are necessary, and some have proved more successful than others. But they need to be seen for what they are: desperate measures that, at the national level, have achieved little in terms of solving the fundamental problem of attracting sufficient numbers of science and mathematics graduates into teaching.

The solution to this problem lies in increasing the numbers of people taking science and mathematics at A-level and beyond, but this is much more easily said than done. There are four fundamental issues here that need to be dealt with.

*Issues that the STEM community may reasonably accept some responsibility for*

(i) The STEM community must work with Government and others to ensure that science and mathematics attract considerably more people into teaching,

33 The dearth of physics in other secondary schools in Northern Ireland contrasts with the strength of this subject in its grammar schools, and suggests that much more could be achieved if the appropriate teaching resources existed.

through stimulating curricula, appropriate, better systems of assessment, enthusiastic teaching augmented by regular subject-based CPD, and wide access to high quality careers advice.

(ii) The under-recruitment of men into teaching, which is a particular problem at primary level, (Royal Society 2010*b*) and especially worrying given that more male than female STEM UK graduates are produced each year.

*Wider issues*

(iii) Students' disruptive behaviour within and outside the classroom,[34] as well as parents' overall control of their children and their respect for their children's teachers.[35]

(iv) Teachers' workload and stress.

For the moment, however, it is clear that there will be a long-term dependence on these 'sticking plaster' initiatives to squeeze as much expertise into the system as possible.

> **Recommendation 1**
> The UK Government and Devolved Administrations must do all they can to maximise the number of mathematics, chemistry and physics specialist teachers available for employment in secondary schools and colleges.[36] This demands working closely with employers, the STEM community and educational institutions to address weaknesses in the UK's educational systems.

### 4.3.3 The availability of choice: institutions and qualifications as limiting factors

#### *4.3.3.1 Provision of Level 3 qualifications: constraints on choice*

While a very few institutions in Scotland offer the International Baccalaureate or GCE A-levels, the great majority pursue the qualifications awarded by the Scottish Qualifications Authority. Owing to the availability of specialist teachers, most institutions can offer Highers in all the core sciences and mathematics, and through collaboration, they are increasingly able to offer Advanced Highers in these subjects.

Elsewhere in the UK, the situation is different, and in England in particular the qualifications landscape has become increasingly heterogeneous. While A-levels were once upheld as the 'gold standard', year-on-year improvements in pass rates and numbers gaining the top grades, and concomitant concerns over grade inflation fuelled by allegations of 'dumbing down' amidst fierce competition for business among the awarding bodies, have tarnished their reputation. With the support of the previous Government (and seemingly the new Government), for whom 'choice' and 'flexibility' were watchwords, A-levels are coming under increasing challenge from competitor qualifications, including the International Baccalaureate, BTEC and OCR Nationals, Diplomas and the Cambridge Pre-U.[37] For instance, the number of International Baccalaureate Diploma candidates in the UK increased almost four-fold between 2000 and 2009, rising from 930 to 3,665 (albeit that by no means all of these specialised in science and/or mathematics).[38]

Although A-levels still continue to predominate, the emergence of these competitors has inevitably created a patchwork of provision, with institutions having to make tough decisions about which qualifications and subjects to offer for study post-16. Notwithstanding the fact that progression routes from some of these qualifications are unclear, which leads to confusion, this increased 'choice' is actually creating inequity in the system, with students potentially being unable to access the course(s) they desire or are best suited for.

On a much more prosaic level, having such a wide range of qualifications on offer makes it incredibly difficult to measure and monitor the effectiveness and performance of the qualifications system reliably, particularly when the awarding organisations refuse to make information on participation and attainment freely available (Royal Society 2008*b*).

> **Recommendation 2**
> The increasing diversity of A-level and equivalent qualifications provision (particularly in England) needs to be reviewed, and its impact on the numbers of students taking science and mathematics post-16 evaluated. Awarding organisations should make available detailed data on the participation, attainment and progression of students taking their specifications in science and mathematics.

#### *4.3.3.2 Provision of mainstream Level 3 qualifications: systemic needs*

We have already highlighted that Scotland outperforms the rest of the UK in two measures:

(i) as mentioned earlier, the proportion of the Highers cohort in Scotland taking core sciences with/without mathematics (50%) is greater than the equivalent

34 ATL 2009 (See http://www.atl.org.uk/media-office/media-archive/primary-behaviour-survery.asp, accessed 15 November 2010.)
35 ATL 2009 (See http://www.atl.org.uk/media-office/media-archive/violence-against-teachers.asp, accessed 18 November 2010.)
36 As our first 'state of the nation' report first documented, there are no universally accepted definitions for a 'specialist' science or mathematics teacher across the four Home Nations, and no reliable up-to-date counts exist.
37 BTECs, City & Guilds and OCR Nationals are post-16 work-related qualifications, combining theoretical and practical study, that are available in subjects including science and engineering, and when studied at Level 3 (equivalent to A-levels), can provide a route into HE. Higher National Certificates (HNCs) or Higher National Diplomas (HNDs), offer vocational education at HE level, for example in construction or civil engineering; further progression to a full degree can be made with one or two years of extra study.
38 Matthew Wilson (Management Information Coordinator, IBO), personal communication, 1 November 2010.

(i) proportion of A-level cohorts in England (28%), Wales (27%) and Northern Ireland (37%);

(ii) as is suggested below in § 4.4.2.1, Scottish students appear to be better prepared for STEM higher education.

These differences are undoubtedly hard to explain. Potentially influential effects include the number and deployment of academically well-qualified specialist subject teachers, smaller pupil–teacher ratios, differences in school infrastructure, and the retention of separate sciences at Standard Grade and above. However, perhaps the obvious explanation for the differential is the fact that Scottish students generally take five Highers (usually including English and mathematics) while their counterparts elsewhere in the UK typically take three A-levels. Figures 3.3–3.5 (Chapter 3) suggest that although the proportions of students in England, Wales and Northern Ireland who choose to focus on science and mathematics are increasingly taking A-level combinations involving two core sciences and mathematics, this is already established practice in Scotland. Given that higher education institutions tend to want STEM undergraduates to have taken more than one science subject (excluding mathematics), and that many students would welcome being able to take a wider range and number of subjects at A-level, it is clear that A-levels are not fit for purpose. A Baccalaureate-type approach to post-16 education has already been, or is being, taken forward in Wales and Scotland in respect of sciences and modern languages. On 6 September 2010, the Education Secretary announced plans for a GCSE-based English Baccalaureate, in order to drive up the numbers of young people completing five good GCSEs.[39] An A-level-based Baccalaureate is needed, too, based on attainment within a coherent framework of educational programmes. The argument for this is consistent with ACME's recent proposals for reforming Level 3 mathematics in England from 2016.[40]

**Recommendation 3**

In undertaking reforms to A-level qualifications in England, the Department for Education should consider modifying their structure to enable students to study a wider range and increased number of subjects than is usually the case now.

#### *4.3.3.3 Using intermediate qualifications to increase A-level and Scottish Higher numbers*

Advanced Subsidiary (AS-level) qualifications were specifically introduced as a replacement for Advanced Supplementary qualifications in 2000 to boost progression into A2 (the full A-level). However, the unreliability of data relating to AS-level qualifications, caused by the flexibility in sitting the end-of-year examinations and the lack of restriction on retakes, does not allow any meaningful analysis of the effect of these qualifications in promoting more students to take A-levels in England, Wales and Northern Ireland (Royal Society 2008*b*, p. 51). This is a pity. Some of the students within the pool of those who hold at least one core science and/or mathematics subject at A-level also hold AS-levels in other core sciences and/or mathematics. Certain higher education institutions will take science and mathematics AS-levels into account in terms of entry onto STEM degree courses.

By contrast, in Scotland, most students progress to Higher science and mathematics after having gained Standard Grade qualifications at Credit level. The introduction of courses at Intermediate II level allowed students to progress from General level at Standard Grade and then move on to Higher in S6. This stepping-stone allowed more students than before to achieve awards at Higher than before the introduction of Intermediate level courses. In previous years, many of these students would have sat Highers in S5, but failed to gain an award. In some schools, students have been entered into Intermediate II qualifications as, for some subjects, these articulate better with and aid progression to Highers.

Table 4.1 shows that the proportion of students taking SCQF Level 6 or higher qualifications who also took Intermediate II qualifications grew from 62.7% to 77.9% between 2005 and 2009, while the numbers of students with Intermediate II, Higher, and Advanced Higher qualifications also rose 83% in this period. Table 4.2 provides equivalent data specifically focusing on core sciences participation, from which it is calculable that the proportion of all students that were taking core sciences Intermediates with Highers and/or Advanced Highers doubled from 7% to 14% between 2005 and 2009.

It is clear, then, that while AS-levels have most probably helped increase the numbers of students taking A-level science and mathematics, Scottish Intermediates have certainly enhanced progression to Highers, leading to greater levels of participation in the latter than would have been the case had Intermediates not been available.[41]

**Recommendation 4**

Scottish Intermediates have proven effective in helping maximise the number of students progressing to Scottish Highers. The Scottish Government should ensure that in reforming its qualification system to suit the new 'Curriculum for Excellence', Intermediates are replaced by a similar and equally successful option.

39 Michael Gove to Westminster Academy, 6 September 2010, updated 9 September 2010. (See http://www.education.gov.uk/inthenews/speeches/a0064281/michael-gove-to-westminster-academy, accessed 17 November 2010.)

40 See http://www.acme-uk.org/downloaddoc.asp?id=228, accessed 17 November 2010.

41 Although no hard evidence for this contention appears to exist, discussions with the Scottish Government and the Royal Society of Edinburgh's Education Committee during 10 and 11 November 2010 have indicated that this is the case.

Table 4.1. *Numbers of students entering SCQF Level 6 or higher qualifications (all subjects, Scotland 2005, 2007, 2009).*

| Qualification level combination | 2005 | 2007 | 2009 | Overall percentage change in numbers since 2005 |
|---|---|---|---|---|
| Intermediate II and Highers | 17,725 | 17,632 | 20,515 | 15.7% |
| Intermediate II, Highers and Advanced Highers | 4,392 | 5,974 | 8,055 | 83.4% |
| Highers only | 7,292 | 5,210 | 4,431 | –39.2% |
| Highers and Advanced Highers | 5,818 | 4,262 | 3,631 | –37.6% |
| Advanced Highers only | 30 | 27 | 22 | –26.7% |
| Total size of Highers/Advanced Highers cohort | 35,257 | 33,105 | 36,654 | 4.0% |

*Source:* Scottish Government.

Table 4.2. *Core sciences participation by qualification type amongst students taking Highers in Scotland.*[a]

| | | 2005 | 2007 | 2009 |
|---|---|---|---|---|
| No core sciences taken | | 14,927 | 13,288 | 14,398 |
| Core sciences at... | Intermediate II only | 2,899 | 3,090 | 4,023 |
| | Intermediate II and Highers | 2,345 | 2,750 | 4,029 |
| | Intermediate II, Highers and Advanced Highers | 240 | 518 | 922 |
| | Highers only | 11,666 | 10,321 | 10,105 |
| | Highers and Advanced Highers | 3,172 | 3,131 | 3,166 |
| | Advanced Highers only | 8 | 7 | 11 |
| Total size of Highers/ Advanced Highers cohort | | 35,257 | 33,105 | 36,654 |

*Source:* Scottish Government.

(a) Core science Highers: B, H, C, P. Core science Advanced Highers: B, C, P. (Data only include students who entered any Higher or Advanced Higher, and includes entries in Intermediate II, Highers, and Advanced Highers in previous academic years. Data for students entering Intermediate II qualifications exclude students without Highers or Advanced Highers.)

## 4.4 The quality of the pool of post-16 students taking mainstream science and mathematics

### 4.4.1 The significance of choosing biology versus mathematics combinations

Higher education entry requirements suggest that having only a single science qualification is not encouraged for entry to many STEM degrees. Data from this report suggest that, across the UK, of the numbers of students taking biological sciences and/or chemistry and/or physics, a comparatively small proportion takes physics or chemistry alone. However, the proportion of students with a single biology qualification is, by comparison, very large.

While a qualification in the biological sciences alone (or possibly alongside geography or psychology) may allow entry to courses such as psychology, sports science, environmental science or nursing, students who have a single A-level/Higher in biology have a reduced number of STEM degree options (which includes being able to study biological sciences at many HEIs) compared with those who have studied, say, both biological sciences and chemistry.[42]

When these combinations data are disaggregated to show the effect of mathematics, it is evident that there is an increasing tendency for students to take mathematics alongside core sciences. Indeed, while the percentage of the entire A-level/Highers cohort in each Home Nation taking core sciences and/or mathematics has fallen, considerably more of these candidates have opted to take mathematics together with core sciences. Although it was beyond the scope of this report to investigate, and thereby comment on, the quality of mathematics provision within

42 In Scotland, students often take Higher biology on its own because biology is often seen as a bridge subject between arts and science lines. Many young people take biology as the sole science because they want to follow arts-type courses and they will probably have four other Highers, including English, social subjects, arts and humanities subjects, etc. Jack Jackson (Visiting Professor, University of Strathclyde), personal communication, 30 November 2010.

mainstream post-16 science and/or mathematics courses, this is seemingly very encouraging news (i) because higher education courses that are explicitly STEM or STEM-related ideally require well-developed mathematical competence, and (ii) because many of these institutions have decried the often poor mathematical skills of freshly recruited undergraduates (Royal Society 2006*a*; SCORE 2009).

Equally, while it is not absolutely clear what is fundamentally responsible for this trend developing in the first place—a matter that merits investigation in its own right—it is important (i) that it should continue and (ii) critically that it should grow in tandem with an overall increase in the numbers of students within a particular year-cohort taking combinations of these subjects.

### 4.4.2 The 'fitness' of the pool of students taking science and/or mathematics

There are two aspects of 'fitness', which may be defined as candidates' suitability for STEM higher education. These are: (a) the relevance of science and mathematics combinations to universities' entry requirements; and (b) the extent to which students are achieving the grades they would need to progress to undergraduate studies in these or related disciplines.

#### *4.4.2.1 Combinations' suitability*

A recent report commissioned by SCORE provided indications of the combinations of A-level subjects accepted onto specific first degree STEM courses (excluding medicine (and related degrees), dentistry and veterinary sciences) (Stagg 2009). Across different university types (Russell Group, Pre-1960 (non-Russell Group), 1960–92 and post-1992), the top three subjects for acceptance to:

(a) biology first degree courses (JACS code, C1) were biology, chemistry and mathematics;

(b) chemistry first degree courses (JACS code F1) were chemistry, mathematics and biology;

(c) physics first degree courses (JACS code F3) were physics, mathematics and chemistry.

(d) civil, electronic and electrical and mechanical engineering (JACS codes H2, H3 and H6) were mathematics, physics and chemistry.

The data from this report for 2009 (cf. tables E.9, W.8, NI.8 and S.9)[43] indicate that across England, Wales, Northern Ireland and Scotland:

(a) an absolute maximum (ie regardless of grade) of 16%, 15%, 15% and 26%, respectively, of all 16–18 year old students taking core sciences exactly match the most popular combinations among students accepted onto biology or chemistry first degree courses; and

(b) an absolute maximum of 10%, 10%, 9% and 26%, respectively, of all 16–18 year old students taking core sciences exactly match the most popular combinations among students accepted onto physics or engineering first degree courses.[44]

It must be said that many more students took combinations including at least two of these subjects, but in respect of the exact match for first degree entry across the major biological, chemical, physical and engineering sciences, it appears that Scottish students are especially well prepared to potentially progress to undergraduate studies in these disciplines.

#### *4.4.2.2 Attainment*

Measured against the standard requirements governing entry into STEM higher education courses from students taking A-levels or Scottish Highers, it is clear that the majority (70% or more) of candidates taking core sciences and/(or) mathematics gain A–C grades. This is heartening on the one hand, but it also confirms that the quality of the pool of prospective STEM higher education undergraduates is just as important as its size.

### 4.4.3 Continuing professional development

Teachers will have a more positive influence on students if they are confident and interested in the subject they are teaching. This requires that they have access to high quality subject-specific CPD. The momentum towards 'professionalising' teaching has been increasing over recent years, particularly with the launch of the national network of Science Learning Centres and the National Centre for Excellence in the Teaching of Mathematics. It is vital that continued investment is provided to these organisations, whose funding is due to run out at the end of March 2011. It is equally important that the Scottish Schools Equipment Research Centre, which performs a similar vital role in providing CPD to science and mathematics teachers in Scotland, should continue to be appropriately funded and supported when current funding ends this year.

**Recommendation 5**

Science and mathematics teachers should undertake subject-specific continuing professional development (CPD) as part of their overall CPD entitlement. Funding should be maintained for the National Science Learning Centre, the National Centre for Excellence in the Teaching of Mathematics and the Scottish Schools Equipment Research Centre, to allow these bodies to continue to support effective subject-specific CPD for science and mathematics teachers.

43 A complete version of table S.9, providing data for all core sciences combinations, may be found in the electronic appendix (table AS.1).

44 In both cases, the percentages calculated for Scotland are conservative, being based on students who took biology, rather than human biology.

### 4.4.4 Laboratory facilities and technicians

Access to the necessary resources in terms of laboratory space, high quality modern equipment and the availability of suitably qualified technicians are further factors limiting the number of institutions able to offer science subjects. Notably, SCORE is undertaking a study of the needs of institutions in respect of facilitating high quality practical work required for science teaching, and the funding implications of this. Meantime, the National Audit Office has just reported that at the current rate of progress, the previous Government's target of bringing all school laboratories up to a good or excellent standard by 2010 will not be met until at least 2021 (NAO 2010).

### 4.4.5 Restrictions on course entry

In England, Wales and Northern Ireland, a combination of provision and accountability factors may have an even earlier effect on restricting the pool of A-level students with science and mathematics qualifications. While students taking GCSEs in biology, chemistry and physics are more likely to progress to studying A-level science than those taking alternative GCSE science combinations, almost half of all state secondary schools were failing to offer triple science in 2008/09 (NAO 2010). The previous Government had promised an 'entitlement' to enable all students gaining Level 6 or above in Key Stage 3 tests (notwithstanding the abolition of Key Stage 3 tests in 2008), to progress to triple science GCSE studies by 2008. In Scotland, separate sciences were always retained at Standard Grade and students were able to choose to study one, two or all three science subjects. This is likely to have been a key factor in promoting further study of the separate sciences at Higher level and above.

An additional contributing factor to the take-up of science and mathematics post-16 is the imposition of entry requirements on students at A-level or equivalent. This restriction may not be the same across all post-16 subjects, and often appears to be driven in England by school or college accountability measures. For example, if an institution's position in 'league' tables depends on the number of A–C grades achieved by its students at A-level,[45] then it may dissuade students from taking A-levels in subjects in which they are unlikely to achieve at least a C grade.

### 4.4.6 Types of institution

Our findings indicate that physics and mathematics A-levels are being taught in progressively fewer institutions across England, Wales and Northern Ireland. Without further investigation it is not possible to pinpoint why this is, although it is likely that there are nation-specific factors operating. However, while closures of small institutions, and the struggle to provide replacement specialists for retirees are particularly plausible explanations in England and Wales, in Northern Ireland the lack of provision available in other (ie non-grammar) secondary schools may relate to difficulties in attracting specialists in these subjects.

A further consideration that merits investigation is the impact on science and mathematics progression of the increasingly diverse nature of institutions in England. It is not just that England now has a mixture of maintained schools, most of which are 'specialist' in one way or another, and academies, the age ranges that these schools cover has also become increasingly variable.

England is a divided nation, retaining a mixture of state-funded two-tier education systems (wherein students progress directly from primary to secondary schools) and three-tier education systems (wherein students progress to a middle school before progressing to upper secondary school). In addition, a growing number of 5–18 'through' schools has been emerging, seemingly encouraged by the lead given by the previous Government in order to counter the dips in performance that many students suffer upon transferring to secondary education.

A recent study involving 55 maintained schools (five 11–16 schools, forty-six 11–18 schools and four 13–18 schools), varying in their gender make-up, specialism and selection policies, identified a variety of factors that contributed to high uptake of science post-16 concerning leadership, pedagogy and the curriculum (DCSF 2008*b*). However, it remains unclear which of these schooling systems works best for educating children and which, more specifically, is most appropriately geared to optimising attainment and progression in science and mathematics. In Scotland, schools have a much more homogeneous nature, with all but one local education authority schools being comprehensives.[46]

> **Recommendation 6**
> The Department for Education should investigate the diversity of schooling structures in England to establish which of these is generally best suited to educating students, and optimising performance and progression in science and mathematics.

### 4.4.7 The effect of attitudes on student choice: gender, socioeconomic status and the curriculum

Quite apart from the limitations in course provision described in the preceding subsections, a whole suite of interrelating factors combines to affect students' choices when they are determining which subjects to pursue post-16. As discussed in the second and third 'state of the nation' reports (Royal Society 2008*b*, 2010*b*), while measured attitude rarely correlates with attainment in science and mathematics, a positive attitude towards these

45 It should be noted that the first A-level results to include the new A* grade introduced across England, Wales and Northern Ireland were published in 2010. There are concerns about the impact this may have on entry to, and tuition fees for, certain universities.

46 The exception is Jordanhill (formerly Jordanhill College) School, Glasgow.

subjects is crucial in influencing study and career choices. There is evidence that science and mathematics are less preferred in comparison to other subjects even in primary school, and thereafter attitudes towards these subjects decline. These differences in attitudes, and their implications for participation rates, act to reduce the numbers taking post-16 science and mathematics qualifications and therefore also the size of the pool that may realistically access STEM higher education.

#### *4.4.7.1 Gender*

The data in this report have confirmed well-known and long-established gender effects among students taking post-16 public examinations in science and mathematics: that males tend to prefer physics and mathematics and that females tend to prefer biological sciences, and that this is the case across all the Home Nations. Notably, females with equivalent prior attainment are much less likely than males to choose to study physics and mathematics post-16 (Royal Society 2008*b*). As yet there are still no clear explanations for the effect of gender differences on subject choice. Suggestions made include curriculum content, career expectations, cultural socialisation and the lack of female specialist physics teachers.

#### *4.4.7.2 Socioeconomic status*

Differences in participation rates in science and mathematics post-16 are also influenced by socioeconomic status to a small extent, as well as ethnic background. Patterns of participation are complex, and a more detailed analysis can be found in previous Royal Society reports (Royal Society 2008*a*,*b*). Initiatives that increase post-16 uptake of science and mathematics in underrepresented groups should therefore continue to be supported.

#### *4.4.7.3 The curriculum*

As has been suggested elsewhere, an important factor impacting on students' attitudes towards, and choice of, subjects to study post-16 is their previous experience with these subjects, in terms of the content of GCSEs or equivalent qualifications studied. This experience will be informed largely by the effectiveness of the teaching. It must be remembered that a curriculum is only as good as the teachers who deliver it and, as we have noted here and in our previous 'state of the nation' reports, there is a shortage of science and mathematics specialist primary and secondary teachers across much of the UK (Royal Society 2007, 2008*b*, 2010*b*).

### Recommendation 7

Science and mathematics curricula need to be inspiring and engaging for both boys and girls, whilst retaining rigorous development of subject-specific knowledge and skills. Governments should work closely with experts from learned societies, the higher education sector and other key stakeholders to develop appropriate subject curricula.

Taken together, the issues highlighted in this section mean that some students with the aptitude to study science and mathematics may be denied the chance to study them

## 4.5 Progression to STEM higher education

### 4.5.1 Conversion from A-level and Highers/ Advanced Highers to STEM undergraduates

In order to understand the full extent to which the size of the student cohort limits the overall supply of STEM skills to higher education and beyond, the destinations of school and college leavers would need to be analysed. Students holding science and mathematics qualifications have a range of options before them, only one of which might be to study a STEM subject at degree level. Analysing data relating to further studies in HE in detail, for example by considering UCAS acceptance data, was beyond the scope of this study, but is a necessary avenue for further research. Plausible explanations as to why students might not choose to continue studying science and mathematics at university mirror those at the post-16 boundary: lack of enjoyment of the subject, perceived difficulty, insufficient prior attainment, or a lack of knowledge about the types of STEM careers that can lead from a STEM degree could all contribute to constraints on the conversion rate. A further issue could be the formation of STEM 'deserts' in higher education, which already exist in the physical sciences. Indeed, an A-level student who lives in Norwich and wants to study physics at university will have to travel to London to do so, or a similar distance. As higher education funding is cut and tuition fees rise, these 'deserts' may become much more expansive and could even extend to the biological sciences.

Given the many factors outlined above, which affect the flow of students into STEM HE, there is a clear need for further investigation into the transfer from school/college to higher education.

### Recommendation 8

The unique pupil number (UPN), or equivalent, should follow school and college students into and through higher education to make it easier to track student progression. Linking these records to details of STEM initiatives that young people may have experienced could provide an efficient mechanism for measuring their longer-term impact.

### Recommendation 9

Further investigation is needed into understanding motivations for post-16 students' continuing with science and mathematics at university. This could include pursuing the following approaches, with a view to taking appropriate action:

(i) Role models: identifying whether the lack of female physics teachers affects girls' perceptions of physics.

(ii) Educational neuroscience: this emerging field of research is enhancing understanding of neurological processes involved in learning as well as factors that influence motivation to learn.[47] There is scope here for collaboration between neuroscientists, cognitive psychologists and educational researchers aimed at developing a shared and more complete understanding of the factors underlying subject preferences among girls and boys.

### 4.5.2 Alternative pathways to entering STEM higher education and employment

This report has focused attention on the traditional mainstream routes into higher education, yet it is important to recognise that a much wider range of pathways exist to enable students to become part of the STEM workforce that do not necessarily require participation in higher education. In addition, A-levels and mainstream equivalents do not form the only entry route into higher education for young people

In addition to the International Baccalaureate (IB), the Cambridge Pre-U, BTEC Nationals and Diplomas, in England, Wales and Northern Ireland, National Vocational Qualifications (NVQs) and Apprenticeships encourage work-based learning in a range of industry and employment sectors, including engineering. Foundation degrees also offer vocational education at HE level, equivalent to the first two years of an Honours degree course. A new report from the Department for Business, Innovation and Skills and the Royal Academy of Engineering enables the full range of STEM based qualifications on offer in England's FE sector to be appreciated (BIS/Royal Academy of Engineering 2010). It is also important to note that the Coalition Government has commissioned a review of 14–19 vocational qualifications in England,[48] which may prompt further changes in future.

Equally, the Scottish Credit and Qualifications Framework (SCQF) covers Scottish Vocational Qualifications (SVQs), and is designed so that there is the same structure in place for students studying both academic and vocational pathways. SVQs are unique to Scotland, but they operate on a similar model to NVQs, and can also be awarded to those students undertaking Modern Apprenticeships (which are equivalent to Advanced Apprenticeships in England, Wales and Northern Ireland). National Qualification Group Awards, which sit within the SCQF, are occupation-related qualifications that cover a range of sectors including science and engineering. As well as preparing students for employment, they can lead on to study at HE level.

47 Royal Society (2011*b*).
48 See http://www.education.gov.uk/inthenews/inthenews/a0064651/wolf-review-of-vocational-education-call-for-evidence, accessed 13 October 2010.

### 4.5.3 The importance of high quality careers information, advice and guidance

Students' decisions about what to study in school or college, or what career path to pursue are influenced by a range of factors. In addition to their attitude towards subjects (which is likely to be affected by their prior attainment in them), some of the most powerful influences will be their peers, siblings and parents. Yet there is one other factor that should be of crucial importance in helping students make their choices: the quality and impartiality of information, advice and guidance (IAG) they receive from within their school or college.

However, as noted in this report (Chapter 2), 90% of careers advisers do not have a scientific background. This, together with the fact that keeping a full and up-to-date understanding of current and prospective future developments and opportunities within (i) higher education STEM courses and other types of training; (ii) changes to higher education institutions' admission requirements and practices (including university entry tests); (iii) present, new and emerging fields of science, technology and engineering; and (iv) the comparative rewards in terms of, for instance, expected remuneration, mobility, and job satisfaction of STEM careers (SCORE 2009) makes the delivery of high quality STEM careers advice extremely challenging, and perhaps more so than has ever really been appreciated. Students, however, need access to advice on all these fronts, and to be able to understand the implications of the decisions they make.

While a large sixth form college with as many as 2,000 students aged 16–19 may be able to afford a sophisticated IAG service with several full-time specialists, most schools and smaller colleges will not be able to do so. Higher education institutions will have different requirements for entry to what may appear on paper to be very similar courses. Although admissions requirements are published in hard copy and online, it is well known that these are indicative, rather than absolute. This only serves to make into a minefield the landscape through which potential applicants must navigate.

One issue highlighted by HE admissions tutors is that in their recent experience, students applying for science subjects have not realised that, for the specific course chosen at the specific university, an A-level in mathematics is also required (SCORE 2010). The encouraging news from this study is that the message about the importance of mathematics for studying STEM at HE appears to be being heard, though the reason for this is unclear. Overall though, the complexity of the provision, matched with the lack of clarity about which subjects are preferred but not required for particular degree programmes, can make the UCAS process very hard to negotiate especially if a student has little idea of which subject they want to study before they start applying.

**Recommendation 10**

In England, the Department for Business, Innovation and Skills needs to ensure that the new careers service to be launched in September 2011 is adequately equipped to provide high quality and easily accessible information, advice and guidance (IAG) on STEM careers to school and college students. This should include links to STEM careers-related websites, eg *Future Morph* and *Maths Careers*.

## 4.6 Final thoughts

The low levels of participation in mainstream post-16 science and mathematics education found by this report (which are particularly evident in England and Wales), appear to result from a distinct general lack of warmth in the UK population towards science and mathematics. This is despite the fact that a recent survey recorded widely positive attitudes towards science education and careers in science (Wellcome Trust 2009).

Given the fact that scientific and technological developments are advancing faster than ever before, and the ever-increasing dependency there is on these to solve the major threats to human health and well-being, this is a strange dichotomy. It is beyond the scope of this report to examine this in detail, but the roots of this disjunction may lie in the 'unnatural nature' of science and the pace of scientific development (Wolpert 1992). Science and mathematics are, culturally speaking, the dark matter in the Universe—they imbue everyone and everything, yet are only understood in any depth by relatively few people.

The previous Government, prompted by an earlier consultation on science and society, established no less than five expert groups to investigate the matter further. This is indicative of the breadth and depth of the problem.[49] Indeed, evidence provided to one of these groups suggested that 'the place of science within our concept of 'culture' in the UK remains ambiguous and contested' (BIS 2010*a*). The 'Science for all' expert group published a detailed action plan aimed at promoting greater confidence and improved engagement in scientific research and its applications. This demonstrates the steepness of the uphill battle the science community and its partners in Government face if, together, they are to achieve the necessary step-change in numbers taking science and mathematics post-16.

Fundamentally, the methodology we adopted for our investigation has shown that annually published results reporting the number of entries to, and broad attainment in, individual subjects in public examinations are neither a reliable indicator of, nor a sharp enough tool for, understanding the performance of a nation's education system. For instance, with respect to the choices individuals are making, the growth in entries to GCE A-level mathematics in England is not simply due to more people taking mathematics, but closely correlated with the numbers of students taking science. Such observations require explanation. However, while hard data may provide reliable indications of *how* an education system is performing, they cannot explain *why* the patterns and trends observed are occurring. But just as we have identified throughout this series of reports the need for a coherent approach to primary and secondary education, so it is that we have had recourse to revisit these reports in search of plausible explanations, or at least insight, into what may be responsible for producing the findings in this latest report.

**Recommendation 11**

The UK Government and the Devolved Administrations should make better use of the data they are collecting on 5–19 science and mathematics education in England, Wales, Northern Ireland and Scotland. They should conduct regular monitoring of the combinations of subjects and qualifications students are taking, gaining understanding of progression from their prior participation and attainment, in order to determine with greater confidence actions to improve the performance of the education systems they are responsible for.

In concluding our second 'state of the nation' report on 14–19 science and mathematics education in the UK, we said that 'The intensity and diversity of the reform process, and its sometimes erratic character, make it difficult to judge against any kind of stable background whether our systems of science and mathematics education are fit for purpose, let alone whether they are improving' (Royal Society 2008*b*). The findings of this final report of the series, which effectively focus attention on the culmination of 5–19 science and mathematics education, suggest that there is much indeed that needs to be done if we are to have UK education systems that are fit for effective learning and therefore fit for purpose.

49 These expert groups focused, respectively, on 'Science and learning', 'Science for careers', 'Science and the media', 'Science and trust' and 'Science for all'. See http://www.bis.gov.uk/policies/science/science-and-society/science-and-society-strategy

# 5 Supplementary evidence on the individual nations

## 5.1 Background

The Royal Society's second 'state of the nation' report, *Science and mathematics education, 14–19*, provided a comprehensive account of participation[50] trends in public examinations between 1996 and 2007 (Royal Society 2008*b*). Owing to the fact that such data cannot offer detailed insights into student subject choice and how this and attainment vary across the UK nations and, at a finer level, among different types of educational institution, it included a commitment to undertake a study of 'the pattern of post-16 subject combinations in which mathematics and the sciences figure'.

Accordingly, the following supplementary evidence for this report presents an analysis of data from each of the UK nations on the combinations of science and/or mathematics subjects individuals took in traditional post-16 school-leaving examinations in the years 2004/05, 2006/07 and 2008/09. Chapter 3 includes interpretative analysis of cross-national comparisons.

This observational analysis provides insight into the popularity of these subjects in respect of the total 16–18 year old cohorts that sat these examinations. It highlights broad patterns of overall uptake and investigates variation between males and females and across educational institutions. This analysis provides an initial exploration of the very rich, and apparently under-used, datasets maintained by the national educational authorities.

Notwithstanding some recent studies by Cambridge Assessment on subject combinations undertaken by students in England (Bell *et al.* 2005; Emery 2009; Gill 2009) the Society believes that this is the first time that a UK-wide analysis of science and mathematics subject combinations has been performed. Yet these chapters reveal something of the potential power that subject combinations analyses have for understanding student choice and attainment, and for ensuring policy changes are properly informed. Their real virtue lies in their focus on *individuals'* choices and attainment. Consequently, they have the potential to offer a far more penetrating insight into participation, performance and, conceivably, progression than can be gained from scrutinising the annual releases of entry-based data on A-levels and Scottish Highers published by the Joint Council for Qualifications and the Scottish Government, respectively.

## 5.2 Types of GCE A-level science and mathematics combinations taken

Box 1 below illustrates the possible GCE A-level science and mathematics combinations taken by students in England, Wales and Northern Ireland. It provides an early indication of the complexity of the landscape that this report is concerned with mapping. To this may be added the additional complications arising from the fact that the range of mathematics qualifications available differs across each UK nation, and that variation also exists in the science provision. These differences are described separately for each nation.

As Box 1 indicates, for this report, when discussing subject combinations, the following abbreviations will often be used:

B: biological sciences (or biology alone).

C: chemistry.

M: mathematics.

P: physics.

Together, B, C and P represent what are termed in this report the 'core sciences'.

In Scotland, no exact equivalent to the composite 'Other sciences' exists. In addition, 'H' is used to denote human biology in Scotland, which is much more prevalent than elsewhere in the UK.

## 5.3 Additional data

An electronic appendix contains supplementary tables, referenced in the main report by the prefix 'A[E,W,NI,S]', according to the nation being identified (eg Table AE3.2).

## 5.4 Notes on data

(i) Where the sample size is too small (< 5), data have been suppressed. This is in accordance with the national authorities' procedures governing protection of the confidentiality of individuals' personal data.

(ii) The term 'combination' is normally used to describe an aggregate of more than one core science or mathematics subject. However, for ease of reference, a single core science or mathematics subject is also considered as a 'combination' in its own right.

(iii) Although data on the numbers of students taking mathematics as a standalone subject are included, this report focuses particularly on those students who have taken GCE A-level combinations including mathematics and core sciences. These are normally indicated by the notation 'X(M)', where 'X' is one or more of biology, chemistry, physics or mathematics. However, the use of parentheses has been suspended for certain diagrams in Chapter 3, for the sake of clarity.

50 Participation refers to the numbers of entries to A-level and equivalent examinations in Scotland.

| *Box 1. Possible range of GCE A-level sciences and mathematics subject combinations taken by 16–18 year old students in England, Wales and Northern Ireland* | |
|---|---|
| 1 | Biological sciences[(a)] (B) |
| | Chemistry (C) |
| | Mathematics[(b)] (M) |
| | Other sciences[(c)] |
| | Physics (P) |
| 2 | Biological sciences and chemistry |
| | Biological sciences and mathematics |
| | Biological sciences and other sciences |
| | Biological sciences and physics |
| | Chemistry and mathematics |
| | Chemistry and other sciences |
| | Chemistry and physics |
| | Mathematics and mathematics |
| | Other sciences and mathematics |
| | Other sciences and other sciences |
| | Physics and mathematics |
| | Physics and other sciences |
| 3 | Biological sciences, chemistry and mathematics |
| | Biological sciences, chemistry and other sciences |
| | Biological sciences, chemistry and physics |
| | Biological sciences, mathematics and mathematics |
| | Biological sciences, mathematics and other sciences |
| | Biological sciences, mathematics and physics |
| | Biological sciences, other sciences and other sciences |
| | Biological sciences, other sciences and physics |
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| | Mathematics, other sciences and other sciences |
| | Physics, mathematics and mathematics |
| | Physics, mathematics and other sciences |
| | Physics, other sciences and other sciences |

| | |
|---|---|
| 4 (or more) | Biological sciences, biological sciences, chemistry and mathematics |
| | Biological sciences, chemistry, mathematics and mathematics |
| | Biological sciences, chemistry, mathematics, mathematics and mathematics |
| | Biological sciences, chemistry, mathematics and other sciences |
| | Biological sciences, chemistry, mathematics, mathematics and other sciences |
| | Biological sciences, chemistry, mathematics, other sciences, other sciences |
| | Biological sciences, chemistry, physics and mathematics |
| | Biological sciences, chemistry, physics, mathematics and mathematics |
| | Biological sciences, chemistry, physics, mathematics, mathematics and mathematics |
| | Biological sciences, chemistry, physics and other sciences |
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| | Biological sciences, physics, mathematics and mathematics |
| | Biological sciences, physics, mathematics and other sciences |
| | Chemistry, mathematics, mathematics and mathematics |
| | Chemistry, other sciences, mathematics and mathematics |
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| | Chemistry, physics, mathematics, mathematics and mathematics |
| | Chemistry, physics, mathematics and other sciences |
| | Chemistry, physics, mathematics, mathematics and other sciences |
| | Chemistry, physics, other sciences and other sciences |
| | Physics, mathematics, mathematics and mathematics |
| | Physics, mathematics, mathematics and other sciences |
| | Physics, mathematics, mathematics, mathematics and other sciences |
| | Physics, mathematics, mathematics and other sciences |

(a) Biological sciences comprises biology and human biology. This term will tend to be applied only to England, Northern Ireland and Wales.

(b) Mathematics includes mathematics, pure mathematics, statistics, use of mathematics, further mathematics and additional mathematics. Use of mathematics was introduced in 2008/09 as a pilot, and just 29 students are recorded in the DCSF statistics as having taken the final A-level examination.

(c) 'Other sciences' is a very broad category that includes courses in design and technology, information communication technology (ICT), home economics and 'other science', a category that includes: astronomy, electronics, environmental, geology, psychology (as a science), rural science and science for public understanding. (*Source:* www.dcsf.gov.uk/rsgateway/DB/SFR/s000906/index.html, accessed 8 September 2010.)

# Supplementary evidence England

## E.1 Introduction

This chapter considers data on the A-level (GCE science/ mathematics and applied science equivalent) qualifications taken by 16–18 year old students in England during 2005, 2007 and 2009. The data were received directly from the Department for Children, Schools and Families (DCSF, now the Department for Education) in February 2010.

Details of the methodology used for this analysis are provided in the electronic appendix (see http://royalsociety.org/education-policy/projects/).However, it is important to note that the figures for the total number of male and female students taking GCE A-levels in England (eg table E.1) do not match the sum totals for male and female students taking these examinations given in tables E.14 and E.15. This is because in comparing records from the candidate and results databases, 212 cases were found where gender was recorded differently. These anomalies have been excluded from the specific investigations into gender patterns of participation.

The chapter is divided into three major sections, as follows:

Section A. Summary data on all 16–18 year old students taking science and/or mathematics subject combinations in 2005, 2007 and 2009.

Section B. A more detailed examination of core sciences and mathematics GCE A-level combinations candidature among 16–18 year old students considering variation by gender and institution type.

Section C. An analysis of attainment in GCE A-level core sciences and mathematics subject combinations.

## E.2 Background information

### E.2.1 Subjects and institution types investigated

For the purposes of this report, the following subjects and institutions, as categorised within the datasets provided by the DCSF, were investigated.

#### *E.2.1.1 Science*

*A-levels (GCE)*

For the purposes of this study, 'Science' includes: the 'core' sciences (biology, human biology,[51] chemistry and physics) and other sciences.

51 The categorisation 'biological sciences', used throughout this chapter, combines data on students taking biology and human biology. Over the three years measured, a total of just 7,850 students in England took human biology. Owing to data suppression issues, it was decided not to analyse human biology combinations separately.

'Other sciences' is an umbrella term encompassing courses in information and communication technology, design and technology, home economics and it includes a further subcategory, 'other science', which includes astronomy, electronics, environmental, geology, psychology (as a science), rural science and science for public understanding. Such categorisations have been determined by the Department.

*Vocational A-levels (VCE)*

This study focused on applied science. During the period covered by this study, the original dataset received from the Department included data for 2005, 2007 and 2009 on applied GCE A-level/AS-level, single- and double-award vocational GCE qualifications (AVCE) and single- and double-award applied GCE qualifications (applied A-levels). For simplicity, these will simply be referred to as VCE.

#### *E.2.1.2 Mathematics (GCE only)*

Mathematics includes: mathematics, pure mathematics, statistics, use of mathematics, further mathematics and additional mathematics.

### E.2.2 Institution types

Institution types were pre-categorised by the Department as follows: Academy/City Technology College (CTC), FE sector, Independent, Maintained, Sixth Form Centres and Colleges, Other (including hospital schools, pupil referral units and special schools). No alternative categorisation was permitted. (Note: table E.18 includes comparative information on the numbers of these institutions in which 16–18 students took GCE A-levels.)

### E.2.3 Entries and students

It is important to distinguish between entries (a simple count of the numbers of examinations taken) and the combinations of subjects taken by individual candidates. Table E.1 illustrates this distinction by comparing the number of GCE A-level and vocational A-level (VCE) examinations taken in 2005, 2007 and 2009 with the number of GCE A-level candidates. It also shows the proportions of the total number of entries across all subjects represented by the number of entries to each subject or subject group, and compares the percentage change over time.

The figures in Table E.1 give an initial indication of the popularity of different subjects and indicate changes in their relative popularity over time. They show that the

*Table E.1. Comparison of GCE A-level and VCE entries and candidate numbers among 16–18 year old students (England, 2005, 2007, 2009).*

| Subject group | 2005 Entries | 2005 % all GCE A-level entries | 2007 Entries | 2007 % all GCE A-level entries | 2009 Entries | 2009 % all GCE A-level entries | Overall percentage change in no. of entries between 2005 and 2009 |
|---|---|---|---|---|---|---|---|
| Biological sciences | 47,571 | 6.5% | 48,691 | 6.5% | 50,560 | 6.2% | 6.3% |
| Chemistry | 34,356 | 4.7% | 36,196 | 4.8% | 38,842 | 4.8% | 13.1% |
| Physics | 25,291 | 3.5% | 24,797 | 3.3% | 26,937 | 3.3% | 6.5% |
| **All core sciences (total)** | **107,218** | **14.7%** | **109,684** | **14.6%** | **116,339** | **14.4%** | 8.5% |
| Other sciences | 47,655 | 6.6% | 42,172 | 5.6% | 35,675 | 4.4% | –25.1% |
| **Mathematics** | **53,604** | **7.4%** | **62,625** | **8.3%** | **77,546** | **9.6%** | 44.7% |
| Arts | 179,755 | 24.7% | 186,395 | 24.8% | 206,697 | 25.5% | 15.0% |
| MFL[a] | 29,815 | 4.1% | 31,648 | 4.2% | 33,852 | 4.2% | 13.5% |
| Social sciences | 222,142 | 30.5% | 230,294 | 30.6% | 255,177 | 31.5% | 14.9% |
| Other subjects | 87,070 | 12.0% | 88,611 | 11.8% | 85,417 | 10.5% | –1.9% |
| **Total number of entries across all GCE A-level subjects** | **727,259** | **100.0%** | **751,429** | **100.0%** | **810,703** | **100.0%** | **11.5%** |
| Total number of entries across all vocational A-level subjects (VCE) | 77,262 | | 35,514 | | 45,177 | | –41.5% |
| Total number of entries to VCE applied science (single and double award) | 1,633 | | 1,334 | | 2,265 | | 38.7% |
| Total number of entries (all GCE and VCE) | 804,521 | | 786,943 | | 855,880 | | 6.4% |
| Total number of GCE A-level candidates only | 251,910[b] | | 258,485[c] | | 283,798[d] | | 12.7% |

*Source:* DCSF.

(a) MFL, modern foreign languages.

(b) Of this number, 28,344 took both GCE A-levels and vocational A-levels.

(c) Of this number, 27,368 took both GCE A-levels and vocational A-levels.

(d) Of this number, 30,770 took both GCE A-levels and vocational A-levels.

core sciences were less popular than the arts or social sciences, but that there was a surge in the numbers taking mathematics, with entries to mathematics subjects growing by at least three times the rate of growth in other subjects. Among the sciences, only in chemistry and mathematics did the percentage increase in entries over time correspond with the overall percentage increase in the number of candidates, so while entries to physics and biological sciences both grew, these subjects effectively lost market share. Table E.1 also shows that entries to VCEs practically halved between 2005 and 2009, but that over this whole period entries to applied science VCEs actually increased some 39%, albeit from a low base.

While such data provide an approximate indication of the popularity of science subjects, it is impossible to identify the individual subject choices that students are making. This may only be done by investigating the subject *combinations* taken by individual students.

Consequently, the remainder of this chapter is concerned with investigating the *combinations* of science and mathematics subjects students took during the academic years 2004/05, 2006/07 and 2008/09.

## A. Overall data on science and mathematics combinations taken by all 16–18 year old GCE A-level and VCE candidates in England during 2005, 2007 and 2009

### E.3 Overall numbers of students taking GCE A-levels in the core sciences, mathematics and other sciences in 2005, 2007 and 2009

Details of the numbers of GCE A-level students in England who (i) took or did not take core sciences (biological sciences and/or chemistry and/or physics) with other sciences and mathematics, and (ii) took other sciences and mathematics, but no core sciences, are described in tables E.2–E.4. Looking across all institution types, the modal (ie the most common) number of A-levels taken by students in 2005, 2007 and 2009 was three (tables AE.1 and AE.2).

Key message E1. During 2005–09, most students taking GCE A-levels in England took examinations in three subjects.

From these tables it may be calculated that the percentage of the total number of GCE A-level candidates in England not taking any core or other sciences subjects rose from 58% to 63% between 2005 and 2009 (table E.2), and although the actual numbers taking core sciences A-levels (with or without mathematics) grew 8% between 2005 and 2009, they fell as a proportion of the total GCE A-level cohort size from 29% to 28% (table E.3).

Further, almost two-thirds of GCE A-level candidates did not take any core sciences or mathematics subjects during this period (table E.3), and more than half did not take any core sciences, other sciences or mathematics (table E.4), with the percentage increasing over time from 52% to 55% during 2005–09. This demonstrates that while the publicly available data on entries and grades published by the JCQ and the Department have generally shown increases in science and, particularly, mathematics entries over recent years, the fact is that nearly two-thirds of all 16–18 year old GCE A-level candidates have not pursued any A-level qualifications in core sciences or mathematics. Moreover, if compared with the total number of 17 year olds in the population (the nearest proxy to the age of the A-level cohort, given that the majority of A-level candidates are aged 17 at the start of the academic year in which they take their A-level examinations), the proportion of young people taking core sciences A-levels (with or without mathematics) is very small (table E.5).

Key message E2. While the actual numbers of young people taking core sciences GCE A-levels (with or without mathematics) have risen, they are small and have fallen as a proportion of the size of the total A-level cohort.

Key message E3. It appears that less than 12% of all potentially eligible 17 year olds in England take GCE A-levels in core sciences and/or mathematics subjects.

The numbers of students taking mathematics alone, or in combination with core sciences subjects, increased overall; (table E.3). By contrast, combinations including mathematics and other sciences, with or without core

*Table E.2. Numbers of 16–18 year old students taking GCE A-level core sciences and other sciences (England, 2005, 2007, 2009).*

| Core sciences | Other sciences | 2005 Students | 2005 % of cohort | 2007 Students | 2007 % of cohort | 2009 Students | 2009 % of cohort |
|---|---|---|---|---|---|---|---|
| No core sciences taken | No other sciences taken | 145,676 | 57.8% | 154,630 | 59.8% | 179,234 | 63.2% |
| | Other sciences taken | 33,554 | 13.3% | 30,048 | 11.6% | 26,024 | 9.2% |
| **Total nos. of students who take no core sciences** | | **179,230** | **71.1%** | **184,678** | **71.4%** | **205,258** | **72.3%** |
| Core sciences taken | Other sciences not taken | 61,747 | 24.5% | 64,289 | 24.9% | 70,677 | 24.9% |
| | Other sciences taken | 10,933 | 4.3% | 9,518 | 3.7% | 7,863 | 2.8% |
| **Total numbers taking core sciences** | | **72,680** | **28.9%** | **73,807** | **28.6%** | **78,540** | **27.7%** |
| **Total size of GCE A-level (only) cohort** | | **251,910** | | **258,485** | | **283,798** | |

*Source:* DCSF.

*Table E.3. Numbers of 16–18 year old students taking GCE A-level core sciences and mathematics[(a)] (England, 2005, 2007, 2009).*

| | | 2005 | | 2007 | | 2009 | |
|---|---|---|---|---|---|---|---|
| Core sciences | Mathematics | Students | % of cohort | Students | % of cohort | Students | % of cohort |
| No core sciences taken | No mathematics taken | 161,754 | 64.2% | 163,766 | 63.4% | 178,582 | 62.9% |
| | Mathematics taken | 17,476 | 6.9% | 20,912 | 8.1% | 26,676 | 9.4% |
| Total nos. of students who take no core sciences | | **179,230** | **71.1%** | **184,678** | **71.4%** | **205,258** | **72.3%** |
| Core sciences taken | No mathematics taken | 42,023 | 16.7% | 39,675 | 15.3% | 37,631 | 13.3% |
| | Mathematics taken | 30,657 | 12.2% | 34,132 | 13.2% | 40,909 | 14.4% |
| Total numbers taking core sciences | | **72,680** | **28.9%** | **73,807** | **28.6%** | **78,540** | **27.7%** |
| Total size of GCE A-level (only) cohort | | 251,910 | | 258,485 | | 283,798 | |

*Source:* DCSF.

(a) Mathematics includes all mathematics subjects: pure mathematics, statistics, use of mathematics, further mathematics and additional mathematics.

*Table E.4. Numbers of 16–18 year old students taking GCE A-level core sciences, mathematics[(a)] and other sciences (England, 2005, 2007, 2009).*

| | | 2005 | | 2007 | | 2009 | |
|---|---|---|---|---|---|---|---|
| Core sciences | Mathematics | Students | % of cohort | Students | % of cohort | Students | % of cohort |
| No core sciences taken | No mathematics or other sciences | 131,940 | 52.4% | 137,564 | 53.2% | 156,363 | 55.1% |
| | Mathematics | 13,736 | 5.5% | 17,066 | 6.6% | 22,871 | 8.1% |
| | Mathematics and other sciences | 3,740 | 1.5% | 3,846 | 1.5% | 3,805 | 1.3% |
| | Other sciences | 29,814 | 11.8% | 26,202 | 10.1% | 22,219 | 7.8% |
| Total | | **179,230** | **71.1%** | **184,678** | **71.4%** | **205,258** | **72.3%** |
| Core sciences taken | No mathematics or other sciences | 35,346 | 14.0% | 34,046 | 13.2% | 33,662 | 11.9% |
| | Mathematics | 26,401 | 10.5% | 30,243 | 11.7% | 37,015 | 13.0% |
| | Mathematics and other sciences | 4,256 | 1.7% | 3,889 | 1.5% | 3,894 | 1.4% |
| | Other sciences | 6,677 | 2.7% | 5,629 | 2.2% | 3,969 | 1.4% |
| Total numbers taking core sciences | | **72,680** | **28.9%** | **73,807** | **28.6%** | **78,540** | **27.7%** |
| Total size of GCE A-level (only) cohort | | 251,910 | | 258,485 | | 283,798 | |

*Source:* DCSF.

(a) Mathematics includes all mathematics subjects: mathematics, pure mathematics, statistics, use of mathematics, further mathematics and additional mathematics.

sciences, were rarest (table E.4), which probably reflects the limited provision (ie availability) of other sciences courses.

Notably, increasingly fewer numbers of students took other sciences subjects, either alone or in combination with core sciences subjects.

### E.3.1 The 'other science' subcategory of 'other sciences'[52]

The limited provision of other sciences was established by examining the numbers of students taking these subjects

52 It is important to acknowledge that these categorisations are governmental.

*Table E.5. Numbers of 16–18 year old students taking core sciences GCE A-levels as a function of population size (England, 2005, 2007, 2009).*

| | 2005 | 2007 | 2009 |
|---|---|---|---|
| Total size of GCE A-level cohort | 251,910 | 258,485 | 283,798 |
| Total numbers of students taking core sciences GCE A-levels | 72,680 | 73,807 | 78,540 |
| **Percentage of A-level cohort taking core sciences A-levels** | **28.9%** | **28.6%** | **27.7%** |
| Population of 17 year olds[(a)] | 667,574 | 666,772 | 666,927 |
| **Percentage of 17 year olds taking core sciences GCE A-levels** | **10.9%** | **11.1%** | **11.8%** |

*Sources:* DCSF, ONS.

(a) All data are as at 1 April of each calendar year. The 2005 and 2007 data were revised, reflecting revisions due to improved migration, and published by ONS on 13 May 2010. The 2009 data were published by ONS on 24 June 2010.

(ie entries). Table E.6 compares the numbers of 16–18 year old students taking GCE A-level 'other science' examinations in 2005, 2007 and 2009 with the total number of students taking 'other sciences' subjects in these years. Unlike the other subjects included within the 'other sciences' category (design and technology, ICT and home economics), it was considered that those in the subcategory 'other science' contain scientific content that is most appropriate for progression to first degree level STEM studies or, conceivably, employment concerned with increasing knowledge of the natural world.

From table E.6 it may be calculated that, if psychology is excluded, there was a net 10% or so increase in the numbers taking 'other science' subjects, yet candidature in these subjects decreased from 1.6% to 1.4% as a proportion of the total A-level cohort. Indeed, it is notable that not one person took astronomy, rural science or science for public understanding in each of the years studied. As a result these subjects are not considered in further detail.

Key message E4. Participation levels in 'other sciences' A-level subjects have consistently been very low, and have progressively decreased in recent years. Regardless of whether this reflects a simple lack of demand among students or an inability or unwillingness among schools and colleges to offer these subjects, the value of continuing to offer these qualifications is questionable.

## E.4 Overall numbers of students taking core sciences

Table E.7 provides a breakdown of students taking core science A-levels by institution type in 2005, 2007 and 2009. It shows that more than half came from the maintained sector and that with the exception of the FE

*Table E.6. Numbers of 16–18 year old students taking 'other science' GCE A-levels (England, 2005, 2007, 2009).*

| Other science subject | 2005 | 2007 | 2009 |
|---|---|---|---|
| Astronomy | 0 | 0 | 0 |
| Electronics | 1,291 | 1,241 | 1,156 |
| Environmental science | 1,205 | 1,205 | 1,362 |
| Geology | 1,445 | 1,511 | 1,551 |
| Psychology (as a Science) | 5,781 | 5,197 | 0[(a)] |
| Rural science | 0 | 0 | 0 |
| Science for public understanding | 0 | 0 | 0 |
| Total no. of students taking 'Other science' | 9,722 | 9,154 | 4,069 |
| Total no. of students taking 'Other sciences' | 33,554 | 30,048 | 26,024 |
| Percentage of students taking 'other science' subjects (excluding psychology) in respect of the total GCE A-level cohort | 1.6% | 1.5% | 1.4% |

*Source:* DCSF.

(a) For the 2008/09 academic year, psychology was classified under the category 'Social sciences'.

*Table E.7. Numbers of 16–18 year old students taking core sciences GCE A-levels by institution type (England, 2005, 2007, 2009).*[(a)]

| | 2005 | 2007 | 2009 |
|---|---|---|---|
| Academies/CTCs | 521 | 556 | 946 |
| FE colleges | 6,096 | 5,673 | 5,783 |
| Independent | 14,237 | 14,193 | 14,824 |
| Maintained | 39,974 | 40,945 | 43,388 |
| Sixth Form Centres and Colleges | 11,428 | 12,140 | 12,856 |
| Other | 424 | 300 | 743 |
| **Grand total (core sciences)** | **72,680** | **73,807** | **78,540** |
| **Total size of GCE A-level cohort** | **251,910** | **258,485** | **283,798** |

*Source:* DCSF.

(a) These figures exclude 212 individuals across the three years whose gender could not be identified within the records. These confounding records have been excluded from the entire analysis.

sector, the numbers of students taking core sciences increased overall across all institutions in these years. From table E.7 it may also be calculated that the numbers of students taking combinations of core sciences increased 8% overall between 2005 and 2009, confirming what tables E.2 and E.3 have already shown.

Investigation of the numbers of students taking one or more core science subjects (B,C,P) among their GCE A-level combinations shows that the majority completed examinations in a single science subject (table E.8), regardless of the total number of A-levels taken. However, from table E.8 it may be shown that while the numbers taking one core science or two core sciences rose 6% and 13%, respectively, the numbers taking three or more core sciences A-levels fell 4%.

Most importantly, the number of students taking any core science or combination of core sciences as a percentage of the total A-level cohort in the years measured was consistently less than one-third and actually fell from 28.9% to 27.7% between 2005 and 2009 (table E.5).

*Table E.8. Numbers of 16–18 year old students taking core sciences subjects by number of GCE A-level subjects taken and number of core science subjects taken (England, 2005, 2007, 2009).*

| Number of core science subjects taken | Year | Number of GCE A-levels taken | | | | Total no. of students |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 (or more) | |
| 1 | 2005 | 1,029 | 4,095 | 22,602 | 14,233 | 41,959 |
| | 2007 | 947 | 3,766 | 22,561 | 14,341 | 41,615 |
| | 2009 | 897 | 3,993 | 25,246 | 14,283 | 44,419 |
| 2 | 2005 | | 786 | 14,797 | 11,322 | 26,905 |
| | 2007 | | 646 | 15,435 | 12,427 | 28,508 |
| | 2009 | | 666 | 16,959 | 12,818 | 30,443 |
| 3 (or more) | 2005 | | | 1,420 | 2,396 | 3,816 |
| | 2007 | | | 1,174 | 2,510 | 3,684 |
| | 2009 | | | 1,103 | 2,575 | 3,678 |
| | Grand total | 2,873 | 13,952 | 121,297 | 86,905 | |

*Source:* DCSF.

## E.5 Overall numbers of students taking core sciences together with mathematics

Across England, despite the fact that overall candidate numbers (ie across all subjects) increased in each of the years examined, the numbers of students taking core sciences combinations without mathematics (ie those taking B, BC, C, P, BCP, CP, BP) decreased 10% between 2005 and 2009. However, it is calculable from table E.9 that the numbers taking core sciences with mathematics increased by a third, in line with the increases in candidate numbers during this period, indicating the growing tendency of students to take mathematics with science. Of all the core sciences and mathematics combinations, P(M) was consistently the most popular, followed closely by BC(M), with both of these combinations being taken by 3% or 4% of all 16–18 year old GCE A-level candidates in 2005, 2007 and 2009. Notably, numbers taking single sciences (B, C, P only) accounted for approximately one-third of all students taking core sciences combinations with or without mathematics in each of these years.

But however these figures are viewed, it is inescapable that the percentages of students taking core sciences or core sciences with mathematics are very small, regardless of the institution in which they are associated (for further discussion, see § E.10).

## E.6 Overall numbers taking VCE applied science A-level combinations

Table E.10 provides an overall indication of the numbers of 16–18 year old students taking VCE examinations in applied science (single and double award). It shows that numbers fluctuated between 2005 and 2009, rising 43% from a very small base. It shows, too, that most people (more than half in 2007 and 2009) taking applied science VCE examinations did not also take mathematics or any other sciences A-levels. Notwithstanding the very small numbers of people involved (and excluding the fact that the figures for single- and double-award have been aggregated), it is notable that combinations of VCE applied science with GCE A-level mathematics and/or other sciences almost trebled during this period and that there was a near doubling in the numbers of students taking a combination of VCE applied science and other sciences.

Tables E.11 and E.12 examine the numbers of 16–18 year old students who took applied science VCE and core sciences A-levels in 2005, 2007 and 2009. Table E.11 shows that since 2007 at least two-thirds of students taking applied science VCE did not take any core sciences A-levels, and that there was a decrease in the (very small) numbers of people taking VCE applied science together with biological sciences and/or chemistry and/or physics A-levels.

Table E.12 shows that from 2005 onwards more than half the total number of students taking applied science VCEs did not take either core sciences or mathematics A-levels. Very few students taking applied science VCEs also took mathematics – but no core sciences – though their numbers more than trebled between 2005 and 2009. While data have had to be suppressed (for confidentiality reasons), and therefore cannot be shown, the numbers taking applied science VCEs together with core sciences A-levels and mathematics never exceeded 7% of all those taking applied science VCEs.

Key message E5. There was a modest growth in the numbers of students taking applied science VCE/applied A-levels between 2005 and 2009, but very few of these students also took either core sciences and/or mathematics A-levels.

# B. Science and mathematics subject combinations: gender and institutional variation

This section considers how the popularity of GCE A-level science and mathematics subject combinations varied during 2005, 2007 and 2009 according to gender and the type of educational establishment in which they were taken.

## E.7 Overall numbers taking core sciences by gender

The number of males and females taking any core sciences rose 9.5% and 6.5% overall between 2005 and 2009, and the number of males taking core sciences consistently exceeded the number of females taking them (table E.13). Perhaps the most striking observation is the consistency of subject choice among both genders: biological sciences (alone) and the singular combination BC feature in the top three choices of each gender. However, the percentage of female students who took biological sciences (alone) was almost double the equivalent percentage of males for each year measured, and the number of females who took the singular combination BC was around 15 percentage points greater than the number of males (though this differential falls over time to nearer 13 percentage points when BCP is also considered).

Across the years measured, three-quarters of females taking core sciences combinations took either biological sciences (alone) or the specific combination BC, while subject choice among males was more evenly spread, with physics (alone) being consistently the most popular core science 'combination'. The specific combination BP was consistently taken by least numbers of students regardless of gender.

Overall, core sciences combinations including:

(i) biological sciences were taken by at least 80% of females compared with 50% of males over the years surveyed;

(ii) chemistry were taken by 50%–52% of females and by 45%–47% of males, with candidature increasing by two percentage points in each gender during this period;

*Table E.9. Numbers of 16–18 year old students taking GCE A-level core sciences combinations with or without mathematics, ranked by popularity (England, 2005, 2007, 2009).*

| Subject combination | 2005 | % All GCE A | Subject combination | 2007 | % All GCE A | Subject combination | 2009 | % All GCE A |
|---|---|---|---|---|---|---|---|---|
| B | 19,500 | 7.7% | B | 18,731 | 7.2% | B | 17,990 | 6.3% |
| BC | 11,795 | 4.7% | BC | 11,818 | 4.6% | P(M) | 12,018 | 4.2% |
| P(M) | 10,151 | 4.0% | P(M) | 10,513 | 4.1% | BC | 10,976 | 3.9% |
| BC(M) | 7,327 | 2.9% | BC(M) | 8,964 | 3.5% | BC(M) | 10,947 | 3.9% |
| CP(M) | 4,816 | 1.9% | CP(M) | 5,137 | 2.0% | CP(M) | 5,800 | 2.0% |
| P | 3,552 | 1.4% | B(M) | 3,645 | 1.4% | B(M) | 4,909 | 1.7% |
| B(M) | 3,145 | 1.2% | C(M) | 3,247 | 1.3% | C(M) | 4,154 | 1.5% |
| C(M) | 2,845 | 1.1% | P | 2,883 | 1.1% | P | 2,722 | 1.0% |
| C | 2,777 | 1.1% | C | 2,605 | 1.0% | C | 2,627 | 0.9% |
| BCP | 2,428 | 1.0% | BCP | 2,113 | 0.8% | BCP | 1,877 | 0.7% |
| BCP(M) | 1,378 | 0.5% | BCP(M) | 1,562 | 0.6% | BCP(M) | 1,801 | 0.6% |
| BP(M) | 995 | 0.4% | BP(M) | 1,064 | 0.4% | BP(M) | 1,280 | 0.5% |
| CP | 990 | 0.4% | BP | 775 | 0.3% | BP | 779 | 0.3% |
| BP | 981 | 0.4% | CP | 750 | 0.3% | CP | 660 | 0.2% |
| Numbers taking core sciences combinations only | 42,023 | 16.7% | Core sciences combinations only | 39,675 | 15.3% | Core sciences combinations only | 37,631 | 13.3% |
| Numbers taking core sciences combinations with mathematics | 30,657 | 12.2% | Numbers taking core sciences combinations with mathematics | 34,132 | 13.2% | Numbers taking core sciences combinations with mathematics | 40,909 | 14.4% |
| Numbers taking core sciences combinations with/without mathematics | 72,680 | 28.9% | Numbers taking core sciences combinations with/without mathematics | 73,807 | 28.6% | Numbers taking core sciences combinations with/without mathematics | 78,540 | 27.7% |
| All students taking GCE A-levels | 251,910 | 100.0% | All students taking GCE A-levels | 258,485 | 100.0% | All students taking GCE A-levels | 283,798 | 100.0% |

*Source:* DCSF.

*Table E.10. Numbers of 16–18 year old students taking single- and double-award applied science VCE with GCE A-level mathematics and/or other sciences (England, 2005, 2007, 2009).*

| Examination(s) entered | Mathematics[a] and/or other sciences | 2005 | 2007 | 2009 |
|---|---|---|---|---|
| VCE applied science and GCE… | No mathematics or other sciences | 490 | 757 | 1,144 |
| | Mathematics | 36 | 57 | 110 |
| | Mathematics with other sciences | | | |
| | Other sciences | 118 | 156 | 232 |
| VCE only | | 835 | 208 | 624 |
| Total nos. taking applied science | | **1,479** | **1,178** | **2,110** |

*Source:* DCSF.

(a) Mathematics potentially includes: mathematics, pure mathematics, statistics, use of mathematics, further mathematics and additional mathematics.

(b) Data suppressed by the Department.

*Table E.11. Numbers of 16–18 year old students taking single- and double-award applied science (VCE) with GCE A-level core sciences and their combinations (England, 2005, 2007, 2009).*

| Examination type(s) entered | Core sciences | Core science combinations | 2005 | 2007 | 2009 |
|---|---|---|---|---|---|
| VCE applied science and GCE | Core sciences (GCE A-level) | No core sciences | 591 | 879 | 1,426 |
| | | Biological sciences | 25 | 47 | 35 |
| | | Chemistry | 21 | 24 | 10 |
| | | Physics | 7 | 6 | 5 |
| | | Biological sciences + chemistry | | 14 | 10 |
| | | Biological sciences + physics | | | |
| | | Chemistry + physics | | | |
| | Total no. of VCE applied science students taking core sciences (GCE A-level) | | 53 | 91 | 60 |
| Total nos. taking VCE applied science only | | | 835 | 208 | 624 |
| Grand total | | | 1,479 | 1,178 | 2,110 |

*Source:* DCSF.

(iii) physics were taken by 16% of females and 50% of males in 2005, 2007 and 2009, meaning that three times as many males took physics.

Key message E6. When combinations of purely core sciences subjects are considered, a clear preference for biological sciences among females and physics among males emerges, while chemistry attracts broadly similar proportions of each gender.

A very different picture of candidature emerges when combinations of core sciences with mathematics are disaggregated. Tables E.14 and E.15 compare the popularity of combinations of core sciences with or without mathematics among females and males taking GCE A-levels.

It is calculable from tables E.14 and E.15 that the proportion of females taking GCE A-level core sciences only exceeded that of males by 19.5, 18.4 and 16.9 percentage points, respectively, in 2005, 2007 and 2009. However, while at least 20% more females took core sciences A-levels in the three years covered by this study, only half as many females took core sciences in combination with mathematics than did males (in 2005)—although this differential fell to nearer

*Table E.12. Numbers of 16–18 year old students taking single- and double-award applied science VCE together with GCE A-level core sciences and mathematics subjects (England, 2005, 2007, 2009).*

| Examination type(s) entered | Core sciences | Mathematics[a] | 2005 | 2007 | 2009 |
|---|---|---|---|---|---|
| VCE/GCE | No core sciences (GCE A-level) | No mathematics | 558 | 833 | 1,318 |
| | | Mathematics | 33 | 46 | 108 |
| | Total no. not taking core sciences (GCE A-level) | GCE/VCE All with VCE applied science | **591** | **879** | **1,426** |
| | Core sciences (GCE A-level) | No mathematics | 53 | 91 | 60 |
| | | Mathematics | | | |
| Total nos. taking VCE applied science only | | | **835** | **208** | **624** |
| Grand total | | | 1,479 | 1,178 | 2,110 |

*Source:* DCSF.

(a) Mathematics potentially includes: mathematics, pure mathematics, statistics, use of mathematics, further mathematics and additional mathematics.

40% in 2009—and the number of females taking core sciences with mathematics increased 44% between these years. Nevertheless, it is evident that a considerably greater number of males than females took mathematics with core sciences.

In contrast to the relative popularity among males and females of biological sciences and the singular combination BC revealed by table E.13, tables E.14 and E.15 show that when mathematics is also taken into account, half as many females as males took the specific combination BC(M) and the number of males and females seen to be taking BC (alone) was much more even than the figures in table E.13 suggest. Moreover, while more males than females took physics alone (albeit that the difference in both numbers and percentages fell considerably between 2005 and 2009), it may be shown that males accounted for over 80% of students taking physics in combination with other core science subjects and mathematics (subject combinations P(M), CP(M), BCP(M) and BP(M)) in each year studied. Similarly, chemistry proved more popular among females, with more females taking the subject both in isolation and in combination with other core science subjects and mathematics (cf. table E.13), yet a higher and increasing percentage of males took chemistry alone.

Overall, when core sciences combinations are disaggregated, they reveal that (table E.15):

(i) the numbers of males taking core sciences combinations including biological sciences increased overall from *ca*. 19,500 to *ca*. 21,500 during 2005–09, and the percentage of these who also took mathematics increased from 15% to 21% in the same interval;

(ii) the numbers of males taking core sciences combinations including chemistry increased overall from *ca*. 17,500 to *ca*. 20,000 during 2005–09, and the percentage of these who also took mathematics increased from 24% to 30% in the same interval; and

(iii) the numbers of males taking core sciences combinations including physics increased overall from *ca*. 20,000 to *ca*. 21,000 during 2005–09, and the percentage of these who also took mathematics increased from 36% to 39% in the same interval.

By contrast, for females, the same disaggregation (table E.14) shows that:

(i) the numbers of females taking core sciences combinations including biological sciences increased overall from *ca*. 28,000 to *ca*. 29,000 during 2005–09, and the percentage of these who also took mathematics increased from 20% to 28% in the same interval;

(ii) the numbers of females taking core sciences combinations including chemistry increased overall from *ca*. 17,000 to *ca*. 19,000 during 2005–09, and the percentage of these who also took mathematics increased from 21% to 28% in the same interval; and

(iii) the numbers of females taking core sciences combinations including physics increased overall from *ca*. 5,000 to *ca*. 6,000 during 2005–09, and the percentage of these who also took mathematics increased from 10% to 12% in the same interval.

**Key message E7. Of all students who took core sciences GCE A-levels during 2005, 2007 and 2009, the proportions of males and females taking mathematics together with core sciences increased, with the former increasing by 8.5 percentage points and the latter growing by 11.2 percentage points over this period (tables E.14 and E.15).**

So far the consideration of mathematics has involved aggregating data across all mathematics GCE A-level

*Table E.13. Numbers of 16–18 year old females and males taking core sciences GCE A-level combinations (England, 2005, 2007, 2009).*

| Core sciences | 2005 | | | | 2007 | | | | 2009 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Females | | Males | | Females | | Males | | Females | | Males | |
| B | 14,291 | 42.2% | 8,352 | 21.5% | 13,951 | 40.3% | 8,422 | 21.5% | 14,056 | 39.0% | 8,843 | 20.8% |
| P | 2,088 | 6.2% | 11,612 | 29.9% | 2,250 | 6.5% | 11,144 | 28.4% | 2,625 | 7.3% | 12,115 | 28.5% |
| C | 2,494 | 7.4% | 3,127 | 8.1% | 2,697 | 7.8% | 3,155 | 8.1% | 3,132 | 8.7% | 3,649 | 8.6% |
| BC | 11,680 | 34.5% | 7,439 | 19.2% | 12,606 | 36.4% | 8,172 | 20.9% | 12,944 | 35.9% | 8,979 | 21.1% |
| BP | 563 | 1.7% | 1,413 | 3.6% | 528 | 1.5% | 1,311 | 3.3% | 586 | 1.6% | 1,473 | 3.5% |
| CP | 1,223 | 3.6% | 4,583 | 11.8% | 1,158 | 3.4% | 4,729 | 12.1% | 1,338 | 3.7% | 5,121 | 12.0% |
| BCP | 1,505 | 4.4% | 2,301 | 5.9% | 1,422 | 4.1% | 2,253 | 5.7% | 1,359 | 3.8% | 2,319 | 5.5% |
| **Grand total** | **33,844** | **100%** | **38,827** | **100%** | **34,612** | **100%** | **39,186** | **100%** | **36,040** | **100%** | **42,499** | **100%** |

*Source:* DCSF.

*Table E.14. Numbers of 16–18 year old females taking GCE A-level core sciences subject combinations (with or without mathematics), ranked by popularity (England, 2005, 2007, 2009).*

| Subject combination | 2005 | % of females taking core sciences combinations with/without mathematics | Subject combination | 2007 | % of females taking core sciences combinations with/without mathematics | Subject combination | 2009 | % of females taking core sciences combinations with/without mathematics |
|---|---|---|---|---|---|---|---|---|
| B | 12,406 | 36.7% | B | 11,734 | 33.9% | B | 11,122 | 30.9% |
| BC | 7,434 | 22.0% | BC | 7,377 | 21.3% | BC | 6,650 | 18.5% |
| BC(M) | 4,246 | 12.5% | BC(M) | 5,229 | 15.1% | BC(M) | 6,294 | 17.5% |
| B(M) | 1,885 | 5.6% | B(M) | 2,217 | 6.4% | B(M) | 2,934 | 8.1% |
| P(M) | 1,610 | 4.8% | P(M) | 1,834 | 5.3% | P(M) | 2,189 | 6.1% |
| C | 1,276 | 3.8% | C(M) | 1,467 | 4.2% | C(M) | 1,862 | 5.2% |
| C(M) | 1,218 | 3.6% | C | 1,230 | 3.6% | C | 1,270 | 3.5% |
| CP(M) | 1,031 | 3.0% | CP(M) | 1,023 | 3.0% | CP(M) | 1,233 | 3.4% |
| BCP | 1,015 | 3.0% | BCP | 868 | 2.5% | BCP | 731 | 2.0% |
| BCP(M) | 490 | 1.4% | BCP(M) | 554 | 1.6% | BCP(M) | 628 | 1.7% |
| P | 478 | 1.4% | P | 416 | 1.2% | P | 436 | 1.2% |
| BP | 296 | 0.9% | BP(M) | 295 | 0.9% | BP(M) | 339 | 0.9% |
| BP(M) | 267 | 0.8% | BP | 233 | 0.7% | BP | 247 | 0.7% |
| CP | 192 | 0.6% | CP | 135 | 0.4% | CP | 105 | 0.3% |
| All females taking core sciences combinations only | 23,097 | 68.2% | All females taking core sciences combinations only | 21,993 | 63.5% | All females taking core sciences combinations only | 20,561 | 57.1% |
| All females taking core sciences with mathematics only | 10,747 | 31.8% | All females taking core sciences with mathematics only | 12,619 | 36.5% | All females taking core sciences with mathematics only | 15,479 | 42.9% |
| All females taking core sciences with or without mathematics | 33,844 | 100% | All females taking core sciences with or without mathematics | 34,612 | 100.0% | All females taking core sciences with or without mathematics | 36,040 | 100.0% |
| Total size of female GCE A-level cohort | 135,651 | | Total size of female GCE A-level cohort | 140,297 | | Total size of female GCE A-level cohort | 153,894 | |

*Source:* DCSF.

*Table E.15. Number of 16–18 year old males taking GCE A-level core sciences subject combinations (with or without mathematics), ranked by popularity (England, 2005, 2007, 2009).*

| Subject combination | 2005 | % males taking core sciences combinations with/without mathematics | Subject combination | 2007 | % males taking core sciences combinations with/without mathematics | Subject combination | 2009 | % males taking core sciences combinations with/without mathematics |
|---|---|---|---|---|---|---|---|---|
| P(M) | 8,540 | 22.0% | P(M) | 8,677 | 22.1% | P(M) | 9,829 | 23.1% |
| B | 7,093 | 18.3% | B | 6,994 | 17.8% | B | 6,868 | 16.2% |
| BC | 4,359 | 11.2% | BC | 4,439 | 11.3% | BC(M) | 4,653 | 10.9% |
| CP(M) | 3,785 | 9.7% | CP(M) | 4,114 | 10.5% | CP(M) | 4,566 | 10.7% |
| BC(M) | 3,080 | 7.9% | BC(M) | 3,733 | 9.5% | BC | 4,326 | 10.2% |
| P | 3,072 | 7.9% | P | 2,467 | 6.3% | C(M) | 2,292 | 5.4% |
| C(M) | 1,627 | 4.2% | C(M) | 1,780 | 4.5% | P | 2,286 | 5.4% |
| C | 1,500 | 3.9% | B(M) | 1,428 | 3.6% | B(M) | 1,975 | 4.6% |
| BCP | 1,413 | 3.6% | C | 1,375 | 3.5% | C | 1,357 | 3.2% |
| B(M) | 1,259 | 3.2% | BCP | 1,245 | 3.2% | BCP(M) | 1,173 | 2.8% |
| BCP(M) | 888 | 2.3% | BCP(M) | 1,008 | 2.6% | BCP | 1,146 | 2.7% |
| CP | 798 | 2.1% | BP(M) | 769 | 2.0% | BP(M) | 941 | 2.2% |
| BP(M) | 728 | 1.9% | CP | 615 | 1.6% | CP | 555 | 1.3% |
| BP | 685 | 1.8% | BP | 542 | 1.4% | BP | 532 | 1.3% |
| All males taking core sciences only | 18,920 | 48.7% | All males taking core sciences only | 17,677 | 45.1% | All males taking core sciences only | 17,070 | 40.2% |
| All males taking core sciences with mathematics only | 19,907 | 51.3% | All males taking core sciences with mathematics only | 21,509 | 54.9% | All males taking core sciences with mathematics only | 25,429 | 59.8% |
| All males taking core sciences with or without mathematics | 38,827 | 100.0% | All males taking core sciences with or without mathematics | 39,186 | 100.0% | All males taking core sciences with or without mathematics | 42,499 | 100.0% |
| Total size of male GCE A-level cohort | 116,212 | | Total size of male GCE A-level cohort | 118,157 | | Total size of male GCE A-level cohort | 129,903 | |

*Source:* DCSF.

qualifications. When mathematics is disaggregated into mathematics and further mathematics and considered in respect of core sciences combinations and the total number of GCE A-level students, it is clear that increasing numbers of both male and female students have been combining core sciences with mathematics and with further mathematics (tables E.16 and E.17), particularly in relation to biological sciences (alone) and combinations involving BC. There have also been concomitant falls in the numbers of students of both genders not taking any mathematics

*Table E.16. Numbers of 16–18 year old males taking core sciences GCE A-levels with mathematics and further mathematics (England 2005, 2007, 2009).*

| Mathematics (overall) | Mathematics and/or further mathematics? | Core sciences | 2005 | 2007 | 2009 | Overall % change in numbers since 2005 |
|---|---|---|---|---|---|---|
| No mathematics entered | No mathematics taken | B | 7,093 | 6,994 | 6,868 | –3.2% |
| | | BC | 4,359 | 4,439 | 4,326 | –0.8% |
| | | BCP | 1,413 | 1,245 | 1,146 | –18.9% |
| | | BP | 685 | 542 | 532 | –22.3% |
| | | C | 1,500 | 1,375 | 1,357 | –9.5% |
| | | CP | 798 | 615 | 555 | –30.5% |
| | | P | 3,072 | 2,467 | 2,286 | –25.6% |
| | Total | | 18,920 | 17,677 | 17,070 | –9.8% |
| Mathematics entered | Mathematics only | B | 1,226 | 1,367 | 1,872 | 52.7% |
| | | BC | 2,911 | 3,510 | 4,367 | 50.0% |
| | | BCP | 807 | 868 | 989 | 22.6% |
| | | BP | 691 | 689 | 868 | 25.6% |
| | | C | 1,403 | 1,497 | 1,897 | 35.2% |
| | | CP | 2,814 | 2,889 | 3,077 | 9.3% |
| | | P | 6,945 | 6,621 | 7,108 | 2.3% |
| | Total | | 16,797 | 17,441 | 20,178 | 20.1% |
| | Mathematics and further mathematics | B | 33 | 61 | 103 | 212.1% |
| | | BC | 169 | 223 | 285 | 68.6% |
| | | BCP | 81 | 140 | 184 | 127.2% |
| | | BP | 36 | 80 | 73 | 102.8% |
| | | C | 222 | 283 | 395 | 77.9% |
| | | CP | 968 | 1,225 | 1,488 | 53.7% |
| | | P | 1,589 | 2,054 | 2,721 | 71.2% |
| | Total | | 3,098 | 4,066 | 5,249 | 75.2% |
| Total no. of males taking mathematics and/or further mathematics (with core sciences) | | | 19,895 | 21,507 | 25,427 | 27.8% |
| Total no. of males taking mathematics only (without any core sciences) | | | 9,314 | 10,598 | 13,266 | 42.4% |
| Total no. of students taking GCE A-level core sciences | | | 72,680 | 73,807 | 78,540 | 8.1% |
| Total size of GCE A-level cohort | | | 251,910 | 258,485 | 283,798 | 12.7% |

*Source:* DCSF.

with core sciences combinations. Growth was also evident in the numbers of males and females taking mathematics alone (or in combination with non-science subjects). Each of these increases greatly exceeded the overall rise in student numbers during this period.

Key message E8. There has been a substantial increase in the numbers of male and female students taking mathematics (and further mathematics) together with core sciences subjects, but many more males than females take mathematics.

*Table E.17. Numbers of 16–18 year old females taking core sciences GCE A-levels with mathematics and further mathematics (England, 2005, 2007, 2009).*

| Mathematics (overall) | Mathematics and/or further mathematics? | Core sciences | 2005 | 2007 | 2009 | Overall % change in numbers since 2005 |
|---|---|---|---|---|---|---|
| No mathematics taken | No mathematics taken | B | 12,406 | 11,734 | 11,122 | –10.3% |
| | | BC | 7,434 | 7,377 | 6,650 | –10.5% |
| | | BCP | 1,015 | 868 | 731 | –28.0% |
| | | BP | 296 | 233 | 247 | –16.6% |
| | | C | 1,276 | 1,230 | 1,270 | –0.5% |
| | | CP | 192 | 135 | 105 | –45.3% |
| | | P | 478 | 416 | 436 | –8.8% |
| | Total | | 23,097 | 21,993 | 20,561 | –11.0% |
| Mathematics taken | Mathematics only | B | 1,829 | 2,140 | 2,811 | 53.7% |
| | | BC | 4,115 | 5,000 | 5,975 | 45.2% |
| | | BCP | 463 | 509 | 565 | 22.0% |
| | | BP | 255 | 274 | 304 | 19.2% |
| | | C | 1,075 | 1,274 | 1,577 | 46.7% |
| | | CP | 754 | 709 | 808 | 7.2% |
| | | P | 1,230 | 1,289 | 1,434 | 16.6% |
| | Total | | 9,721 | 11,195 | 13,474 | 38.6% |
| | Mathematics and further mathematics | B | 56 | 77 | 123 | 119.7% |
| | | BC | 130 | 229 | 319 | 145.4% |
| | | BCP | 25 | 45 | 63 | 152.0% |
| | | BP | 12 | 21 | 35 | 191.7% |
| | | C | 142 | 193 | 285 | 100.7% |
| | | CP | 276 | 314 | 425 | 54.0% |
| | | P | 379 | 545 | 755 | 99.2% |
| | Total | | 1,020 | 1,424 | 2,005 | 96.6% |
| Total no. of females taking mathematics and/or further mathematics (and core sciences) | | | 10,741 | 12,619 | 15,479 | 44.1% |
| Total no. of females taking mathematics only (without any core sciences) | | | 6,938 | 8,435 | 10,892 | 56.9% |
| Total no. of students taking GCE A-level core sciences | | | 72,680 | 73,807 | 78,540 | 8.1% |
| Total size of GCE A-level cohort | | | 251,910 | 258,485 | 283,798 | 12.7% |

*Source:* DCSF.

## E.8 Numbers of 16–18 year old students taking core sciences: institutional differences

### E.8.1 Background

In the account that follows, it is worth bearing in mind that the total number of institutions (schools and colleges) in England grew 2.5% between 2007 and 2009 (calculable from table E.18). While the number of maintained secondary schools and sixth form centres and colleges both fell very slightly from year to year during this period, the number of FE sector colleges also decreased 5% overall. However, the numbers of academies more than trebled, there was a near six-fold increase in the numbers of 'other' institutions and the number of independent schools also grew overall.

### E.8.2 Analysis

It is calculable from table E.18 that the number of 16–18 year old students taking GCE A-levels in England increased across all institutions (by 13% overall) between 2005 and 2009. The maintained sector was by far the largest contributor, consistently accounting for over 60% of all relevant educational institutions and 50% or more of all 16–18 year old GCE A-level candidates. The independent sector was the second most sizeable in terms of the number of institutions (21%), but only contributed between 13% and 14% of all 16–18 year old GCE A-level candidates in 2005, 2007 and 2009. By contrast, sixth form centres accounted for just 4% of all institutions but contributed *ca*. 20% of all such candidates. Similarly, *ca*. 9% of all institutions were FE sector colleges, which accounted for a very similar percentage of A-level candidates to that provided by the independent sector. The number of new academies more than trebled during the study period, but still accounted for just 1% of all A-level candidates in 2009.

Within each school type, it is striking that while there are about a third as many independent schools as there are maintained schools, with around a quarter the number of 16–18 year old GCE A-level students, a higher proportion of students in independent schools (*ca*. 10%) took core sciences A-levels in 2005, 2007 and 2009 and the proportionate participation of students in core sciences was highest in independent schools compared with all other institution types. In addition, it can be calculated from table E.18 that little more than a quarter of all 16–18 year old students took core sciences A-levels.

Tables AE.2–AE.7 compare the numbers of students across each institution type who took core sciences A-levels with the number of core science subjects they took in respect of the total numbers of A-levels they took. They show that, across all institution types, it was most common for students to take three A-levels, and for them to take either two or three core sciences in combination.

Of all the core sciences subject 'combinations' taken, consistently the most popular were B, P and BC (alone), and this is consistently observable across all institution types (tables AE.8–AE.13). However, BCP (all core sciences) was universally one of the least popular core science combinations, and BP was actually the least popular core science subject combination. Notably, when compared, the percentages of students taking each combination show a high degree of consistency across all institution types (tables AE.8–AE.13).

Disaggregation of numbers taking core sciences with mathematics across institution type (tables AE.14–AE.19) reveals a fair amount of consistency in respect of the top five BCP(M) combinations chosen by students. Biological sciences (alone) and the specific combinations BC, P(M) and BC(M) were always among the top five combinations taken by students in the largest sectors (maintained, independent, sixth form and FE), but by 2009 the combination CP(M) had replaced P as the fifth most popular option across all of these types of institution. Perhaps the most dramatic change took place in the independent sector, where P(M) became the most popular combination in 2009, the first time within the time-period measured that a physics combination was observed as being the most popular in any sector.

On the evidence of the three years studied, table E.19 shows (i) that most students who take vocational A-levels (VCEs) in applied science come from maintained schools and sixth form centres and (ii) that very few students take a combination of GCE A-levels and VCEs.

# C. Attainment in GCE A-level core sciences and mathematics subject combinations

While information on the numbers taking science and mathematics A-levels provides an indication of the size of the 'pool of talent' available to study for first degrees in science, technology, engineering or mathematics, a more refined understanding of this pool may be gained from considering attainment data.

Since entry into many higher education first degree courses is dependent on students gaining combinations of A–C grades, this section examines the proportion of the pool that gained good GCE A-levels in combinations of core sciences and core sciences with mathematics among students taking three (or more) A-levels (three being the modal number of A-level subjects taken (cf. table E.8)). Although students gaining grades A–C in a single core science or mathematics subjects may subsequently go on to pursue STEM studies at higher education level, generally it is expected that students wishing to study for a STEM first degree will have gained passes in at least two 'science-related subjects' at A-level (notwithstanding their attainment in other subjects).[53]

53 Science Community Representing Education 2009 *Choosing the right STEM degree course. Investigating the information available for prospective applicants*. London: SCORE.

Table E.18. *Comparison of the numbers of educational institutions with the numbers of 16–18 year old students taking GCE A-level qualifications (England, 2005, 2007, 2009).*

| Type of institution | Nos. of institution type | | | No. of 16–18 year old students taking examinations in GCE A-level subjects only | | | Percentage of students taking core sciences GCE A-levels by institution type[b] | | | Number of students taking core sciences GCE A-levels by institution type as a function of the total A-level cohort taking core sciences A-levels | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 |
| Academy/CTC[a] | 24 | 32 | 78 | 1,552 | 1,855 | 3,863 | 33.6% | 30.0% | 24.5% | 0.7% | 0.8% | 1.2% |
| FE sector | 269 | 240 | 255 | 31,929 | 29,981 | 33,955 | 19.1% | 18.9% | 17.0% | 8.4% | 7.7% | 7.4% |
| Independent | 580 | 575 | 588 | 35,108 | 35,793 | 38,275 | 40.6% | 39.7% | 38.7% | 19.6% | 19.2% | 18.9% |
| Maintained | 1,755 | 1,736 | 1,729 | 133,280 | 138,786 | 148,891 | 30.0% | 29.5% | 29.1% | 55.0% | 55.5% | 55.2% |
| Sixth Form Centres and Colleges | 118 | 112 | 106 | 48,755 | 51,012 | 55,435 | 23.4% | 23.8% | 23.2% | 15.7% | 16.4% | 16.4% |
| Other | 13 | 20 | 72 | 1,286 | 1,058 | 3,379 | 33.0% | 28.4% | 22.0% | 0.6% | 0.4% | 0.9% |
| **Total** | **2,759** | **2,715** | **2,828** | **251,910** | **258,485** | **283,798** | **72,680** | **73,807** | **78,540** | **100.0%** | **100.0%** | **100.0%** |

*Source:* DCSF.

(a) CTC, city technology college.

(b) The actual numbers of 16–18 students taking GCE A-level core sciences may be found in tables AE.8–AE.13.

*Table E.19. Numbers of 16–18 year old students taking VCE applied science in isolation or in combination with GCE A-level science or mathematics subjects by institution type (England, 2005, 2007, 2009).*

<table>
<tr><th rowspan="2">Examination types</th><th rowspan="2">Mathematics or other sciences</th><th colspan="3">Academy/CTC</th><th colspan="3">FE sector</th><th colspan="3">Independent</th></tr>
<tr><th>2005</th><th>2007</th><th>2009</th><th>2005</th><th>2007</th><th>2009</th><th>2005</th><th>2007</th><th>2009</th></tr>
<tr><td rowspan="4">GCE/VCE</td><td>No mathematics or other sciences</td><td rowspan="3">20</td><td rowspan="3">51</td><td rowspan="3">84</td><td>47</td><td>50</td><td>73</td><td rowspan="5">6</td><td rowspan="5">14</td><td rowspan="5">9</td></tr>
<tr><td>Mathematics</td><td rowspan="2">11</td><td rowspan="2">8</td><td rowspan="2">5</td></tr>
<tr><td>Mathematics and other sciences</td></tr>
<tr><td>Other sciences</td><td></td><td></td><td></td><td>12</td><td>10</td><td>10</td></tr>
<tr><td>VCE</td><td>VCE only</td><td>25</td><td>9</td><td>51</td><td>288</td><td>55</td><td>92</td></tr>
<tr><td colspan="2">Grand total</td><td>45</td><td>60</td><td>135</td><td>358</td><td>123</td><td>180</td><td>6</td><td>14</td><td>9</td></tr>
</table>

<table>
<tr><th rowspan="2">Examination types</th><th rowspan="2">Mathematics or other sciences</th><th colspan="3">Maintained</th><th colspan="3">Other</th><th colspan="3">Sixth form centres and colleges</th></tr>
<tr><th>2005</th><th>2007</th><th>2009</th><th>2005</th><th>2007</th><th>2009</th><th>2005</th><th>2007</th><th>2009</th></tr>
<tr><td rowspan="4">GCE/VCE</td><td>No mathematics or other sciences</td><td>286</td><td>475</td><td>711</td><td rowspan="5">10</td><td rowspan="5">11</td><td rowspan="5">23</td><td>131</td><td>177</td><td>275</td></tr>
<tr><td>Mathematics</td><td rowspan="2">17</td><td rowspan="2">29</td><td rowspan="2">74</td><td rowspan="3">25</td><td rowspan="3">61</td><td rowspan="3">72</td></tr>
<tr><td>Mathematics and other sciences</td></tr>
<tr><td>Other sciences</td><td>84</td><td>88</td><td>160</td></tr>
<tr><td>VCE</td><td></td><td>309</td><td>89</td><td>332</td><td>208</td><td>51</td><td>139</td></tr>
<tr><td colspan="2">Grand total</td><td>696</td><td>681</td><td>1,277</td><td>10</td><td>11</td><td>23</td><td>364</td><td>289</td><td>486</td></tr>
</table>

*Source:* DCSF.

## E.9 Numbers of students taking three or more GCE A-levels and obtaining grades A–C in two or more core sciences and/or mathematics subjects

### E.9.1 Overview

Table E.20 provides summary data on the numbers of students taking three or more GCE A-levels and gaining A–C grades in two or more core science and/or mathematics subjects. It shows that between 2005 and 2009 the percentage of these students gaining grades A–C grades increased from 69% to 73%, and the proportion of students gaining straight A grades in at least two core sciences and/or mathematics rose to more than a quarter of all such students. Even so, it may be calculated that the percentage of those taking core sciences and/or mathematics qualifications that were (i) either just taking a single science and/or (ii) not being awarded (an) A–C grade(s) fell from 31% to 28%.

Key message E9. There has been an increase in the numbers and proportions of students taking three or more A-levels and gaining A–C grades in at least two core sciences and/or mathematics subjects. Also, the proportion of such students who fail to attain these grades in two or more core sciences and/or mathematics subjects has fallen.

### E.9.2 Comparison by institution type

Table E.21 breaks the figures in table E.20 down by institution type and compares these with the total number of students taking A-levels in each type of institution. Perhaps the most striking observation to be made is that in 2005 and 2007 similar numbers of students in the

*Table E.20. Numbers of 16–18 year old students taking three or more GCE A-levels and gaining grades A–C in two or more core sciences and/or mathematics subjects (England, 2005, 2007, 2009).*

| Grades | 2005 Students | 2005 % | 2007 Students | 2007 % | 2009 Students | 2009 % |
|---|---|---|---|---|---|---|
| All A | 10,953 | 23.7% | 13,119 | 26.3% | 15,381 | 27.5% |
| A–B | 22,323 | 48.3% | 25,474 | 51.1% | 29,342 | 52.5% |
| A–C | 31,983 | 69.1% | 35,715 | 71.6% | 40,480 | 72.5% |
| Other[(a)] | 14,273 | 30.9% | 14,184 | 28.4% | 15,367 | 27.5% |
| Grand total | 46,256 | 100.0% | 49,899 | 100.0% | 55,847 | 100.0% |
| Total no. of 16–18 year old students taking core sciences | 72,680 | | 73,807 | | 78,540 | |

*Source:* DCSF.

(a) Other denotes candidates who were not awarded a grade A, B or C in *all* their science or mathematics A-levels. Data for 'other' are not cumulative.

independent sector gained straight A grades in two or more core sciences or mathematics subjects compared with students in the maintained sector, despite the fact that the size of the cohort taking A-levels in independent schools was approximately one-quarter the size of that of the maintained sector during the years investigated. That said, the figures for 2009 appear to indicate a substantial increase in the numbers of maintained school students gaining straight A grades compared with their peers in the independent sector. Indeed, while the proportion of maintained sector students attaining straight A grades increased from 10% to *ca*. 13%, the percentage change in the number of students being awarded straight A grades increased 51% between 2005 and 2009.

Of all students taking core science and/or mathematics A-levels, the proportion of students being awarded straight A grades in the FE sector remained constant over the whole time-period; and although it increased by just 1% in sixth form colleges, this belies a near 50% increase in actual numbers gaining straight A grades in this sector.

In respect of all students taking core sciences and/or mathematics A-levels in this time-period, within the bounds of this analysis, the proportion of students taking three A-levels and being awarded A–C grades in two core sciences/mathematics subjects increased overall among maintained schools and sixth form colleges (by 3% and by 1%, respectively), and by a much smaller amount in the rapidly expanding academies sector, it decreased in the independent and FE sectors (by 1% and by less than 1%, respectively). Notably, approximately half of all students taking two or more core sciences and/or mathematics subjects in a suite of three or more A-levels fail to attain good grades in one or more of them.

Key message E10. There has been a substantial increase in the number of students in maintained schools taking three or more A-levels and gaining A grades in two or more core sciences and/or mathematics subjects.

### E.9.3 Comparison by subject combination (aggregated data for all institution types)

The data in table E.20 may also be disaggregated by core sciences and/or mathematics combinations to show the numbers of students taking three A-levels and gaining A, A or B and A–C grades in at least two core sciences and/or mathematics combinations (table E.22), compared with the total numbers of students taking core sciences and/or mathematics in each year.

Against the background of an 8% overall increase in the numbers taking core sciences and/or mathematics combinations between 2005 and 2009, table E.22 shows that there were increases in the numbers obtaining good A-levels in these subjects, with overall increases in the numbers gaining straight A grades, A or B grades and A–C grades (equivalent to 40%, 31% and 27% rises, respectively) and a much lower level of increase in the numbers failing to gain good grades in combinations of these subjects (up 8% over this time-period). There were also healthy increases in the numbers of students gaining good A-levels in combinations of mathematics subjects.

A more detailed examination of table E.22 shows that there were increases in the numbers obtaining good A-levels in what were consistently the five most popular combinations taken (B,[54] BC, BC(M), CP(M) and P(M); cf. table E.9), with the exception of BC, where a 1.6% overall increase in straight A grades was offset by 2.1% and 5.4% decreases in the numbers of students gaining A or B and A–C grades.

54 Owing to the focus on two (or more) subject combinations, biology by itself has to be excluded from this analysis.

*Table E.21. Numbers of 16–18 year old students taking three or more GCE A-levels and gaining grades A–C in two or more core sciences and/or mathematics subjects, split by institution type (England, 2005, 2007, 2009).*

| Type of institution | Grades | 2005 Students | 2005 % | 2007 Students | 2007 % | 2009 Students | 2009 % |
|---|---|---|---|---|---|---|---|
| Academy/CTC | All A | 56 | 0.1% | 63 | 0.1% | 120 | 0.2% |
| | A–B | 125 | 0.3% | 144 | 0.3% | 260 | 0.5% |
| | A–C | 184 | 0.4% | 235 | 0.5% | 405 | 0.7% |
| | Other | 130 | 0.3% | 116 | 0.2% | 214 | 0.4% |
| Total no. of students taking core sciences and/or mathematics combinations in academies/CTCs | | 1,552 | | 1,855 | | 3,863 | |
| FE sector | All A | 454 | 1.0% | 454 | 0.9% | 537 | 1.0% |
| | A–B | 1,159 | 2.5% | 1,145 | 2.3% | 1,295 | 2.3% |
| | A–C | 1,909 | 4.1% | 1,923 | 3.9% | 2,105 | 3.8% |
| | Other | 1,434 | 3.1% | 1,490 | 3.0% | 1,483 | 2.7% |
| Total no. of students taking core sciences and/or mathematics combinations in FE sector colleges | | 31,929 | | 29,981 | | 33,955 | |
| Independent | All A | 4,341 | 9.4% | 4,903 | 9.8% | 5,461 | 9.8% |
| | A–B | 7,352 | 15.9% | 7,949 | 15.9% | 8,689 | 15.6% |
| | A–C | 9,226 | 19.9% | 9,777 | 19.6% | 10,540 | 18.9% |
| | Other | 1,690 | 3.7% | 1,599 | 3.2% | 1,677 | 3.0% |
| Total no. of students taking core sciences and/or mathematics combinations in independent schools | | 35,108 | | 35,793 | | 38,275 | |
| Maintained | All A | 4,660 | 10.1% | 5,847 | 11.7% | 7,051 | 12.6% |
| | A–B | 10,440 | 22.6% | 12,391 | 24.8% | 14,431 | 25.8% |
| | A–C | 15,676 | 33.9% | 18,070 | 36.2% | 20,672 | 37.0% |
| | Other | 8,563 | 18.5% | 8,433 | 16.9% | 9,076 | 16.3% |
| Total no. of students taking core sciences and/or mathematics combinations in maintained schools | | 133,280 | | 138,786 | | 148,891 | |
| Other | All A | 46 | 0.1% | 43 | 0.1% | 130 | 0.2% |
| | A–B | 117 | 0.3% | 97 | 0.2% | 265 | 0.5% |
| | A–C | 182 | 0.4% | 132 | 0.3% | 380 | 0.7% |
| | Other | 88 | 0.2% | 37 | 0.1% | 123 | 0.2% |
| Total no. of students taking core sciences and/or mathematics combinations in other schools | | 1,286 | | 1,058 | | 3,379 | |
| Sixth form centres and colleges | All A | 1,396 | 3.0% | 1,809 | 3.6% | 2,082 | 3.7% |
| | A–B | 3,130 | 6.8% | 3,748 | 7.5% | 4,402 | 7.9% |
| | A–C | 4,806 | 10.4% | 5,578 | 11.2% | 6,378 | 11.4% |
| | Other | 2,368 | 5.1% | 2,509 | 5.0% | 2,794 | 5.0% |
| Total no. of students taking core sciences and/or mathematics combinations in sixth form centres and colleges | | 48,755 | | 51,012 | | 55,435 | |
| Total no. of students taking at least three GCE A-levels and two or more core sciences and/or mathematics subjects | | 46,256 | 100.0% | 49,899 | 100.0% | 55,847 | 100.0% |
| Total no. of students taking core sciences | | 72,680 | | 73,807 | | 78,540 | |

*Source:* DCSF.

*Table E.22. Numbers of 16–18 year old students taking three or more GCE A-levels and gaining A–C grades in at least two core sciences and/or mathematics subjects (England, 2005, 2007, 2009).*

| | All A | | | A–B | | | A–C | | | Other[b] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Subject combination[a] | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 |
| BC | 1,808 | 1,927 | 1,837 | 4,547 | 4,829 | 4,453 | 7,217 | 7,427 | 6,830 | 4,012 | 3,902 | 3,656 |
| BC(M) | 2,312 | 3,169 | 3,892 | 4,432 | 5,570 | 6,923 | 5,775 | 7,243 | 8,892 | 1,518 | 1,719 | 2,046 |
| BCP | 452 | 419 | 364 | 1,064 | 990 | 820 | 1,590 | 1,418 | 1,211 | 831 | 694 | 662 |
| BCP(M) | 688 | 776 | 976 | 1,022 | 1,198 | 1,438 | 1,201 | 1,402 | 1,625 | 163 | 156 | 170 |
| B(M) | 460 | 560 | 804 | 1,116 | 1,378 | 1,961 | 1,800 | 2,206 | 3,036 | 1,156 | 1,268 | 1,612 |
| BP | 45 | 26 | 26 | 142 | 129 | 107 | 319 | 259 | 264 | 538 | 446 | 420 |
| BP(M) | 146 | 192 | 191 | 378 | 419 | 499 | 627 | 670 | 818 | 367 | 393 | 462 |
| C(M) | 655 | 833 | 1,115 | 1,358 | 1,588 | 2,124 | 1,908 | 2,207 | 2,854 | 764 | 852 | 1,044 |
| CP | 63 | 37 | 40 | 187 | 131 | 122 | 371 | 255 | 228 | 474 | 387 | 343 |
| CP(M) | 1,664 | 1,831 | 2,117 | 2,877 | 3,121 | 3,583 | 3,747 | 4,026 | 4,568 | 1,061 | 1,109 | 1,228 |
| M(+M) | 540 | 787 | 1,108 | 769 | 1,219 | 1,686 | 960 | 1,507 | 2,064 | 238 | 324 | 368 |
| P(M) | 2,120 | 2,562 | 2,911 | 4,431 | 4,902 | 5,626 | 6,467 | 7,095 | 8,090 | 3,143 | 2,925 | 3,356 |
| Grand total | 10,953 | 13,119 | 15,381 | 22,323 | 25,474 | 29,342 | 31,983 | 35,715 | 40,480 | 14,273 | 14,184 | 15,367 |
| Total no. of students taking core sciences combinations | 72,680 | 73,807 | 78,540 | 72,680 | 73,807 | 78,540 | 72,680 | 73,807 | 78,540 | 72,680 | 73,807 | 78,540 |

*Source:* DCSF.

(a) Data for combinations of biological sciences and human biology have had to be suppressed.

(b) Other denotes candidates who were not awarded a grade A, B or C in *all* their science or mathematics A-levels. This category includes students awarded grades D, E and U grades.

*Table E.23. Numbers of 16–18 year old students taking three or more GCE A-levels and gaining A–C grades in at least two core sciences/mathematics subjects (top five most popular combinations) (England, 2005, 2007, 2009).*

| Institution | Top five core sciences/ mathematics combinations | 2005 A–C | 2007 A–C | 2009 A–C |
|---|---|---|---|---|
| Maintained sector | B[(a)] | 0 | 0 | 0 |
| | BC | 3,458 | 3,706 | 3,464 |
| | BC(M) | 2,782 | 3,604 | 4,564 |
| | CP(M) | 1,885 | 2,090 | 2,299 |
| | P(M) | 3,192 | 3,553 | 4,053 |
| Maintained sector total (top five) | | **11,317** | **12,953** | **14,380** |
| Total no. of students taking core sciences combinations in maintained schools | | **39,974** | **40,945** | **43,388** |
| % of students taking at least three GCE A-levels and gaining A–C grades in at least two of the top five most popular sciences/mathematics combinations | | 28.3% | 31.6% | 33.1% |
| Independent sector | B[(a)] | 0 | 0 | 0 |
| | BC | 1,961 | 1,782 | 1,579 |
| | BC(M) | 1,657 | 2,009 | 2,225 |
| | CP(M) | 1,182 | 1,259 | 1,375 |
| | P(M) | 1,756 | 1,918 | 2,185 |
| Independent sector total (top five) | | **6,556** | **6,968** | **7,364** |
| Total no. of students taking core sciences combinations in independent schools | | **14,237** | **14,193** | **14,824** |
| % of students taking at least three GCE A-levels and gaining A–C grades in at least two of the top five most popular sciences/mathematics combinations | | 46.0% | 49.1% | 49.7% |
| FE sector | B[(a)] | 0 | 0 | 0 |
| | BC | 408 | 425 | 385 |
| | BC(M) | 330 | 336 | 414 |
| | CP(M) | 236 | 188 | 203 |
| | P(M) | 460 | 431 | 492 |
| FE sector total (top five) | | **1,434** | **1,380** | **1,494** |
| Total no. of students taking core sciences combinations in FE sector colleges | | **6,096** | **5,673** | **5,783** |
| % of students taking at least three GCE A-levels and gaining A–C grades in at least two of the top five most popular sciences/mathematics combinations | | 23.5% | 24.3% | 25.8% |
| Sixth Form Centres and Colleges | B[(a)] | 0 | 0 | 0 |
| | BC | 1,289 | 1,423 | 1,267 |
| | BC(M) | 953 | 1,226 | 1,515 |
| | CP(M) | 405 | 445 | 601 |
| | P(M) | 978 | 1,119 | 1,203 |
| Sixth form centres and colleges total (top five) | | **3,625** | **4,213** | **4,586** |
| Total no. of students taking core sciences and/or mathematics combinations in sixth form centres and colleges | | **11,428** | **12,140** | **12,856** |
| % of students taking at least three GCE A-levels and gaining A–C grades in at least two of the top five most popular sciences/mathematics combinations | | 31.7% | 34.7% | 35.7% |

| | | | | |
|---|---|---|---|---|
| Academy/CTC | B[(a)] | 0 | 0 | 0 |
| | BC | 46 | 54 | 63 |
| | BC(M) | 30 | 43 | 96 |
| | CP(M) | 23 | 33 | 61 |
| | P(M) | 42 | 55 | 78 |
| Academy/CTC total | | 141 | 185 | 298 |
| Total no. of students taking core sciences combinations in academies and CTCs | | 521 | 556 | 946 |
| % of students taking at least three GCE A-levels and gaining A–C grades in at least two of the top five most popular sciences/mathematics combinations | | 27.0% | 33.3% | 31.5% |

*Source:* DCSF.

(a) Number taking biology and human biology.

It is worth highlighting, too, that the numbers of students gaining straight A grades, A or B grades and A–C grades in the specific combination BC(M) increased 68%, 56% and 54%, respectively, between 2005 and 2009. Further, in comparison with the total number of students taking BC(M) (cf. the figures in table E.9),[55] it may be calculated from table E.22 that the numbers gaining straight A grades in this combination rose from 31.5% to 35.6% and that the numbers gaining A–C grades rose from 79% to 81% over the same period.

### E.9.4 Comparison by subject combination and institution

Table E.23 disaggregates the data in table E.21 and combines these data with information from table E.22. This makes it possible to shed light on the distribution of students gaining good A-levels (A–C grades) in the top five most popular core sciences and/or mathematics combinations across the five largest types of institutions.

Table E.23 shows that the numbers of students who sat three or more A-levels and took two or more of the five most popular core sciences and/or mathematics combinations and gained good grades in them increased overall across all institutions during 2005–09. While *ca*. 50% of these students in independent schools gained A–C grades, equivalent performance among such students in all other institution types was considerably lower.

Across all institutions, the numbers taking three A-levels and gaining good grades in the specific combination BC fell during this time-period or remained static, but they increased amongst those taking the combinations BC(M) and P(M), particularly in the maintained sector (where the numbers achieving good grades in BC(M) increased 64% over this period).

55 The relevant figures are 7,327, 8,964 and 10,947 for 2005, 2007 and 2009.

# Wales

## W.1 Introduction

This chapter considers data on the A-level (GCE science/mathematics and applied science equivalent) examinations taken by 16–18 year old students in Wales during 2005, 2007 and 2009. The data were received directly from the Welsh Assembly's School Statistics and Post-16 Education Statistics departments.

Regretfully, data for 2005 A-level and VCE examinations in the FE sector were not available, so the analysis for Wales is therefore incomplete. This may best be explained as follows. The Lifelong Learning Wales Record (LLWR) was introduced in the 2003/04 academic year as the new data collection system for further education and local authority community learning, and by 2004/05 it was also used to collect all work-based learning (WBL) data, and replaced the two legacy collection systems. At this stage award data were submitted via the LLWR, but it was not until 2006/07 that a direct link was established between the learning activity data and the award data. As a consequence 2006/07 was the first year for which attainment data were published, which means that for the purposes of this report there are no attainment data available for the FE sector in Wales in 2005.[56] Owing to these data constraints, the number of students in the 2005 cohort will not be compared to cohort numbers in 2007 and 2009, and tabular data for 2005 will be shaded to provide a visual reminder warning.

For details of the methodology used for the analysis, please refer to the electronic appendix accompanying this report (http://royalsociety.org/education-policy/projects/).

This chapter is divided into three major sections, as follows:

Section A. Summary data on all 16–18 students taking science and/or mathematics subject combinations in 2005, 2007 and 2009.

Section B. A more detailed examination of core sciences and mathematics GCE A-level combinations candidature among 16–18 year old students, considering variation by gender and institution type.

Section C. An analysis of attainment in GCE A-level core sciences and mathematics subject combinations.

## W.2 Background information

### W.2.1 Subjects and institution types investigated

For the purposes of this report, the following subjects and institutions, as categorised within the datasets provided by the Welsh Assembly, were investigated.

56 Siobhan Evans (Post-16 Education Statistics, Welsh Assembly Government), personal communications, 4 August 2010 and 14 January 2011.

#### *W.2.1.1 Science*

Science includes: the 'core' sciences (biology, human biology,[57] chemistry and physics), other science (an umbrella term encompassing astronomy, electronics, environmental, geology, psychology (as a science), rural science and science for public understanding) and applied science.

#### *W.2.1.2 Mathematics*

Mathematics includes the following subjects: mathematics, statistics and further mathematics.

### W.2.2 Institution types

Institution types were pre-categorised by the Assembly as, Maintained, Independent, and Further Education. Table W.11 includes comparative data on the number of each of these institutions in which GCE A-levels were taken.

## W.3 Entries and students

It is important to distinguish between entries (a simple count of the numbers of examinations taken) from the individual combinations of subjects taken by individual candidates. Table W.1 illustrates this distinction by comparing the number of A-level and vocational A-level (VCE) examinations taken in 2005, 2007 and 2009 with the number of A-level candidates. It also shows the proportions of the total number of entries across all subjects represented by the number of entries to each subject or subject group.

The figures in table W.1 give an initial indication of the popularity of different subjects and indicate changes in their relative popularity over time in Wales. They show a greater number of entries for social sciences and arts subjects than for the core sciences, with core science subjects forming less than 20% of A-level entries in Wales in any given year. The rate of growth was also smaller amongst the core sciences than in social sciences and arts.

The numbers who entered mathematics and other science subjects rose 3.3% and 12.3%, respectively, between 2007 and 2009. Of the core sciences, chemistry and physics showed growth of 5–7%, which exceeded the overall percentage growth of A-level entries. The numbers taking biological sciences dropped 4.7% in the same period. The data also show a 12% drop in the entries across all VCE subjects between 2005 and 2009.

57 The categorisation 'biological sciences', used throughout this chapter, combines data on students taking biology and human biology. Over the three years measured, a total of just four students in Wales took human biology. Owing to data suppression issues, it was decided not to analyse human biology combinations separately.

*Table W.1. Comparison of GCE and VCE A-level entries and candidate numbers among 16–18 year old students (Wales, 2005, 2007, 2009).*

| Subject group | 2005[58] Entries | 2005[58] % all GCE A-level entries | 2007 Entries | 2007 % all GCE A-level entries | 2009 Entries | 2009 % all GCE A-level entries | Overall percentage change in entries since 2007 | |
|---|---|---|---|---|---|---|---|---|
| Biological sciences | 2,370 | 8.5% | 2,658 | 7.3% | 2,532 | 6.7% | –4.7% | |
| Chemistry | 1,712 | 6.2% | 1,982 | 5.4% | 2,115 | 5.6% | 6.7% | |
| Physics | 1,144 | 4.1% | 1,344 | 3.7% | 1,418 | 3.8% | 5.5% | |
| All core sciences (total) | 5,226 | 18.8% | 5,984 | 16.4% | 6,065 | 16.2% | 1.4% | |
| Other sciences | 2,437 | 8.8% | 3,312 | 9.1% | 3,421 | 9.1% | 3.3% | |
| Mathematics | 2,222 | 8.0% | 2,925 | 8.0% | 3,286 | 8.8% | 12.3% | |
| Arts | 6,338 | 22.8% | 8,539 | 23.4% | 9,177 | 24.5% | 7.5% | |
| MFL[(a)] | 2,157 | 7.8% | 2,583 | 7.1% | 2,408 | 6.4% | –6.8% | |
| Social sciences | 8,164 | 29.4% | 11,440 | 31.4% | 11,773 | 31.4% | 2.9% | |
| Other subjects | 1,208 | 4.4% | 1,646 | 4.5% | 1,397 | 3.7% | –15.1% | |
| Total number of entries across all GCE A-level subjects | 27,752 | 100.0% | 36,429 | 100.0% | 37,527 | 100.0% | 3.0% | N/A |
| Total number of entries across all vocational A-level subjects (VCE) | 2,400 | | 2,217 | | 2,107 | | –5.0% | |
| Total number of entries to VCE applied science (single and double award) | 17 | | 28 | | 39 | | 39.3% | |
| Total number of entries (all GCE/ VCE subjects) | 30,152 | | 38,646 | | 39,634 | | 2.6% | |
| Total size of GCE/VCE A-level cohort | 11,701 | | 15,198 | | 15,558 | | 2.4% | |

*Source:* Welsh Assembly Government.

(a) MFL, modern foreign languages.

Applied science (single and double award) accounted for less than 2% of all entries to vocational qualifications included in this dataset for each of the years investigated, and although entries to applied science more than doubled between 2005 and 2009, the level of candidature was extremely low. VCE subjects consisted of around 5% of all exam entries in Wales in 2007 and 2009.

Comparison of the total numbers of entries to GCE A-levels and vocational A-levels (VCE) in 2007 and 2009 shows that GCE A-levels consistently account for more than 90% of all entries (table W.1). However, while the total number of entries to all GCE A-levels remained stable, entries to vocational A-levels (all subjects) fell by 12% overall between 2007 and 2009. (In contrast, it is gratifying to note, across the same time-period, that entries to single and double award VCE applied science more than doubled, albeit from a very small base.)

## A. Overall data on science and mathematics combinations taken by all A-level and VCE candidates in Wales during 2005, 2007 and 2009

### W.4 Overall numbers of students taking GCE A-levels in core sciences, mathematics and other sciences[59]

Details of the numbers of GCE A-level students in Wales who (i) took or did not take core sciences (biological sciences

58 Note that the figures for 2005 do not include data for FE sector students.
59 'Other sciences' is a very broad category that includes courses in design and technology, information communication technology (ICT), home economics and 'other science', a category that includes: astronomy, electronics, environmental, geology, psychology (as a science), rural science and science for public understanding. (Source: http://wales.gov.uk/docs/statistics/2010/100525glossaryen.pdf)

and/or chemistry and/or physics) with other sciences and mathematics, and (ii) took other sciences and mathematics, but no core sciences, are described in tables W.2–W.3.

The cohort of GCE A-level students in Wales taking STEM-related subjects was relatively stable between 2007 and 2009. The proportion of the GCE A-level cohort not studying core science or other science subjects in Wales rose from 56% to 57% between 2007 and 2009 (calculable from table W.2). In the same period, the proportion of students not taking GCE A-level core science or mathematics subjects increased from 62% to 66% (calculable from table W.3). There was a small rise in students taking GCE A-level mathematics during 2007–09, from 19.0% to 20.2% of the whole cohort. However, it is also calculable that there was a slight fall in the proportion taking core sciences A-levels, from 27.5% to 26.6% between 2007 and 2009.

Whilst table W.1 demonstrates strong growth in the entries within GCE A-level mathematics and other science subjects, the proportion of students studying these subjects showed little change. Around 20% of the GCE A-level student cohort took other science subjects in 2007 and 2009.

When a wider demographic perspective is taken, it can be seen from table W.4 that the proportion of the A-level cohort taking sciences and/or mathematics subjects fell during 2007–09 to just 26.6%, and that in respect of all 17 year olds in the population (this being the best proxy for estimating the age of the A-level cohort given that most A-level candidates are aged 17 at the start of the academic year in which they take their examinations), only about 10% took sciences and/or mathematics A-levels.

Key message W1. The numbers of GCE A-level core science subject entries between 2007 and 2009 increased slightly. In mathematics entries rose at a rate greater than that of overall A-level entries. However the proportion of students taking A-levels in core sciences with or without mathematics fell.

*Table W.2. Numbers of GCE A-level students taking core sciences and other sciences, Wales (2005, 2007, 2009).*

| Not taking/taking core science | Not taking/taking other sciences | 2005 | 2007 | 2009 |
|---|---|---|---|---|
| No core sciences taken | No other sciences taken | 5,672 | 8,242 | 8,528 |
| | Other sciences taken | 1,681 | 2,346 | 2,551 |
| Total nos. of students who took no core sciences | | **7,353** | **10,588** | **11,079** |
| Core sciences taken | Other sciences not taken | 2,969 | 3,348 | 3,406 |
| | Other sciences taken | 531 | 672 | 602 |
| **Total no. of students taking core sciences** | | **3,500** | **4,020** | **4,008** |
| **Total size of GCE A-level cohort** | | **10,853** | **14,608** | **15,087** |

*Source:* Welsh Assembly Government.

*Table W.3. Numbers of GCE A-level students taking core sciences and mathematics,[(a)] Wales (2005, 2007, 2009).*

| Not taking/taking core sciences | Not taking/taking mathematics | 2005 | 2007 | 2009 |
|---|---|---|---|---|
| No core sciences taken | No mathematics taken | 6,709 | 9,569 | 9,943 |
| | Mathematics taken | 644 | 1,019 | 1,136 |
| Total nos. of students who took no core sciences | | **7,353** | **10,588** | **11,079** |
| Core sciences taken | No mathematics taken | 2,063 | 2,267 | 2,097 |
| | Mathematics taken | 1,437 | 1,753 | 1,911 |
| **Total numbers of students taking core sciences** | | **3,500** | **4,020** | **4,008** |
| **Total size of GCE A-level cohort** | | **10,853** | **14,608** | **15,087** |

*Source:* Welsh Assembly Government.

(a) Mathematics includes mathematics, statistics, and further mathematics.

Key message W2. Approximately 10% of all potentially eligible 17 year olds in Wales take GCE A-levels in core sciences and/or mathematics subjects.

## W.5 Overall numbers of students taking core sciences

Table W.5 provides a breakdown of students taking core sciences GCE A-levels by institution type in 2005, 2007 and 2009. The maintained sector was responsible for producing 74% and 76% of students taking GCE A-level core sciences in 2007 and 2009, respectively. The numbers of students who took core sciences in the independent and FE sectors fell 11% and 5% over the same period, with a 15% overall fall being recorded in the former from 2005 onwards.

When looking at the proportion of students taking core sciences subjects at GCE A-level, the data show that around 55% of students taking core sciences GCE A-levels attempted just a single core sciences subject (table W.6). However, of those within the GCE A-level core sciences cohort recorded as taking four or more A-levels, 68% attempted two or more core sciences A-levels in 2007, rising to 70% in 2009. From table W.6 it is calculable that the proportion of core sciences students attempting at least two core sciences at A-level fell from 45% to 43% between 2007 and 2009.

## W.6 Overall numbers of students taking GCE A-level core sciences together with mathematics

Table W.7 shows subject combinations of core sciences and mathematics subjects taken by students at GCE A-level in Wales in 2005, 2007 and 2009. The proportion of all GCE A-level students taking core sciences without any mathematics subjects dropped from 15.5% to 13.9% between 2007 and 2009. The proportion of all GCE A-level students taking core sciences with mathematics varied between 12% and 13% in the same period.

Within the group of students taking core sciences with or without mathematics GCE A-level subjects, biological sciences and the singular combination BC were consistently the most popular in Wales in the years investigated, but their popularity waned as more students took mathematics with core sciences subjects. It is calculable that the proportion of students choosing all B and BC subject combinations without mathematics dropped from 46% to 22% between 2007 and 2009, with 21% of students taking B or BC combinations with mathematics in 2009, compared to 20% in 2007. The type and popularity of the top five core sciences with or without mathematics combinations were consistent for each of the years analysed.

*Table W.4. Numbers of students taking core sciences, other sciences and/or mathematics GCE A-levels as a function of population size (Wales, 2005, 2007, 2009).*

| | 2005 | 2007 | 2009 |
|---|---|---|---|
| Total size of GCE A-level cohort | 10,853 | 14,608 | 15,087 |
| Total numbers of students taking core sciences | 3,500 | 4,020 | 4,008 |
| Percentage of A-level cohort taking core sciences | 32.2% | 27.5% | 26.6% |
| Population of 17 year olds[a] | 40,188 | 39,774 | 40,396 |
| Percentage of 17 year olds taking core sciences | 8.7% | 10.1% | 9.9% |

*Sources:* Welsh Assembly Government, ONS.

(a) All data are as at 1 April of each calendar year. The 2005 and 2007 data were revised, reflecting revisions due to improved migration, and published by ONS on 13 May 2010. The 2009 data were published by ONS on 24 June 2010.

*Table W.5. Numbers of students taking core science GCE A-levels by institution type, Wales (2005, 2007, 2009).*

| Institution Type | 2005 | 2007 | 2009 |
|---|---|---|---|
| Maintained | 3,158 | 2,980 | 3,040 |
| Independent | 342 | 328 | 291 |
| FE sector | – | 712 | 677 |
| Total-core science students | 3,500 | 4,020 | 4,008 |
| Total size of GCE A-level cohort | 10,853 | 14,608 | 15,087 |

*Source:* Welsh Assembly Government.

*Table W.6. Numbers of students taking core science subjects by number of GCE A-level subjects taken and number of core science subjects taken (Wales, 2005, 2007, 2009).*

| Number of core science subjects taken | Year | Number of GCE A-levels taken | | | Grand total |
|---|---|---|---|---|---|
| | | 1–2 | 3 | 4 (or more) | |
| 1 | 2005 | 466 | 1,338 | 146 | 1,950 |
| | 2007 | 511 | 1,585 | 184 | 2,280 |
| | 2009 | 497 | 1,502 | 196 | 2,195 |
| 2 | 2005 | 61 | 1,087 | 226 | 1,374 |
| | 2007 | 81 | 1,162 | 273 | 1,516 |
| | 2009 | 89 | 1,193 | 287 | 1,569 |
| 3 (or more) | 2005 | N/A | 95 | 81 | 176 |
| | 2007 | N/A | 107 | 117 | 224 |
| | 2009 | N/A | 119 | 125 | 244 |

*Source:* Welsh Assembly Government.

One of the key aspects of the Welsh cohort was that just over 4,000 students entered for core science GCE A-level examinations in Wales in 2007 and 2009, with fewer than half of them taking additional mathematics GCE A-level subjects.

## B. Science and mathematics subject combinations: gender and institutional variation

This section considers how the popularity of core sciences and mathematics subject combinations varied during 2007 and 2009 according to gender and the type of educational establishment in which they were taken.

### W.7 Overall numbers taking core sciences by gender

The number of male students studying core sciences subjects consistently exceeded the number of females studying core sciences A-levels in each of the years investigated, although the numbers of females in the cohort consistently exceeded the number of males (table W.8). It is also calculable from table W.8 that of all males taking GCE A-levels, the proportion taking core sciences GCE A-level subjects and combinations remained relatively stable at 33% during 2007 and 2009 while the equivalent proportion of females taking core sciences dropped from 23.4% to 21.5% between 2007 and 2009.

Core sciences combinations involving B and BC were amongst the most popular among both male and female students. However, the proportion of the female cohort taking B and BC combinations was consistently greater than that of the male cohort; double the proportion of females chose B alone, while approximately a third more female students took the specific combination BC. Physics was the most popular subject taken on its own and in combination amongst male students, with more than three times as many males as females taking physics on its own and in combination with other core sciences (P, CP, BP, BCP) during this period. Still while the proportion of males taking physics (alone) and core science combinations including physics grew from 50% to 51% during 2007–09, the proportion of females taking physics combinations jumped from 14% to 16% over the same period.

Despite the overwhelming popularity of biological sciences amongst female students, the data indicate a shift away from subject combinations involving biological sciences being chosen by females, with proportions dropping from 82% to 80% between 2007 and 2009. The proportions of males taking biological sciences combinations fell similarly during this period, from 53% to 50%.

There was a modest growth in the proportion of females who studied chemistry and combinations including chemistry, rising from 52% to 54%, while the proportions of males taking combinations involving chemistry also grew, from 47% to 52%.

Tables W.9 and W.10 compare the popularity of combinations of core sciences with or without mathematics among males and females taking GCE A-levels in Wales. As noted in the discussion of core science combinations, more male students chose core sciences subjects at GCE A-level than female students. Further investigation of these subject combinations, along with mathematics subjects, shows that a higher proportion

*Table W.7. Numbers of 16–18 year old students taking GCE A-level core sciences combinations (with or without mathematics),*[(a)] *ranked by popularity (Wales, 2005, 2007, 2009).*

| Subject combination | 2005 | % All GCE A | Subject combination | 2007 | % All GCE A | Subject combination | 2009 | % All GCE A |
|---|---|---|---|---|---|---|---|---|
| B | 965 | 8.9% | B | 1,010 | 6.9% | B | 894 | 5.9% |
| BC | 603 | 5.6% | BC | 666 | 4.6% | BC | 608 | 4.0% |
| P(M) | 404 | 3.7% | P(M) | 529 | 3.6% | P(M) | 546 | 3.6% |
| BC(M) | 339 | 3.1% | BC(M) | 453 | 3.1% | BC(M) | 499 | 3.3% |
| CP(M) | 260 | 2.4% | CP(M) | 246 | 1.7% | CP(M) | 302 | 2.0% |
| B(M) | 166 | 1.5% | B(M) | 200 | 1.4% | C(M) | 208 | 1.4% |
| C(M) | 142 | 1.3% | P | 194 | 1.3% | C | 192 | 1.3% |
| C | 141 | 1.3% | C(M) | 176 | 1.2% | B(M) | 189 | 1.3% |
| P | 132 | 1.2% | C | 171 | 1.2% | P | 166 | 1.1% |
| BCP | 110 | 1.0% | BCP | 130 | 0.9% | BCP | 138 | 0.9% |
| BCP(M) | 66 | 0.6% | BCP(M) | 94 | 0.6% | BCP(M) | 106 | 0.7% |
| BP | 61 | 0.6% | BP(M) | 55 | 0.4% | CP | 62 | 0.4% |
| BP(M) | 60 | 0.6% | BP | 50 | 0.3% | BP(M) | 61 | 0.4% |
| CP | 51 | 0.5% | CP | 46 | 0.3% | BP | 37 | 0.2% |
| Numbers taking core sciences combinations only | 2,063 | 19.1% | Numbers taking core sciences combinations only | 2,267 | 15.5% | Numbers taking core sciences combinations only | 2,097 | 13.9% |
| Numbers taking core sciences combinations with mathematics | 1,437 | 13.2% | Numbers taking core sciences combinations with mathematics | 1,753 | 12.0% | Numbers taking core sciences combinations with mathematics | 1,911 | 12.7% |
| Numbers taking core sciences with/without mathematics | 3,500 | 32.2% | Numbers taking core sciences with/without mathematics | 4,020 | 27.5% | Numbers taking core sciences with/without mathematics | 4,008 | 26.6% |
| All students taking GCE A-level | 10,853 | 100.0% | All students taking GCE A-level | 14,608 | 100.0% | All students taking GCE A-level | 15,087 | 100.0% |

*Source:* Welsh Assembly Government.

(a) Mathematics includes: mathematics, statistics, and further mathematics.

*Table W.8. Numbers of 16–18 year old females and males taking core sciences GCE A-level combinations (Wales, 2005, 2007, 2009).*

| Core sciences | 2005 | | | | 2007 | | | | 2009 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Females | | Males | | Females | | Males | | Females | | Males | |
| B | 739 | 44.8% | 392 | 21.2% | 755 | 40.2% | 455 | 21.3% | 680 | 37.8% | 403 | 18.2% |
| BC | 546 | 33.1% | 396 | 21.4% | 679 | 36.1% | 440 | 20.6% | 643 | 35.8% | 464 | 21.0% |
| BCP | 67 | 4.1% | 109 | 5.9% | 70 | 3.7% | 154 | 7.2% | 81 | 4.5% | 163 | 7.4% |
| BP | 32 | 1.9% | 89 | 4.8% | 31 | 1.6% | 74 | 3.5% | 27 | 1.5% | 71 | 3.2% |
| C | 133 | 8.1% | 150 | 8.1% | 179 | 9.5% | 168 | 7.8% | 184 | 10.2% | 216 | 9.8% |
| CP | 55 | 3.3% | 256 | 13.8% | 52 | 2.8% | 240 | 11.2% | 62 | 3.4% | 302 | 13.7% |
| P | 77 | 4.7% | 459 | 24.8% | 113 | 6.0% | 610 | 28.5% | 121 | 6.7% | 591 | 26.7% |
| Grand total | 1,649 | 100% | 1,851 | 100% | 1,879 | 100% | 2,141 | 100% | 1,798 | 100% | 2,210 | 100% |
| GCE A-level cohort size | 5,986 | | 4,867 | | 8,029 | | 6,579 | | 8,348 | | 6,739 | |

*Source:* Welsh Assembly Government.

of male students chose their core science subjects with mathematics subjects at A-level. Fifty-five per cent of male students who chose GCE A-level core science subjects also entered for GCE A-level mathematics subjects in 2009, in contrast to just 38% of female students. Overall, it can be calculated from tables W.9 and W.10 that while 64% of those students studying GCE A-level core sciences subjects with mathematics in 2009 were male, males accounted for less than half (45%) of all GCE A-level candidates that year.

Key message W3. A greater proportion of male students took core sciences, with or without mathematics, than female students. As in England, there is a clear preference for biological sciences among females and physics among males, while chemistry attracts broadly similar proportions of each gender.

Overall, when core sciences combinations are disaggregated, they reveal that overall between 2007 and 2009:

(i) the percentage of males taking core sciences combinations including biological sciences decreased 2% from 1,123 to 1,101, while the proportion of these students who also took mathematics increased 1.2% from 17.6% to 18.8%.

(ii) the numbers of males taking core sciences combinations including chemistry rose from 1,002 to 1,145 (a proportional increase of 5%), and the proportions of these students who also took mathematics increased from 25.4% to 29.5%.

(iii) the percentage of males taking core sciences combinations including physics stayed steady at just over 50%, but the proportion of these students who also took mathematics increased from 35% to 37%.

By contrast, for females, the same disaggregation shows that:

(i) the proportion of females taking core sciences combinations with biological sciences dropped 2% (as previously shown), but that the proportion of these students who also took mathematics increased modestly from 22.7% to 24.4%, meaning that over 70% of female students did *not* take mathematics in addition to their biological sciences combinations.

(ii) the proportion of females taking core sciences combinations with chemistry rose from 52% to 54%, and the proportion of these students who also took mathematics increased from 22.6% to 25.8%.

(iii) the proportion of females taking core sciences combinations including physics increased 2% (from 14% to 16% of the total who took core sciences with or without mathematics), and the proportion of these students who also took mathematics rose from 9% to 11%.

Key message W4. Of all students who took core sciences A-levels during 2005, 2007 and 2009, the proportions of males and females taking mathematics together with core sciences increased, with the former rising by 4.7% and the latter growing by 7.9% over this period (tables W.10 and W.11).

## W.8 Numbers of students taking core sciences GCE A-levels: institutional differences

As indicated in table W.11, the number of institutions in each education sector in Wales remained largely stable. Against this stability, over 70% (and an increasing

*Table W.9. Number of 16–18 year old females taking core sciences GCE A-level combinations (with or without mathematics), ranked by popularity (Wales, 2005, 2007, 2009).*

| Subject combination | 2005 | % females taking core sciences combinations with/without mathematics | Subject combination | 2007 | % females taking core sciences combinations with/without mathematics | Subject combination | 2009 | % females taking core sciences combinations with/without mathematics |
|---|---|---|---|---|---|---|---|---|
| B | 636 | 38.6% | B | 641 | 34.1% | B | 564 | 31.4% |
| BC | 363 | 22.0% | BC | 404 | 21.5% | BC | 368 | 20.5% |
| BC(M) | 183 | 11.1% | BC(M) | 275 | 14.6% | BC(M) | 275 | 15.3% |
| B(M) | 103 | 6.2% | B(M) | 114 | 6.1% | B(M) | 116 | 6.5% |
| C | 71 | 4.3% | C | 96 | 5.1% | C(M) | 100 | 5.6% |
| P(M) | 65 | 3.9% | P(M) | 90 | 4.8% | P(M) | 97 | 5.4% |
| C(M) | 62 | 3.8% | C(M) | 83 | 4.4% | C | 84 | 4.7% |
| CP(M) | 48 | 2.9% | BCP | 46 | 2.4% | CP(M) | 54 | 3.0% |
| BCP | 43 | 2.6% | CP(M) | 43 | 2.3% | BCP | 47 | 2.6% |
| BCP(M) | 24 | 1.5% | BCP(M) | 24 | 1.3% | BCP(M) | 34 | 1.9% |
| BP(M) | 18 | 1.1% | P | 23 | 1.2% | P | 24 | 1.3% |
| BP | 14 | 0.8% | BP | 18 | 1.0% | BP(M) | 14 | 0.8% |
| P | 12 | 0.7% | BP(M) | 13 | 0.7% | BP | 13 | 0.7% |
| CP | 7 | 0.4% | CP | 9 | 0.5% | CP | 8 | 0.4% |
| All females taking core sciences only | 1,146 | 69.5% | All females taking core sciences only | 1,237 | 65.8% | All females taking core sciences only | 1,108 | 61.6% |
| All females taking core sciences with mathematics | 503 | 30.5% | All females taking core sciences with mathematics | 642 | 34.2% | All females taking core sciences with mathematics | 690 | 38.4% |
| All females taking core sciences | 1,649 | 100.0% | All females taking core sciences with or without mathematics | 1,879 | 100.0% | All females taking core sciences with or without mathematics | 1,798 | 100.0% |
| Total size of female GCE A-level cohort | 5,986 | | All female GCE A-level students | 8,029 | | All female GCE A-level students | 8,348 | |

*Source:* Welsh Assembly Government.

*Table W.10. Number of 16–18 year old males taking GCE-A level core sciences subject combinations (with or without mathematics), ranked by popularity (Wales, 2005, 2007, 2009).*

| Subject combination | 2005 | % males taking core sciences combinations with/without mathematics | Subject combination | 2007 | % males taking core sciences combinations with/without mathematics | Subject combination | 2009 | % males taking core sciences combinations with/without mathematics |
|---|---|---|---|---|---|---|---|---|
| P(M) | 339 | 18.3% | P(M) | 439 | 20.5% | P(M) | 449 | 20.3% |
| B | 329 | 17.8% | B | 369 | 17.2% | B | 330 | 14.9% |
| BC | 240 | 13.0% | BC | 262 | 12.2% | CP(M) | 248 | 11.2% |
| CP(M) | 212 | 11.5% | CP(M) | 203 | 9.5% | BC | 240 | 10.9% |
| BC(M) | 156 | 8.4% | BC(M) | 178 | 8.3% | BC(M) | 224 | 10.1% |
| P | 120 | 6.5% | P | 171 | 8.0% | P | 142 | 6.4% |
| C(M) | 80 | 4.3% | C(M) | 93 | 4.3% | C | 108 | 4.9% |
| C | 70 | 3.8% | B(M) | 86 | 4.0% | C(M) | 108 | 4.9% |
| BCP | 67 | 3.6% | BCP | 84 | 3.9% | BCP | 91 | 4.1% |
| B(M) | 63 | 3.4% | C | 75 | 3.5% | B(M) | 73 | 3.3% |
| BP | 47 | 2.5% | BCP(M) | 70 | 3.3% | BCP(M) | 72 | 3.3% |
| CP | 44 | 2.4% | BP(M) | 42 | 2.0% | CP | 54 | 2.4% |
| BCP(M) | 42 | 2.3% | CP | 37 | 1.7% | BP(M) | 47 | 2.1% |
| BP(M) | 42 | 2.3% | BP | 32 | 1.5% | BP | 24 | 1.1% |
| All males taking core sciences only | 917 | 49.5% | All males taking core sciences only | 1,030 | 48.1% | All males taking core sciences only | 989 | 44.8% |
| All males taking core sciences with mathematics | 934 | 50.5% | All males taking core sciences with mathematics | 1,111 | 51.9% | All males taking core sciences with mathematics | 1,221 | 55.2% |
| All males taking core sciences | 1,851 | 100.0% | All males taking core sciences with or without mathematics | 2,141 | 100.0% | All males taking core sciences with or without mathematics | 2,210 | 100.0% |
| All male GCE A-level students | 4,867 | | All male GCE A-level students | 6,579 | | All male GCE A-level students | 6,739 | |

*Source:* Welsh Assembly Government.

*Table W.11. Comparison of the numbers of educational institutions with the numbers of 16–18 year old students taking any GCE A-level qualifications (Wales, 2005, 2007, 2009).*[(a)]

| Type of institution | Nos. of institution type | | | Nos. of 16–18 year old students taking examinations in GCE A-level subjects only | | | Percentage of students taking core sciences GCE A-levels by institution type[(b)] | | | Number of students taking core sciences GCE A-levels by institution type as a function of the total A-level cohort taking core sciences A-levels | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 |
| Maintained | 170 | 168 | 169 | 10,128 | 10,408 | 10,976 | 31.2% | 28.6% | 27.7% | 90.2% | 74.1% | 75.8% |
| Independent | 18 | 17 | 19 | 725 | 732 | 702 | 47.2% | 44.8% | 41.5% | 9.8% | 8.2% | 7.3% |
| FE sector | – | 20 | 20 | – | 3,468 | 3,409 | – | 20.5% | 19.9% | – | 17.7% | 16.9% |
| Total | 188 | 205 | 208 | 10,853 | 14,608 | 15,087 | 3,500 | 4,020 | 4,008 | 100.0% | 100.0% | 100.0% |

*Source:* Welsh Assembly Government.

(a) No data are available for the FE sector for 2005.

(b) The actual numbers of 16–18 year old students taking GCE A-level core sciences may be found in tables AW.1–AW.2.

proportion) of students completing GCE A-level qualifications in Wales came from maintained schools (in 2007 and 2009), but a decreasing percentage of GCE A-level students in this sector took core sciences A-levels. The second largest education sector was the FE sector, with over 3,400 students studying GCE A-level qualifications in 2007 and 2009 (albeit that the numbers fell 1.7% during this period, and only about 20% of 16–18 year olds in the FE sector studying for A-levels pursued core sciences subjects). The proportion of students taking GCE A-level qualifications in Wales from the independent sector was *ca*. 5% of the cohort in 2007 and 2009, and although proportionally this sector recorded the highest percentage of core sciences candidature across all institutions, this proportion declined from 2005 onwards.

Key message W5. Participation in core sciences subjects fell in each of the education sectors in Wales. Despite a fall in the proportion taking core sciences in the overall cohort, there were rises in the school sectors in the proportion of students studying core sciences along with mathematics subjects.

Table W.12 provides insight into the recent historical distribution of GCE A-level subject combinations involving core sciences with/without mathematics and with/without other sciences. From this it is calculable (i) that almost half of all GCE A-level students in maintained schools do not take any sciences or mathematics A-levels, and (ii) that the equivalent proportions of students in independent schools and FE sector colleges are *ca*. 38% and over 60%, respectively.

Key message W6. A greater proportion of students took GCE A-levels involving core sciences with or without mathematics in the independent sector than in the maintained or FE sectors.

## C. Attainment in core science and mathematics subject combinations

While information on the numbers taking science and mathematics A-levels provides an indication of the size of the 'pool of talent' available to study for first degrees in science, technology, engineering or mathematics, a more refined understanding of this pool may be gained from considering attainment data.

Since entry into many higher education first degree courses is dependent on students gaining combinations of A–C grades, this section examines the proportion of the pool that gains good GCE A-levels in combinations of core sciences and core sciences with mathematics among students taking three A-levels (this being the modal number of A-level subjects taken (cf. table W.6)). Although students gaining

*Table W.12. Number of students taking GCE A-level core sciences with/without mathematics and other sciences by institution type in Wales (2005, 2007, 2009).*

| Subject combinations | | Maintained | | | Independent | | | FE sector[a] | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 | 2007 | 2009 |
| No core sciences | Mathematics | 401 | 496 | 593 | 60 | 83 | 64 | 209 | 194 |
| | Other sciences | 1,463 | 1,744 | 1,873 | 35 | 46 | 64 | 325 | 329 |
| | Mathematics and other sciences | 172 | 183 | 223 | 11 | 11 | 13 | 37 | 49 |
| | No mathematics or other sciences | 4,934 | 5,005 | 5,247 | 277 | 264 | 270 | 2,185 | 2,160 |
| No core sciences total | | 6,970 | 7,428 | 7,936 | 383 | 404 | 411 | 2,756 | 2,732 |
| Core sciences | Mathematics | 1,056 | 1,053 | 1,232 | 159 | 161 | 163 | 258 | 240 |
| | Other sciences | 293 | 304 | 256 | 16 | 22 | 11 | 65 | 59 |
| | Mathematics and other sciences | 203 | 213 | 218 | 19 | 9 | 13 | 59 | 45 |
| | No mathematics or other sciences | 1,606 | 1,410 | 1,334 | 148 | 136 | 104 | 330 | 333 |
| Core sciences total | | 3,158 | 2,980 | 3,040 | 342 | 328 | 291 | 712 | 677 |
| Size of GCE A-level cohort (only) | | 10,128 | 10,408 | 10,976 | 725 | 732 | 702 | 3,468 | 3,409 |

*Source:* Welsh Assembly Government.

(a) FE data unavailable for 2005.

*Table W.13. Numbers of 16–18 year old students taking three or more GCE A-levels and gaining grades A–C in two or more core sciences and/or mathematics subjects (Wales, 2005, 2007, 2009).*

| | 2005 | | 2007 | | 2009 | |
|---|---|---|---|---|---|---|
| Grades | Students | % | Students | % | Students | % |
| All A | 534 | 24.8% | 594 | 23.8% | 684 | 26.3% |
| A–B | 1,062 | 49.3% | 1,231 | 49.3% | 1,367 | 52.5% |
| A–C | 1,531 | 71.1% | 1,791 | 71.8% | 1,942 | 74.6% |
| Other[a] | 623 | 28.9% | 705 | 28.2% | 662 | 25.4% |
| **Grand total** | **2,154** | **100.0%** | **2,496** | **100.0%** | **2,604** | **100.0%** |
| Total size of GCE A-level cohort (only) | 10,853 | | 14,608 | | 15,087 | |

*Source:* Welsh Assembly Government.

(a) Other denotes candidates who were not awarded a grade A, B or C in *all* their science or mathematics A-levels.

*Table W.14. Numbers of 16–18 year old students taking three or more GCE A-levels and gaining grades A–C in two or more core science and/or mathematics A-levels split by institution type (Wales, 2005, 2007, 2009).*

| | | 2005 | | 2007 | | 2009 | |
|---|---|---|---|---|---|---|---|
| Type of institution | Grades | Students | % | Students | % | Students | % |
| Maintained | All A | 425 | 19.7% | 411 | 16.5% | 472 | 18.1% |
| | A–B | 877 | 40.7% | 861 | 34.5% | 999 | 38.3% |
| | A–C | 1,311 | 60.9% | 1,283 | 51.4% | 1,444 | 55.3% |
| | Other | 576 | 26.7% | 544 | 21.8% | 528 | 20.2% |
| Total taking core sciences and/or mathematics combinations in maintained schools | | **1,887** | **87.6%** | **1,827** | **73.2%** | **1,972** | **75.7%** |
| Independent | All A | 109 | 5.1% | 94 | 3.8% | 104 | 4.0% |
| | A–B | 185 | 8.6% | 168 | 6.7% | 157 | 6.0% |
| | A–C | 220 | 10.2% | 214 | 8.6% | 193 | 7.4% |
| | Other | 47 | 2.2% | 34 | 1.4% | 24 | 0.9% |
| Total taking core sciences and/or mathematics combinations in independent schools | | **267** | **12.4%** | **248** | **9.9%** | **217** | **8.3%** |
| FE sector[a] | All A | – | – | 89 | 3.6% | 108 | 4.1% |
| | A–B | – | – | 202 | 8.1% | 212 | 8.1% |
| | A–C | – | – | 294 | 11.8% | 306 | 11.8% |
| | Other | – | – | 127 | 5.1% | 109 | 4.2% |
| Total taking core sciences and/or mathematics combinations in FE colleges | | – | | **421** | **16.9%** | **415** | **15.9%** |
| Total numbers of students taking core sciences and/or mathematics GCE A-levels | | 2,154 | 100.0% | 2,496 | 100.0% | 2,604 | 100.0% |
| Total size of GCE A-level cohort (only) | | 10,853 | | 14,608 | | 15,087 | |

*Source:* Welsh Assembly Government.

(a) No data are available for the FE sector for 2005.

*Table W.15. Numbers of 16–18 year old students taking three or more GCE A-levels and gaining A–C grades in at least two core sciences and/or mathematics combinations (Wales, 2005, 2007, 2009).*

| | All A | | | A–B | | | A–C | | | Other[a] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Subject combination | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 |
| BC | 107 | 122 | 110 | 249 | 277 | 252 | 389 | 413 | 398 | 172 | 195 | 141 |
| BC(M) | 119 | 170 | 180 | 215 | 292 | 327 | 279 | 387 | 424 | 60 | 65 | 74 |
| BCP | 30 | 22 | 29 | 55 | 59 | 56 | 79 | 92 | 87 | 31 | 38 | 51 |
| BCP(M) | 35 | 42 | 53 | 56 | 66 | 77 | 63 | 83 | 96 | *X*[b] | 11 | 10 |
| B(M) | 24 | 14 | 25 | 57 | 56 | 69 | 88 | 104 | 115 | 58 | 74 | 54 |
| BP | *X*[b] | *X*[b] | *X*[b] | 9 | 6 | 7 | 20 | 15 | 11 | 31 | 22 | 20 |
| BP(M) | 8 | 5 | 11 | 23 | 22 | 27 | 39 | 39 | 42 | 21 | 16 | 19 |
| C(M) | 39 | 37 | 42 | 73 | 71 | 94 | 97 | 98 | 136 | 31 | 45 | 46 |
| CP | *X*[b] | *X*[b] | *X*[b] | 15 | 11 | 17 | 21 | 16 | 27 | 21 | 20 | 22 |
| CP(M) | 80 | 71 | 94 | 138 | 139 | 173 | 198 | 189 | 233 | 62 | 57 | 69 |
| M(+M) | 5 | 10 | 17 | 12 | 17 | 26 | 17 | 25 | 32 | *X*[b] | 8 | 5 |
| P(M) | 82 | 99 | 116 | 160 | 215 | 242 | 241 | 330 | 341 | 122 | 154 | 151 |
| Grand total | 534 | 594 | 684 | 1,062 | 1,231 | 1,367 | 1,531 | 1,791 | 1,942 | 623 | 705 | 662 |
| Total size of GCE A-level cohort (only) | 10,853 | 14,608 | 15,087 | 10,853 | 14,608 | 15,087 | 10,853 | 14,608 | 15,087 | 10,853 | 14,608 | 15,087 |

*Source:* Welsh Assembly Government.

(a) Other denotes candidates who were not awarded a grade A, B or C in *all* their science or mathematics A-levels.

(b) Data suppressed.

grades A–C in a single core sciences or mathematics subject may subsequently pursue STEM studies at higher education level, generally it is expected that students wishing to study for a STEM first degree will have gained passes in at least two sciences or mathematics A-levels (notwithstanding their attainment in other subjects).[60]

## W.9 Numbers of students taking three A-levels and obtaining grades A–C in two or more core sciences and/or mathematics subjects

### W.9.1 Overview

Table W.13 provides summary data on the numbers of students gaining A–C grades in two or more core sciences and/or mathematics A-levels. It shows that between 2007 and 2009 the percentage of these students gaining grades A–C increased from 72% to *ca*. 75%, and the proportion of students gaining straight A grades in at least two core sciences and/or mathematics rose to more than a quarter of all students. It may also be calculated that the percentage of those taking core sciences and/or mathematics qualifications that were (i) either just taking a single science and/or (ii) not being awarded (an) A–C grade(s) dropped from 29% to *ca*. 25%.

Key message W7. The proportion of students who took three or more GCE A-levels and gained A–C grades in two or more core science and/or mathematics subjects increased slightly between 2007 and 2009.

### W.9.2 Comparison by institution type

Table W.14 breaks the figures in table W.13 down by institution type and compares these with the total number of students taking A-levels in each type of institution. Perhaps the most striking observation to be made is that the percentages of students gaining A–C grades fell in both the maintained and independent sectors, though it improved very slightly in the FE sector. Secondly, in 2007 and 2009, it is notable that across all institution types at least a quarter of students who took at least three GCE A-levels and attempted two or more core sciences and/or mathematics subjects failed to obtain A–C grades, although it is calculable that the percentage fell from 28% to 25%.

### W.9.3 Comparison by subject combination (aggregated data for all institution types)

The data in table W.13 may also be disaggregated by core sciences/or mathematics combinations to show the numbers of students taking three A-levels and gaining A, A or B and A–C grades in at least two core sciences and/or mathematics combinations (table W.15), compared with the total numbers of students taking core sciences and/or mathematics in each year.

Table W.15 shows that there were increases in the numbers obtaining good A-levels in these subjects, with overall increases in the numbers gaining straight A grades, A or B grades, but not A–C grades and a decrease in the numbers failing to gain good grades in combinations of these subjects (down from 5% to 4% over this time-period). There was also an increase in the numbers of students gaining good A-levels in combinations of mathematics subjects (with the 2009 figures for A–C grades in these combinations being 8% up on 2007), as well as a smaller decrease (6% between 2007 and 2009) in those failing to gain these grades in two or more subjects within these types of combination.

60 SCORE (2009).

# Northern Ireland

## NI.1 Introduction

This chapter explores the combinations of science and mathematics A-level and applied science vocational A-level (VCE) examinations taken by students in Northern Ireland in 2005, 2007 and 2009.

Details of the methodology are provided in the accompanying electronic appendix. The raw data used in this analysis were prepared by RM Data Solutions and made available for analysis by DENI. Definitions of mathematics and other sciences are the same as in England (*viz*. Chapter 3), unless otherwise indicated.

This chapter is divided into three major sections, as follows:

Section A. Summary data on all students taking science and/or mathematics GCE/VCE A-level subject combinations in 2005, 2007 and 2009.

Section B. A more detailed examination of core sciences and mathematics GCE A-level combinations considering variation by gender and institution type.

Section C. An analysis of attainment in core sciences and mathematics GCE A-level subject combinations.

## NI.2 Entries

Table NI.1 shows the number of GCE A-level and vocational A-level entries taken by students in Northern Ireland in 2005, 2007 and 2009 and compares these figures with changes in the candidate numbers during this period. It reveals that despite an overall 8% fall in the number of candidates over this time-period, there was a small growth in entries to core sciences as a whole (which exceeded the overall percentage growth in entries across all subjects) and a substantial increase in mathematics entries.

**Key message NI1. Despite an overall fall in the number of GCE A-level candidates between 2005 and 2009, there was a small growth in entries to core sciences as a whole and a substantial increase in mathematics entries.**

Comparison of the total numbers of entries to GCE A-levels and vocational A-levels (VCE) in 2005, 2007 and 2009 shows that GCE A-levels consistently account for more than 80% of all entries (table NI.1). However, while the total number of entries to all GCE A-levels remained stable, entries to vocational A-levels (all subjects) fell by 16% overall between 2005 and 2009. (In contrast, it is gratifying to note, across the same time-period, an increase of more than 40% in entries to single and double award VCE applied science, albeit that the level of candidature remained small.) It is likely that these fluctuations were caused by a combination of factors including, perhaps, changes to vocational qualifications, reorganisation of the FE college sector in Northern Ireland (involving the merging of 16 colleges into 6 new 'super colleges') and increasing competition between schools and colleges to attract post-16 students (DENI/DELNI 2009, p. 70). Notably, entries to combinations of GCE and VCE subjects increased in grammar and other (non-selective) secondary schools, but decreased in colleges (table NI.2).

The following sections look in greater detail at the *combinations* of science and mathematics subjects being taken by students, thereby enabling a much better understanding of students' decision-making seen in table NI.1.

# A. Overall data on sciences and mathematics combinations taken by GCE and VCE A-level candidates in Northern Ireland during 2005, 2007 and 2009

## NI.3 Overall numbers taking VCE applied science combinations

Owing to the small numbers of students taking single and double award applied science VCE (289 students in 2005, 219 in 2007 and 416 in 2009), it is not possible to include a detailed analysis of GCE A-level combinations taken by these students.

## NI.4 Overall numbers of students taking GCE A-levels in core sciences, mathematics and other sciences

Table NI.3 provides details of the relative general popularity of different combinations of GCE A-level science subjects in Northern Ireland during 2005, 2007 and 2009. It reflects, of course, the increase in uptake of core sciences shown in table NI.1 (ie the modest 1% increase in the total number of students taking combinations of core sciences and other sciences). Nonetheless, these increases were exceeded by an increase in the numbers of students not taking any core sciences or other sciences (as well as a decrease in numbers taking other sciences alone).

Notably, table NI.3 also shows that between 2005 and 2009 the percentage of the total A-level cohort that did not take any core sciences or other sciences A-levels increased from 47% to 50% between 2005 and 2009. Overall, the percentage of all students in the GCE A-level cohort taking any core sciences or combination of core sciences in these years fell very slightly from 37.7% to 37.4%.

As a comparison, table NI.4 provides information on the numbers taking core sciences subjects with or without mathematics. It shows that there was little change in the numbers not taking core sciences or mathematics, and a

*Table NI.1. Comparison of GCE[(a)] and VCE entries and candidate numbers among 16–18 year old students (Northern Ireland, 2005, 2007, 2009).*

| | 2005 | | 2007 | | 2009 | | Overall percentage change in entries since 2005 | |
|---|---|---|---|---|---|---|---|---|
| | Entries | % all GCE A-level entries | Entries | % all GCE A-level entries | Entries | % all GCE A-level entries | | |
| Biological sciences (B) | 3,257 | 10.3% | 3,296 | 10.6% | 3,348 | 10.6% | 2.8% | |
| Chemistry (C) | 1,848 | 5.9% | 1,847 | 5.9% | 1,819 | 5.8% | –1.6% | |
| Physics (P) | 1,353 | 4.3% | 1,299 | 4.2% | 1,356 | 4.3% | 0.2% | |
| **All core sciences (total)** | **6,458** | **20.5%** | **6,442** | **20.7%** | **6,523** | **20.7%** | **1.0%** | |
| Other sciences | 2,801 | 8.9% | 2,470 | 7.9% | 2,318 | 7.4% | –17.2% | |
| **Mathematics** | 2,413 | 7.7% | 2,735 | 8.8% | 2,956 | 9.4% | 22.5% | |
| Arts | 5,721 | 18.2% | 5,734 | 18.4% | 5,881 | 18.7% | 2.8% | |
| MFL[(b)] | 1,664 | 5.3% | 1,638 | 5.3% | 1,647 | 5.2% | –1.0% | |
| Social science | 11,351 | 36.0% | 10,920 | 35.0% | 10,849 | 34.5% | –4.4% | |
| Other subjects | 1,082 | 3.4% | 1,257 | 4.0% | 1,303 | 4.1% | 20.4% | |
| **Total number of entries across all GCE A-level subjects** | **31,490** | **100.0%** | **31,196** | **100.0%** | **31,477** | **100.0%** | **–0.04%** | **N/A[(c)]** |
| Total number of entries across all vocational A-level subjects (VCE) | **5,610** | | **4,228** | | **4,715** | | **–16.0%** | |
| Total number of entries to VCE applied science (single and double award) | **289** | | **219** | | **416** | | 43.9% | |
| Total number of entries (all GCE/VCE) | **37,389** | | **35,643** | | **36,608** | | –2.1% | |
| **Total size of GCE A-level cohort only** | **11,597** | | **11,400** | | **11,805** | | 1.8% | |
| **Total size of GCE/VCE A-level cohort** | **13,995** | | **12,569** | | **12,839** | | –8.3% | |

*Source:* DENI.

(a) GCE A-level entries for 2005 include 96 coded in the data as entries for GCE A-level in vocational subjects.

(b) MFL, modern foreign languages.

(c) Not applicable.

large proportional increase in the numbers taking mathematics alone. There was also a welcome decrease in the numbers taking core sciences without mathematics, and a large proportional rise in the numbers taking combinations of core sciences and mathematics subjects. Table ANI.1 provides equivalent figures for those taking combinations of core sciences, other sciences and mathematics.

Table NI.5 seeks to gain a wider demographic perspective on core sciences/mathematics GCE A-level participation. Notably, it indicates that the proportion of the A-level cohort taking core sciences and/or other sciences and/or mathematics has remained steady at around 37%.

Table NI.5 also shows that if participation in GCE A-level sciences and mathematics subjects is compared with the total numbers of 17 year olds in the population (this being the nearest proxy to the age of the A-level cohort, given that the majority of A-level candidates are aged 17 at the start of the academic year in which they take their A-level examinations), it is evident that the proportion of the eligible population that took core sciences and/or mathematics A-levels rose from 16% to 17% during 2005–09.

Key message NI2. It appears that about 17% of all potentially eligible 17 year olds in Northern Ireland take GCE A-levels in core sciences and/or mathematics subjects.

Table NI.2. *Numbers of students taking GCE/VCE qualifications by institution type (Northern Ireland, 2005, 2007, 2009).*

| Type of institution | Qualification | 2005 | 2007 | 2009 | Overall percentage change in numbers since 2005 |
|---|---|---|---|---|---|
| Grammar schools | GCE | 7,929 | 7,538 | 7,301 | –7.9% |
| | GCE/VCE | 496 | 594 | 1,006 | 102.8% |
| | VCE | 70 | 49 | 38 | –45.7% |
| **Grammar total** | | **8,495** | **8,181** | **8,345** | **–1.8%** |
| Secondary schools | GCE | 1,364 | 1,303 | 1,375 | 0.8% |
| | GCE/VCE | 1,116 | 1,417 | 1,669 | 49.6% |
| | VCE | 1,074 | 937 | 865 | –19.5% |
| **Secondary total** | | **3,554** | **3,657** | **3,909** | **10.0%** |
| Further education colleges | GCE | 515 | 462 | 368 | –28.5% |
| | GCE/VCE | 143 | 71 | 40 | –72.0% |
| | VCE | 1,103 | 178 | 114 | –89.7% |
| **Further education total** | | **1,761** | **711** | **522** | **–70.4%** |
| Other institutions[a] | GCE | 10 | 13 | 22 | 120.0% |
| | GCE/VCE | 24 | 7 | 24 | 0.0% |
| | VCE | 151 | | 17 | –88.7% |
| **Other institutions total** | | **185** | **20** | **63** | **–65.9%** |
| **Total number of GCE and VCE candidates[a]** | | **13,995** | **12,569** | **12,839** | **–8.3%** |

*Source:* DENI.

(a) 'Other' institutions are listed in the DENI dataset, but their type could not be clearly identified from the codes.

## NI.5 Overall numbers of students taking core sciences combinations

### NI.5.1 Distribution across institutions

Table NI.6 provides a breakdown of student participation in core sciences combinations (B, BC, BCP, BP, C, CP and P) by institution type. It shows that most (consistently over 80%) of all students taking the core sciences came from grammar schools during the years surveyed. Further, it is calculable that the total number of students taking A-levels in this type of institution increased 1.8% between 2005 and 2009, and that the percentage of all A-level students taking core sciences in grammar schools increased from 43% to 45% over the same period. In contrast, both the numbers and the percentage of the A-level cohort in other secondary schools taking core sciences fell (the latter falling by 3% from 22.8% in 2005 to 19.3% in 2009), an issue that is discussed further in § NI.8. However, although decreasing numbers of students took core sciences A-levels in FE colleges, the proportion of A-level students taking core science A-levels in these colleges increased from 23% to 25% during this period. It is possible that the decreasing number of students taking GCE A-levels in the core sciences who are enrolled in FE colleges may again reflect the outworking of 'Entitlement Framework' developments and possibly, as mentioned in Chapter 2, an increasing focus in this sector on professional, technical and vocational courses.

### NI.5.2 Numbers of core sciences subjects taken

Investigation of the numbers of students taking one or more core sciences subjects shows that while most students take three A-levels, increasing numbers, now representing about 10% of the cohort, study four or more A-levels (table NI.7). Notable increases occurred in the numbers of students taking three (or more) core sciences A-levels in a combination involving at least four GCE A-level subjects. Among grammar schools – the most populous institution for core sciences studies – the latter increase was particularly associated with higher and increasing numbers of people taking four A-levels involving (all) three core sciences subjects (table ANI.2).

## NI.6 Overall numbers of students taking core sciences together with mathematics

When mathematics is considered in respect of the numbers of students taking core sciences A-levels, it is possible to

*Table NI.3. Numbers of 16–18 year old students taking GCE A-level core sciences and other sciences[a] (Northern Ireland, 2005, 2007, 2009).*

| Core sciences | Other sciences | 2005 Students | 2005 % of cohort | 2007 Students | 2007 % of cohort | 2009 Students | 2009 % of cohort | Overall percentage change in numbers since 2005 |
|---|---|---|---|---|---|---|---|---|
| No core sciences | No other sciences | 5,443 | 46.9% | 5,461 | 47.9% | 5,909 | 50.1% | 8.6% |
| | Other sciences | 1,783 | 15.4% | 1,586 | 13.9% | 1,484 | 12.6% | –16.8% |
| **Total nos. taking no core sciences** | | **7,226** | 62.3% | **7,047** | 61.8% | **7,393** | 62.6% | 2.3% |
| Core sciences | No other sciences | 3,549 | 30.6% | 3,585 | 31.4% | 3,688 | 31.2% | 3.9% |
| | Other sciences | 822 | 7.1% | 768 | 6.7% | 724 | 6.1% | –11.9% |
| **Total nos. taking core sciences with or without other sciences** | | **4,371** | 37.7% | **4,353** | 38.2% | **4,412** | 37.4% | 0.9% |
| **Total size of GCE A-level cohort (only)** | | **11,597** | | **11,400** | | **11,805** | | 1.8% |

*Source:* DENI.

(a) For a definition of 'other sciences', see Chapter 3.

*Table NI.4. Numbers of 16–18 year old students taking GCE A-level core sciences and mathematics (Northern Ireland, 2005, 2007, 2009).*

| Core sciences | Not taking/taking mathematics[a] | 2005 | 2007 | 2009 | Overall percentage change in numbers since 2005 |
|---|---|---|---|---|---|
| No core sciences | No mathematics | 6,595 | 6,260 | 6,572 | –0.3% |
| | Mathematics | 631 | 787 | 821 | 30.1% |
| **Total nos. of students who did not take any core sciences** | | **7,226** | **7,047** | **7,393** | **2.3%** |
| Core sciences | No mathematics | 2,710 | 2,545 | 2,431 | –10.3% |
| | Mathematics | 1,661 | 1,808 | 1,981 | 19.3% |
| **Total nos. of students taking core sciences** | | **4,371** | **4,353** | **4,412** | **0.9%** |
| **Total size of GCE A-level (only) cohort** | | **11,597** | **11,400** | **11,805** | 1.8% |

*Source:* DENI.

(a) Mathematics includes all GCE mathematics subjects.

*Table NI.5. Numbers of 16–18 year old students taking core sciences, other sciences and/or mathematics GCE A-levels as a function of population size (Northern Ireland, 2005, 2007, 2009).*

| | 2005 | 2007 | 2009 |
|---|---|---|---|
| Total size of GCE A-level cohort | 11,597 | 11,400 | 11,805 |
| Total numbers of students taking core sciences | 4,371 | 4,353 | 4,412 |
| **Percentage of GCE A-level cohort taking core sciences** | **37.7%** | **38.2%** | **37.4%** |
| Population of 17 year olds[a] | 27,133 | 25,430 | 25,463[b] |
| **Percentage of 17 year olds taking core sciences** | **16.1%** | **17.1%** | **17.3%** |

*Sources:* DENI, ONS.

(a) All data are as at 1 April of each calendar year. The 2005 and 2007 data were revised, reflecting revisions due to improved migration, and published by ONS on 13 May 2010. The 2009 data were published by ONS on 24 June 2010.

(b) Data for 2009 are provisional.

*Table NI.6. Numbers of 16–18 year old students taking core sciences GCE A-levels by institution type (Northern Ireland, 2005, 2007, 2009).*

| Institution type | 2005 | 2007 | 2009 |
|---|---|---|---|
| Grammar schools | 3,647<br>(8,425)[(a)] | 3,592<br>(8,132) | 3,712<br>(8,307) |
| Secondary schools | 565<br>(2,480) | 614<br>(2,720) | 589<br>(3,044) |
| Further education colleges | 151<br>(658) | 145<br>(533) | 104<br>(408) |
| Total no. of students taking core sciences | 4,371 | 4,353 | 4,412 |
| Total size of GCE A-level cohort (only) | 11,597 | 11,400 | 11,805 |

*Source:* DENI.

(a) Figures in parentheses are the numbers of students taking GCE A-level examinations in these institutions.

*Table NI.7. Numbers of 16–18 year old students taking core sciences subjects by number of GCE A-level subjects taken and number of core sciences subjects taken (Northern Ireland, 2005, 2007, 2009).*

| Number of core sciences subjects taken | Number of GCE A-levels taken | | | |
|---|---|---|---|---|
| | Year | 1–2 | 3 | 4 (or more) |
| 1 | 2005 | 343 | 2,075 | 131 |
| | 2007 | 369 | 1,983 | 196 |
| | 2009 | 463 | 1,925 | 216 |
| 2 | 2005 | 37 | 1,288 | 232 |
| | 2007 | 25 | 1,136 | 360 |
| | 2009 | 25 | 1,026 | 454 |
| 3 (or more) | 2005 | – | 108 | 157 |
| | 2007 | – | 80 | 204 |
| | 2009 | – | 77 | 226 |

*Source:* DENI.

establish, using table NI.8, that the numbers taking mathematics (mathematics, statistics or further mathematics) with core sciences subjects increased 19% overall during 2005–09. The proportion of all candidates taking core sciences combinations that these students represent increased from 38% to 45% during this same period.

The singular combinations P(M), BC(M) and B(M) were consistently among the top five most popular combinations among all students. Fewer students took these individual combinations than took B alone and the singular combination BC, yet their share in respect of (i) all students taking core sciences combinations grew 5.5 percentage points between 2005 and 2009, and the proportion of the total A-level cohort taking these subjects increased from 9.5% to 11.5%.

The percentage of all students taking core sciences combination who took just a single core science subject (ie B, C or P) fell from 39% to 37% between 2005 and 2009. The majority of these students were taking biological sciences.

*Table NI.8. Numbers of 16–18 year old students taking core sciences subject combinations (with or without mathematics), Northern Ireland (2005, 2007, 2009).*

| Subject combination | 2005 | % of all students taking core sciences | % total GCE A-level cohort | 2007 | % of all students taking core sciences | % total GCE A-level cohort | 2009 | % of all students taking core sciences | % total GCE A-level cohort |
|---|---|---|---|---|---|---|---|---|---|
| B | 1,471 | 33.7% | 12.7% | 1,440 | 33.1% | 12.6% | 1,454 | 33.0% | 12.3% |
| BC | 729 | 16.7% | 6.3% | 665 | 15.3% | 5.8% | 607 | 13.8% | 5.1% |
| BC(M) | 396 | 9.1% | 3.4% | 467 | 10.7% | 4.1% | 496 | 11.2% | 4.2% |
| BCP | 140 | 3.2% | 1.2% | 123 | 2.8% | 1.1% | 123 | 2.8% | 1.0% |
| BCP(M) | 125 | 2.9% | 1.1% | 161 | 3.7% | 1.4% | 180 | 4.1% | 1.5% |
| B(M) | 211 | 4.8% | 1.8% | 266 | 6.1% | 2.3% | 310 | 7.0% | 2.6% |
| BP | 68 | 1.6% | 0.6% | 69 | 1.6% | 0.6% | 61 | 1.4% | 0.5% |
| BP(M) | 117 | 2.7% | 1.0% | 104 | 2.4% | 0.9% | 117 | 2.7% | 1.0% |
| C | 89 | 2.0% | 0.8% | 107 | 2.5% | 0.9% | 74 | 1.7% | 0.6% |
| C(M) | 122 | 2.8% | 1.1% | 109 | 2.5% | 1.0% | 115 | 2.6% | 1.0% |
| CP | 50 | 1.1% | 0.4% | 21 | 0.5% | 0.2% | 13 | 0.3% | 0.1% |
| CP(M) | 197 | 4.5% | 1.7% | 194 | 4.5% | 1.7% | 211 | 4.8% | 1.8% |
| P | 163 | 3.7% | 1.4% | 120 | 2.8% | 1.1% | 99 | 2.2% | 0.8% |
| P(M) | 493 | 11.3% | 4.3% | 507 | 11.6% | 4.4% | 552 | 12.5% | 4.7% |
| Total taking core sciences combinations only | **2,710** | 62.0% | 23.4% | **2,545** | 58.5% | 22.3% | **2,431** | 55.1% | 20.6% |
| Total taking core sciences with mathematics | **1,661** | 38.0% | 14.3% | **1,808** | 41.5% | 15.9% | **1,981** | 44.9% | 16.8% |
| Total taking core sciences | 4,371 | 100.0% | 37.7% | 4,353 | 100.0% | 38.2% | 4,412 | 100.0% | 37.4% |
| Total size of GCE A-level cohort (only) | 11,597 | | 100.0% | 11,400 | | 100.0% | 11,805 | | 100.0% |

*Source:* DENI.

# B. Science and mathematics subject combinations: gender and institutional variation

This section considers how the popularity of core sciences and mathematics A-level subject combinations varied during 2005, 2007 and 2009 according to gender and type of institution. As before, small numbers preclude including applied science VCE A-level within this analysis.

## NI.7 Overall numbers taking core sciences by gender

Table NI.9 provides a gender-based breakdown of the numbers of students taking core sciences A-level combinations, and it can clearly be seen that the numbers of both males and females taking these subjects were similar and increased but slightly during 2005–09.

While biological sciences (as a single subject) was the most popular individual combination taken by males and females, almost half of all females took it compared with almost a third of all males. Overall, biological sciences (alone) and combinations involving biological sciences accounted for over 85% of all females taking core sciences and over 60% of their male peers.

Physics (alone) was taken by about a quarter of all males (and was consistently the second most popular option), but only by some 6% or so of females (though it was still the third most popular option among females). Overall, the proportions of males taking physics (alone or in

*Table NI.9. Numbers of 16–18 year old males and females taking core sciences GCE A-level combinations (Northern Ireland, 2005, 2007, 2009).*

| Core sciences | 2005 | | | | 2007 | | | | 2009 | | | | Overall percentage change in entries since 2005 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Male | | Female | | Male | | Female | | Male | | Female | | Male | Female |
| B | 584 | 28.4% | 1,098 | 47.5% | 635 | 31.2% | 1,071 | 46.2% | 623 | 29.8% | 1,141 | 49.1% | 6.7% | 3.9% |
| BC | 423 | 20.6% | 702 | 30.3% | 394 | 19.4% | 738 | 31.8% | 408 | 19.5% | 695 | 29.9% | –3.5% | –1.0% |
| BCP | 149 | 7.2% | 116 | 5.0% | 167 | 8.2% | 117 | 5.0% | 187 | 9.0% | 116 | 5.0% | 25.5% | 0.0% |
| BP | 122 | 5.9% | 63 | 2.7% | 107 | 5.3% | 66 | 2.8% | 110 | 5.3% | 68 | 2.9% | –9.8% | 7.9% |
| C | 91 | 4.4% | 120 | 5.2% | 103 | 5.1% | 113 | 4.9% | 83 | 4.0% | 106 | 4.6% | –8.8% | –11.7% |
| CP | 167 | 8.1% | 80 | 3.5% | 161 | 7.9% | 54 | 2.3% | 170 | 8.1% | 54 | 2.3% | 1.8% | –32.5% |
| P | 521 | 25.3% | 135 | 5.8% | 466 | 22.9% | 161 | 6.9% | 508 | 24.3% | 143 | 6.2% | –2.5% | 5.9% |
| **Total** | **2,057** | **100.0%** | **2,314** | **100.0%** | **2,033** | **100.0%** | **2,320** | **100.0%** | **2,089** | **100.0%** | **2,323** | **100.0%** | 1.6% | 0.4% |

*Source:* DENI.

combination with other core sciences subjects) stayed constant, while the equivalent proportions of females fell slightly from 17.0% to 16.4%.

Notably, there were overall decreases in the numbers of males and females (together) taking chemistry, both singly and in the singular combination CP. It can be calculated from table NI.9 that the proportion of females taking all core sciences combinations including chemistry increased from 44.0% to 41.8% while the equivalent proportion of males stayed at *ca.* 40%.

Tables NI.10 and NI.11 show a breakdown by gender of the numbers of students who took core sciences combinations solely or together with mathematics. It is important to note the imbalance in the numbers of males and females within the A-level cohort during 2005, 2007 and 2009, with males accounting for, on average, 43% of all students taking A-levels during these years.

Despite the fact that there have consistently been more females than males in the GCE A-level cohorts during 2005–09, it is calculable from table NI.10 that the percentage of all females taking core sciences combinations with mathematics increased from 11% to 12%, and the equivalent proportion of males taking core sciences with mathematics grew from 20% to 23%. In respect of the overall GCE A-level cohort (ie all students), the proportions of males and females taking core sciences combinations with mathematics grew from 8% to 10% and from 6% to 7%, respectively, during this period.

The top five most popular subject combinations were consistently the same among each gender (males: B, P(M), BC, BC(M) and CP(M); females: B, BC, BC(M), B(M) and P(M)). While B (as a singular subject) was the most popular core sciences subject among males and females, during the years surveyed, *ca*. 10% of all male students taking GCE A-levels (in all subjects) took it compared with *ca*. 14% of female students.

Key message NI3. Approximately 14% of all females taking GCE A-levels in all subjects take biological sciences (alone) compared with about 10% of males. The focus on a single science is concerning as it will restrict the options for accessing STEM higher education, albeit that it will broaden the educational experience of those studying non-science subjects.

Key message NI4. The percentage of students taking A-levels in mathematics with core sciences is increasing, with males being more likely than females to take such combinations. From the perspective of STEM higher education entry, it is encouraging to see more males and females eschewing physics (alone) in favour of combinations involving physics and mathematics.

## NI.8 Numbers of students taking core sciences: institutional differences

As indicated in table NI.12, the number of institutions in school sectors in Northern Ireland remained largely stable, while the number of FE sector institutions decreased during 2005–09 (reflecting the restructuring of the college sector during this period). Consistent with the information in table NI.5, the majority of students taking core sciences A-levels in Northern Ireland came from grammar schools. In addition, over 40% of students in grammar schools took core sciences A-levels, approximately double the proportion of students in non-selective secondary schools and those in FE colleges in 2007 and 2009. (For comparison, table ANI.3 details equivalent data for all students taking GCE and VCE A-levels.)

In relation to the rise in the proportion of students in Northern Ireland taking core science subjects at A-level over the time-period investigated, the data in table NI.13 show that participation in core sciences subjects also rose in grammar schools and FE colleges. There was a strong shift in the grammar schools in the proportion of students taking core sciences A-levels along with mathematics subjects, up from 41% to 48% between 2005 and 2009. Over 3,500 students from grammar schools completed A-levels in core sciences and/or mathematics subjects in each year investigated.

There is also an increasingly positive trend in respect of the numbers of students in non-selective secondary schools taking core sciences with mathematics, rising from 22% to 31%. In respect of this, it is notable that the Report of the STEM Review in Northern Ireland drew attention to the significant pool of STEM talent in these schools, as represented by their GCSE results, and expressed concern that at present comparatively few proceed to more advanced study in the sciences or mathematics (DENI/DELNI 2009). The reasons for this are almost certainly a complex interaction of factors, including student confidence, perception of difficulty and whether the school has the resources to support A-level teaching in biology, chemistry or physics. The requirement that all students have access to the 'Entitlement Framework' within the developing Area Learning Communities in Northern Ireland should help address this latter problem. In addition, initiatives such as the Step-Up programme, discussed in Chapter 2, have been successful in promoting and supporting students in secondary schools taking GCE A-level applied science.

Key message NI5. There is an increasingly positive trend in the numbers of students in non-selective secondary schools taking core sciences with mathematics, which is encouraging given that the Report of the STEM Review in Northern Ireland expressed concern that at present so few GCSE students in these schools proceed to post-16 study in these subjects.

Key message NI6. Participation in core sciences subjects rose in grammar schools and FE colleges. There was a strong shift in grammar schools in the proportion of students taking core sciences A-levels along with mathematics subjects. The uptake of the core sciences, while dominated by the biological sciences, is more evenly spread in these schools than other institutions.

*Table NI.10. Number of 16–18 year old females taking GCE A-level core sciences subject combinations (with or without mathematics), ranked by popularity (Northern Ireland 2005, 2007, 2009).*

| Subject combination | 2005 | % females taking core sciences combinations with/without mathematics | Subject combination | 2007 | % females taking core sciences combinations with/without mathematics | Subject combination | 2009 | % females taking core sciences combinations with/without mathematics |
|---|---|---|---|---|---|---|---|---|
| B | 965 | 41.7% | B | 892 | 38.4% | B | 960 | 41.3% |
| BC | 463 | 20.0% | BC | 447 | 19.3% | BC | 390 | 16.8% |
| BC(M) | 239 | 10.3% | BC(M) | 291 | 12.5% | BC(M) | 305 | 13.1% |
| B(M) | 133 | 5.7% | B(M) | 179 | 7.7% | B(M) | 181 | 7.8% |
| P(M) | 94 | 4.1% | P(M) | 139 | 6.0% | P(M) | 122 | 5.3% |
| C(M) | 75 | 3.2% | BCP(M) | 66 | 2.8% | BCP(M) | 59 | 2.5% |
| BCP | 65 | 2.8% | C(M) | 58 | 2.5% | C(M) | 59 | 2.5% |
| CP(M) | 61 | 2.6% | C | 55 | 2.4% | BCP | 57 | 2.5% |
| BCP(M) | 51 | 2.2% | BCP | 51 | 2.2% | CP(M) | 52 | 2.2% |
| C | 45 | 1.9% | CP(M) | 45 | 1.9% | C | 47 | 2.0% |
| BP(M) | 41 | 1.8% | BP(M) | 42 | 1.8% | BP(M) | 39 | 1.7% |
| P | 41 | 1.8% | BP | 24 | 1.0% | BP | 29 | 1.2% |
| BP | 22 | 1.0% | P | 22 | 0.9% | P | 21 | 0.9% |
| CP | 19 | 0.8% | CP | 9 | 0.4% | CP | 2 | 0.1% |
| All females taking core sciences only | 1,620 | 70.0% | All females taking core sciences only | 1,500 | 64.7% | All females taking core sciences only | 1,506 | 64.8% |
| All females taking core sciences with mathematics | 694 | 30.0% | All females taking core sciences with mathematics | 820 | 35.3% | All females taking core sciences with mathematics | 817 | 35.2% |
| Total size of female GCE A-level cohort | 6,633 | | Total size of female GCE A-level cohort | 6,567 | | Total size of female GCE A-level cohort | 6,672 | |

*Table NI.11. Number of 16–18 year old males taking GCE A-level core sciences subject combinations (with or without mathematics), ranked by popularity (Northern Ireland 2005, 2007, 2009).*

| Subject combination | 2005 | % males taking core sciences combinations with/without mathematics | Subject combination | 2007 | % males taking core sciences combinations with/without mathematics | Subject combination | 2009 | % males taking core sciences combinations with/without mathematics |
|---|---|---|---|---|---|---|---|---|
| B | 506 | 24.6% | B | 548 | 27.0% | B | 494 | 23.6% |
| P(M) | 399 | 19.4% | P(M) | 368 | 18.1% | P(M) | 430 | 20.6% |
| BC | 266 | 12.9% | BC | 218 | 10.7% | BC | 217 | 10.4% |
| BC(M) | 157 | 7.6% | BC(M) | 176 | 8.7% | BC(M) | 191 | 9.1% |
| CP(M) | 136 | 6.6% | CP(M) | 149 | 7.3% | CP(M) | 159 | 7.6% |
| P | 122 | 5.9% | P | 98 | 4.8% | B(M) | 129 | 6.2% |
| B(M) | 78 | 3.8% | BCP(M) | 95 | 4.7% | BCP(M) | 121 | 5.8% |
| BP(M) | 76 | 3.7% | B(M) | 87 | 4.3% | P | 78 | 3.7% |
| BCP | 75 | 3.6% | BCP | 72 | 3.5% | BP(M) | 78 | 3.7% |
| BCP(M) | 74 | 3.6% | BP(M) | 62 | 3.0% | BCP | 66 | 3.2% |
| C(M) | 47 | 2.3% | C | 52 | 2.6% | C(M) | 56 | 2.7% |
| BP | 46 | 2.2% | C(M) | 51 | 2.5% | BP | 32 | 1.5% |
| C | 44 | 2.1% | BP | 45 | 2.2% | C | 27 | 1.3% |
| CP | 31 | 1.5% | CP | 12 | 0.6% | CP | 11 | 0.5% |
| All males taking core sciences only | 1,090 | 53.0% | All males taking core sciences only | 1,045 | 51.4% | All males taking core sciences only | 925 | 44.3% |
| All males taking core sciences with mathematics | 967 | 47.0% | All males taking core sciences with mathematics | 988 | 48.6% | All males taking core sciences with mathematics | 1,164 | 55.7% |
| All males taking core sciences with or without mathematics | 4,964 | | All males taking core sciences with or without mathematics | 4,833 | | All males taking core sciences with or without mathematics | 5,133 | |

*Table NI.12. Comparison of the numbers of educational institutions with the numbers of 16–18 year old students taking GCE A-level qualifications (Northern Ireland, 2005, 2007, 2009).*

| Type of institution | Nos. of institution type | | | Nos. of 16–18 year old students taking examinations in GCE A-level subjects only | | | Percentage of students taking core sciences GCE A-levels (cf. Table NI.3) by institution type | | | Number of students taking core sciences GCE A-levels by institution type as a function of the total A-level cohort | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 |
| Grammar | 70 | 69 | 69 | 8,425 | 8,132 | 8,307 | 43.3% | 44.2% | 44.7% | 83.4% | 82.5% | 84.1% |
| Secondary | 74 | 88 | 93 | 2,480 | 2,720 | 3,044 | 22.8% | 22.6% | 19.3% | 12.9% | 14.1% | 13.3% |
| FE sector | 13 | 10 | 9 | 658 | 533 | 408 | 22.9% | 27.2% | 25.5% | 3.5% | 3.3% | 2.4% |
| Total[(a)] | 157 | 167 | 171 | 11,597 | 11,400 | 11,805 | 37.7% | 38.2% | 37.4% | 100.0% | 100.0% | 100.0% |

*Source:* DENI.

(a) Note that some institutions in Northern Ireland could not be identified. These have been excluded from the totals in this table pertaining to institution type. Note also that this table does not include those students taking vocational qualifications (VCE only) or institutions with VCE only entries.

*Table NI.13. Participation in core sciences with/without mathematics and other sciences by institution type[(a)] (Northern Ireland, 2005, 2007, 2009).*

| Core sciences | Mathematics and other sciences | Grammar 2005 | Grammar 2007 | Grammar 2009 | Secondary 2005 | Secondary 2007 | Secondary 2009 | Further Education 2005 | Further Education 2007 | Further Education 2009 |
|---|---|---|---|---|---|---|---|---|---|---|
| No core sciences | None | 2,965 | 2,842 | 2,961 | 1,604 | 1,729 | 2,031 | 384 | 284 | 253 |
| | Mathematics | 377 | 460 | 505 | 66 | 127 | 115 | X[(b)] | X[(b)] | X[(b)] |
| | Mathematics and other sciences | 147 | 170 | 176 | 17 | 16 | 15 | X[(b)] | X[(b)] | X[(b)] |
| | Other sciences | 1,289 | 1,068 | 953 | 228 | 234 | 294 | 99 | 91 | 41 |
| **No core sciences total** | | **4,778** | **4,540** | **4,595** | **1,915** | **2,106** | **2,455** | **507** | **388** | **304** |
| Core sciences | None | 1,627 | 1,518 | 1,525 | 381 | 401 | 355 | 102 | 77 | 61 |
| | Mathematics | 1,296 | 1,413 | 1,560 | 115 | 145 | 160 | X[(b)] | X[(b)] | X[(b)] |
| | Mathematics and other sciences | 216 | 203 | 209 | 11 | 15 | 23 | X[(b)] | X[(b)] | X[(b)] |
| | Other sciences | 508 | 458 | 418 | 58 | 53 | 51 | 26 | 37 | 17 |
| **Core sciences total** | | **3,647** | **3,592** | **3,712** | **565** | **614** | **589** | **151** | **145** | **104** |
| **Total no. of 16–18 year old GCE A-level students** | | **8,425** | **8,132** | **8,307** | **2,480** | **2,720** | **3,044** | **658** | **533** | **408** |

*Source:* DENI.

(a) Note that some institutions in Northern Ireland could not be identified. These have been excluded from the totals of this table. Note also that this table does not include those students taking vocational qualifications (VCE only) or institutions with VCE only entries.

(b) Data suppressed.

## C. Attainment in core sciences and mathematics A-level subject combinations

While information on the numbers taking science and mathematics A-levels provides an indication of the size of the 'pool of talent' available to study for first degrees in science, technology, engineering or mathematics, a more refined understanding of this pool may be gained from considering attainment data.

Entry into many higher education STEM first degree courses is dependent on students gaining combinations of A–C grades, particularly in core sciences and/or mathematics subjects, and these are the main focus here. Consequently, this section examines the proportion of the pool that gains good GCE A-levels in combinations of (i) core sciences and (ii) core sciences with mathematics among students taking three (or more) A-levels (three being the modal number of A-level subjects taken (cf. table NI.7)). Although students gaining grades A–C in a single core science or mathematics subjects may subsequently pursue STEM studies at higher education level, generally it is expected that students wishing to study for a STEM first degree will have gained passes in at least two sciences or mathematics A-levels (notwithstanding their attainment in other subjects).[61]

61 SCORE (2009).

## NI.9 Numbers of students taking three A-levels and obtaining grades A–C in two or more core sciences and/or mathematics subjects

### NI.9.1 Overview

Table NI.14 provides summary data on the numbers of students taking three or more A-levels and gaining A–C grades in two or more core sciences and/or mathematics subjects. It shows that between 2005 and 2009 the percentage of these students gaining grades A–C grades increased from 78% to 81%, and it is calculable that the proportion of students gaining straight A grades in at least two core sciences and/or mathematics subjects rose 15% over this time-period. It may also be seen from table N.14 that the percentage of all students taking core sciences and/or mathematics qualifications that were (i) either just taking a single science and/or (ii) not being awarded A–C grades in two or more core sciences and/or mathematics subjects fell from 23% to 19%.

### NI.9.2 Comparison by institution type

Table NI.15 breaks the figures in table NI.14 down by institution type and compares these with the total number of students taking A-levels in each type of institution. It is

*Table NI.14. Numbers of 16–18 year old students taking three or more A-levels and gaining grades A–C in two or more core sciences and/or mathematics subjects (Northern Ireland, 2005, 2007, 2009).*

| | 2005 | | 2007 | | 2009 | |
|---|---|---|---|---|---|---|
| Grades | Students | % | Students | % | Students | % |
| All A | 795 | 30.8% | 873 | 33.2% | 911 | 33.6% |
| A–B | 1,479 | 57.4% | 1,575 | 59.8% | 1,655 | 61.0% |
| A–C | 1,997 | 77.5% | 2,097 | 79.6% | 2,193 | 80.8% |
| Other[a] | 580 | 22.5% | 536 | 20.4% | 520 | 19.2% |
| Grand total | 2,577 | 100.0% | 2,633 | 100.0% | 2,713 | 100.0% |
| Total no. of students taking core sciences | 4,371 | | 4,353 | | 4,412 | |

*Source:* DENI.

(a) Other denotes candidates who were not awarded a grade A, B or C in *all* their science or mathematics A-levels.

*Table NI.15. Numbers of 16–18 year old students taking three or more GCE A-levels and gaining grades A–C in two or more core science and/or mathematics subjects, split by institution type[a] (Northern Ireland, 2005, 2007, 2009).*

| | | 2005 | | 2007 | | 2009 | |
|---|---|---|---|---|---|---|---|
| Type of institution | | Students | % of total students | Students | % of total students | Students | % of total students |
| Grammar schools | All A | 752 | 29.2% | 811 | 30.8% | 870 | 32.1% |
| | A–B | 1,383 | 53.7% | 1,434 | 54.5% | 1,535 | 56.6% |
| | A–C | 1,861 | 72.2% | 1,895 | 72.0% | 2,017 | 74.3% |
| | Other | 488 | 18.9% | 450 | 17.1% | 423 | 15.6% |
| Total no. of students taking core sciences combinations in grammar schools | | 2,349 | 91.2% | 2,345 | 89.1% | 2,440 | 89.9% |
| Non-selective secondary schools | All A | 31 | 1.2% | 53 | 2.0% | 34 | 1.3% |
| | A–B | 68 | 2.6% | 116 | 4.4% | 105 | 3.9% |
| | A–C | 98 | 3.8% | 167 | 6.3% | 152 | 5.6% |
| | Other | 71 | 2.8% | 63 | 2.4% | 75 | 2.8% |
| Total no. of students taking core sciences combinations in non-selective secondary schools | | 169 | 6.6% | 230 | 8.7% | 227 | 8.4% |
| FE colleges | All A | 12 | 0.5% | 9 | 0.3% | 6 | 0.2% |
| | A–B | 28 | 1.1% | 24 | 0.9% | 11 | 0.4% |
| | A–C | 37 | 1.4% | 34 | 1.3% | 19 | 0.7% |
| | Other | 21 | 0.8% | 23 | 0.9% | 22 | 0.8% |
| Total no. of students taking core sciences combinations in FE colleges | | 58 | 2.3% | 57 | 2.2% | 41 | 1.5% |
| Grand total | | 2,577 | 100.0% | 2,633 | 100.0% | 2,713 | 100.0% |
| Total no. of students taking core sciences combinations | | 4,371 | | 4,353 | | 4,412 | |

*Source:* DENI.

(a) Other institutions are excluded from this analysis.

clearly evident from table NI.15 that grammar schools account for the majority of 16–18 year olds obtaining the minimum requirements for (potential) entry into higher education STEM courses. Indeed, as a percentage of the total A-level cohort, it is calculable from table NI.15 that the proportion of students in grammar schools gaining A–C grades in two or more core sciences and/or mathematics A-levels increased overall from 72% to 74% between 2005 and 2009.

The proportion of students from non-selective secondary schools generally considered suitable for STEM higher education studies also increased, and encouragingly, the proportion of these students gaining A–C grades in at least two core sciences and/or mathematics subjects grew 55% overall during 2005–09.

However, the numbers gaining the generally expected minimum requirement for STEM higher education entry almost halved among students from FE sector colleges, and this may have resulted from the reorganisation of this sector mentioned earlier.

### NI.9.3 Comparison by subject combination (aggregated data for all institution types)

The data in table NI.14 may also be disaggregated by core sciences/or mathematics combinations to show the numbers of students taking three A-levels and gaining A, A or B and A–C grades in at least two core sciences and/or mathematics combinations (table NI.16), compared with the total numbers of students taking core sciences and/or mathematics in each year.

Against the background of a 1% overall increase in the numbers taking core sciences and/or mathematics combinations between 2005 and 2009, table NI.16 shows that there were overall increases in the numbers of candidates obtaining A–C grades in most combinations. Indeed, the proportion of students taking core sciences and/or mathematics that gained A–C grades in at least two of these subjects rose, in comparison with the size of the A-level cohort, from 45.6% to 49.7% between 2005 and 2009. However, overall falls in students gaining A–C grades are observed among those taking BCP (–10.5%), BP (–12.5%), C(M) (–6.5%) and CP (–75%).

*Table NI.16. Numbers of 16–18 year old students taking three or more GCE A-levels and gaining A–C grades in at least two core sciences and/or mathematics subjects (Northern Ireland, 2005, 2007, 2009).*

| Subject combination | All A | | | A–B | | | A–C | | | Other[a] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 |
| BC | 149 | 155 | 163 | 331 | 347 | 333 | 495 | 491 | 451 | 205 | 156 | 137 |
| BC(M) | 204 | 235 | 261 | 309 | 365 | 397 | 355 | 423 | 456 | 39 | 44 | 40 |
| BCP | 46 | 44 | 33 | 92 | 68 | 75 | 114 | 101 | 102 | 25 | 22 | 21 |
| BCP(M) | 89 | 104 | 119 | 113 | 140 | 161 | 122 | 158 | 176 | *X*[b] | *X*[b] | *X*[b] |
| B(M) | 50 | 74 | 74 | 110 | 147 | 159 | 153 | 206 | 218 | 46 | 43 | 67 |
| BP | *X*[b] | *X*[b] | *X*[b] | 17 | 18 | 14 | 32 | 30 | 28 | 29 | 34 | 28 |
| BP(M) | 19 | 26 | 35 | 52 | 53 | 61 | 85 | 76 | 86 | 32 | 28 | 31 |
| C(M) | 34 | 28 | 35 | 67 | 55 | 61 | 92 | 76 | 86 | 27 | 30 | 24 |
| CP | 5 | *X*[b] | *X*[b] | 13 | 9 | *X*[b] | 24 | 14 | 6 | 21 | 5 | 6 |
| CP(M) | 88 | 83 | 88 | 138 | 129 | 136 | 172 | 158 | 178 | 24 | 36 | 33 |
| M(+M) | *X*[b] | 7 | *X*[b] | 8 | 9 | *X*[b] | 11 | 11 | 12 | *X*[b] | *X*[b] | 5 |
| P(M) | 106 | 111 | 97 | 229 | 235 | 246 | 342 | 353 | 394 | 128 | 132 | 124 |
| Grand total | 795 | 873 | 911 | 1,479 | 1,575 | 1,655 | 1,997 | 2,097 | 2,193 | 580 | 536 | 520 |
| Total size of GCE A-level cohort (only) | 4,371 | 4,353 | 4,412 | 4,371 | 4,353 | 4,412 | 4,371 | 4,353 | 4,412 | 4,371 | 4,353 | 4,412 |

*Source:* DENI.

(a) Other denotes candidates who were not awarded a grade A, B or C in *all* their core sciences or mathematics A-levels.

(b) Data suppressed.

Overall, it is possible to calculate that of the students who took at least three A-levels and two or more core sciences and/or mathematics subjects including biological sciences in 2005, 2007 and 2009, increases of 14.6% and 9.8%, respectively, were recorded in the proportions obtaining straight A grades and A–C grades. Of the fraction of these students who took mathematics (ie those students who took BC(M), BCP(M), B(M) and BP(M)), there was a 35% improvement in candidates gaining straight A grades and a 31% increase in numbers of candidates gaining A–C grades.

Similarly, of the students who took two or more core sciences and/or mathematics subjects including chemistry in 2005, 2007 and 2009, increases of 14% and 6%, respectively, were recorded in the proportions obtaining straight A grades and A–C grades. Of the fraction of these students who took mathematics (ie those students who took CB(M), CBP(M), C(M) and CP(M)), there was a 21% improvement both in candidates gaining straight A grades and A–C grades.

Of the students who took two or more core sciences and/or mathematics subjects including physics in 2005, 2007 and 2009, increases of 6% and 9%, respectively, were recorded in the proportions obtaining straight A grades and A–C grades. Of the fraction of these students who took mathematics (ie those students who took BP(M), BCP(M), P(M) and PC(M)), there was a 12% improvement in candidates gaining straight A grades and a 16% increase in the numbers of candidates gaining A–C grades.

Finally, in comparing the 'other' data with the grade information in table NI.16, it is possible to conclude that an increasingly smaller percentage of candidates taking at least three GCE A-levels and two core sciences and/or mathematics subjects failed to attain the grades that would generally be required for admission into higher education STEM first degree courses (falling from 13% to 12% between 2005 and 2009).

Key message NI7. The proportion of students taking three GCE A-levels and gaining A–C grades in at least two core sciences and/or mathematics subjects rose from 45.8% to 49.4% between 2005 and 2009.

# Scotland

## S.1 Introduction

This chapter investigates the data on Scottish Higher and Advanced Higher qualifications taken by students in Scotland. It considers primarily the combinations of core science and mathematics subjects taken by school leavers and students of FE colleges (who took at least one Higher), at Higher and Advanced Higher in the years 2004/05, 2006/07, and 2008/09. It must be stated that this analysis excludes any A-level awards made in Scotland. This is because A-levels were only taken in the independent schools and represent a very small proportion of qualifications awarded in Scotland in any given year (cf. SCIS).

Details of the methodology used for this analysis are provided in the electronic appendix (see http://royalsociety.org/education-policy/projects/). In this Chapter 16–18 students form the bulk of the student population covered by the data. However, in order to gain the fullest possible picture, it is important to note that the data included in the tables and commentary here are for school leavers from state-funded and independent schools plus a small number of students registered at FE colleges during these years.

The chapter is separated into four sections:

A. The number of students taking Higher and Advanced Higher qualifications in all subjects during 2005, 2007 and 2009.

B. Science and mathematics subject combinations taken by students during 2005, 2007 and 2009 (at Higher and Advanced Higher).

C. Data on core sciences and mathematics subject combinations disaggregated by gender and institution type.

D. Grade-based information on core sciences and mathematics subject combinations at Higher and Advanced Higher.

There are some clear differences in the structure of the curriculum and qualifications between Scotland and the rest of the UK. Box 2 outlines the structure of secondary education and the qualifications in Scotland. Standard Grade qualifications are broadly equivalent to GCSEs in the UK as the school 'exit' qualification. Standard Grades are typically taken at S3 and S4 (cf. table S.1). 'National Courses' were adopted in 1999, and consist of a range of one-year courses available at a number of different qualification levels. These National Courses were designed to be offered in post-compulsory education, with the intention of meeting the individual needs of the student.

With respect to Intermediate courses, these were intended for students to follow on from their Standard Grades in S5 and S6. For instance, in recent years students gaining Credit level in Standard Grade examinations have generally progressed directly to Higher-level courses, while those gaining General level at Standard Grade have usually continued onto Intermediate II (since their introduction in 1999) in those subjects in S5, as a stepping stone to Higher-level courses (Royal Society 2008*b*). It has been noted that Intermediate I and II qualifications have been increasingly utilised at S4 as they have been considered a better progression route *in some subjects* to Highers than Standard Grades. Highers hold a broad equivalence to A-levels in the UK as the 'gold standard' (Scottish Government 2008). Advanced Highers are separate, well-regarded qualifications usually studied by students who choose not to leave school at the end of S5 and who are seeking challenging qualifications to better prepare them for study at university. Students with strong results in relevant Advanced Highers may be allowed direct entry into the second year of (four-year) first degree courses in Scotland.

One key difference between Scotland and the rest of the UK is the breadth and flexibility in the qualifications that students can take. It is very common for students to take five Highers or a combination of Intermediates and Highers in S5. Students may also take additional Highers along with Advanced Highers in S6, and the uptake is based to some extent on their achievement in Standard Grade and Intermediate courses. The data included in this chapter take account of this flexibility by including entries in Highers and Advanced Highers taken in previous academic years.

## S.2 Subjects and institution types investigated

For the purposes of this report, the following subjects and institutions, as categorised within the datasets provided by the Education Analytical Services division of the Scottish Government, were investigated.

### S.2.1 Science

This report is concerned with the core sciences (biology, human biology, chemistry, physics). Human biology has only been offered at Higher level. In contrast to the rest of the UK, human biology forms an important component of core sciences participation in Scotland; it is a popular option for students progressing to careers in medicine and humanities. Therefore, the biological sciences category used for the rest of the UK will not be adopted for Scotland, with human biology regarded as an individual subject amongst the core sciences. There was a wide range of non-core sciences subjects studied in Scotland. However, as the SQA did not use a category analogous to the other science category used in the rest of the UK, this category will not be used in the following analysis of Scotland data.

### S.2.2 Mathematics

Mathematics generally refers to a range of mathematics courses at Higher and Advanced Higher. These mathematics courses differ in their descriptions, according

*Box 2. Secondary education and the typical SQA qualifications taken.*

| Stage | Age range | Typical qualifications |
|---|---|---|
| S1 | 12–13 | |
| S2 | 13–14 | |
| S3 | 14–15 | Standard Grade |
| S4 | 15–16 | |
| S5 | 16–17 | Intermediate I/II, Higher |
| S6 | 17–18 | Higher/Advanced Higher |

to the nature of their mathematical content. Some mathematics courses contained more mechanics, statistics, or numerical analysis content than the typical mathematics course. All applied mathematics courses were discontinued in 2004. Mathematics courses with an emphasis on statistics, mechanics or numerical analysis were discontinued by 2007. Since 2007, there have been only two active mathematics courses offered at Intermediate II and above; one standard mathematics course offered at Intermediate II, Higher, and Advanced Higher, and an alternative mathematics course with more emphasis on applied mathematics offered at Intermediate II only.

### S.2.3 Institution types

Institution types were pre-divided by the Scottish Government as follows: Local Authority, Grant-aided, Independent, and Further Education. Local Authority and Grant-aided schools are both state-funded and hence are collectively referred to as 'state-funded' schools hereon. Table S.1 provides data on the number of each type of institution in 2005, 2007 and 2009 where students were entered for any Higher subject.

*Table S.1. Number of institutions where students were entered for Highers (2005, 2007, 2009).*

| Institution type | Institutions | | |
|---|---|---|---|
| | 2005 | 2007 | 2009 |
| FE sector | 35 | 37 | 39 |
| Independent | 38 | 37 | 39 |
| State-funded | 369 | 371 | 371 |
| Other[a] | 10 | 9 | 10 |
| Total | 452 | 454 | 459 |

*Source:* Scottish Government.

(a) Includes students registered in multiple institutions and unidentified institutions.

## A. The number of students taking combinations of Higher and Advanced Higher qualifications in all subjects in Scotland during 2005, 2007 and 2009

There were small changes in the patterns of Highers and Advanced Highers uptake since 2005 (table S.2). The modal number of Higher subjects taken was five in each of the three years investigated. However, *ca.* 25% of students took six or more Highers, thereby increasing the range of subjects studied at this level. Over recent years there has been a steady increase in the number of students taking two or more Advanced Highers with nearly half of the students doing so in 2009. The latter trend is particularly notable, perhaps reflecting the increased importance being accorded to these qualifications and the greater competition for university admissions.

Key message S1. The modal number of Highers taken during the years measured was consistently five, while the modal number of Advanced Highers taken was one. Increasing numbers of students have been taking greater numbers of Highers and Advanced Highers.

## B Science and mathematics subject combinations taken by students in Scotland during 2005, 2007 and 2009 (at Higher and Advanced Higher).

### S.3 Overall numbers of students taking Highers and Advanced Highers in core sciences and mathematics

The numbers of students with Highers and/or Advanced Highers in Scotland taking core sciences (biology, human biology, chemistry, and physics) and mathematics are outlined in table S.3.

Table S.3 shows that the proportion of all students taking core sciences at Higher level remained largely unchanged at around 50% of the cohort in each year investigated. The main changes related to the choice of core sciences with or without mathematics. There was a 5% decrease in the proportion of students that took neither core sciences Highers nor Higher or Advanced Higher mathematics qualifications over the period studied, but it is calculable that there was a 38% increase in the proportion taking core sciences Highers and Advanced Highers with Higher and/or Advanced Higher mathematics qualifications (table S.3).

Key message S2. The number of entries into Highers/ Advanced Highers in core sciences and/or mathematics increased during the period 2005–09.

*Table S.2. Number of students taking Highers and Advanced Highers (all subjects, 2005, 2007, 2009).*

| Student numbers by no. of Highers taken | | | | Student numbers by no. of Advanced Highers taken | | | |
|---|---|---|---|---|---|---|---|
| Higher (N) | 2005 | 2007 | 2009 | Advanced Highers | 2005 | 2007 | 2009 |
| 0[(a)] | 30 | 27 | 22 | 0[(b)] | 25,017 | 22,842 | 24,946 |
| 1 | 5,249 | 5,105 | 5,383 | 1 | 5,870 | 5,427 | 6,190 |
| 2 | 3,778 | 3,646 | 3,976 | 2 | 3,135 | 3,262 | 3,648 |
| 3 | 3,833 | 3,489 | 3,956 | 3 | 1,147 | 1,450 | 1,717 |
| 4 | 5,118 | 4,437 | 4,990 | 4 (or more) | 88 | 124 | 153 |
| 5 | 7,355 | 7,036 | 7,950 | Total cohort size | 35,257 | 33,105 | 36,654 |
| 6 | 6,093 | 5,789 | 6,289 | | | | |
| 7 | 3,069 | 2,836 | 3,284 | | | | |
| 8 | 641 | 661 | 740 | | | | |
| 9 (or more) | 91 | 79 | 64 | | | | |
| Total cohort size | 35,257 | 33,105 | 36,654 | | | | |

*Source:* Scottish Government.

(a) These figures account for students who took Advanced Highers only.

(b) These figures account for students who took Highers only.

*Table S.3. Core sciences and mathematics participation amongst students in Scotland (2005, 2007, 2009).*

| Core sciences participation | Higher and/or Advanced HighWer mathematics qualifications | 2005 | 2007 | 2009 | % overall change in numbers since 2005 |
|---|---|---|---|---|---|
| No core sciences at Higher | No mathematics | 13,848 | 12,844 | 14,502 | –4.7% |
| | Mathematics at Higher | 3,864 | 3,403 | 3,768 | –2.4% |
| | Mathematics at Higher and Advanced Higher | 109 | 124 | 146 | 33.9% |
| | Mathematics at Advanced Higher only | 5 | 7 | 5 | 0.0% |
| Total no. of students not taking any Higher core sciences | | 17,826 | 16,378 | 18,421 | 3.3% |
| Core sciences | Mathematics qualifications | 2005 | 2007 | 2009 | % overall change in numbers since 2005 |
| Core sciences at Higher | No mathematics | 5,424 | 5,133 | 5,242 | –3.4% |
| | + Mathematics at Higher | 9,982 | 9,351 | 10,185 | –2.0% |
| | + Mathematics at Higher and Advanced Higher | 2,014 | 2,226 | 2,787 | 38.4% |
| | + Mathematics at Advanced Higher only | 11 | 17 | 19 | 72.7% |
| Total no. of students taking any Higher core sciences[(a)] | | 17,431 | 16,727 | 18,233 | 4.6% |
| Total no. of students taking Highers and/or Advanced Highers | | 35,257 | 33,105 | 36,654 | 13.6% |

*Source:* Scottish Government.

(a) Note: the figures in this row include data for 8, 7 and 11 students in 2005, 2007 and 2009 whose gender was not coded in the records.

*Table S.4. Number of Highers compared with the number of core sciences Highers entered (2005, 2007, 2009).*

| No. of Higher core sciences taken | Year | Number of Highers taken | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 (or more) | Total |
| 1 | 2005 | 409 | 647 | 1,007 | 1,749 | 2,702 | 2,265 | 1,516 | **10,295** |
| | 2007 | 393 | 614 | 935 | 1,551 | 2,579 | 2,094 | 1,360 | **9,526** |
| | 2009 | 354 | 576 | 945 | 1,657 | 2,828 | 2,252 | 1,514 | **10,126** |
| 2 | 2005 | | 66 | 178 | 544 | 1,816 | 1,626 | 1,138 | **5,368** |
| | 2007 | | 78 | 194 | 543 | 1,776 | 1,545 | 1,121 | **5,257** |
| | 2009 | | 80 | 228 | 608 | 2,031 | 1,734 | 1,302 | **5,983** |
| 3 (or more) | 2005 | | | 8 | 88 | 402 | 742 | 520 | **1,760** |
| | 2007 | | | 15 | 94 | 467 | 830 | 531 | **1,937** |
| | 2009 | | | 16 | 92 | 591 | 817 | 597 | **2,113** |

*Source:* Scottish Government.

## S.4 Overall numbers of students taking core sciences

The majority of students in Scotland with core sciences at Higher took one core sciences subject as part of their subject combination at Higher, with the highest proportion of these students taking five Highers in total (table S.4). However, it is calculable from table S.4 that the proportion of students taking two or more core sciences rose 13.5% between 2005 and 2009, and that over 8,000 students studied two or more core sciences Highers in 2009. This represented over 44% of students taking core sciences subjects at Higher that year.

Similarly, there was a notable rise in the proportion and numbers of students taking core sciences at Advanced Higher (table S.5). Whilst the majority of students who took core sciences at Advanced Higher took only one core science, the proportion of students taking two or more core sciences at Advanced Higher increased, with much of the growth attributed to students taking two Advanced Highers in core sciences.

## S.5 Subject combinations at Higher

Table S.6 shows the combinations of core sciences subjects chosen at Higher. It can be calculated from this

*Table S.5. Number of Advanced Highers compared with the number of core sciences Advanced Highers (2005, 2007, 2009).*

| Number of Advanced Higher core sciences taken | Year | Number of Advanced Highers taken | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 (or more) | Total |
| 1 | 2005 | 937 | 1,098 | 350 | 29 | **2,414** |
| | 2007 | 860 | 1,099 | 407 | 30 | **2,396** |
| | 2009 | 904 | 1,248 | 474 | 46 | **2,672** |
| 2 | 2005 | | 456 | 445 | 35 | **936** |
| | 2007 | | 546 | 577 | 54 | **1,177** |
| | 2009 | | 545 | 715 | 68 | **1,328** |
| 3 | 2005 | | | 53 | 17 | **70** |
| | 2007 | | | 59 | 24 | **83** |
| | 2009 | | | 76 | 23 | **99** |

*Source:* Scottish Government.

*Table S.6. Students taking core sciences combinations at Higher level only (2005, 2007, 2009).*

| Higher level core sciences combinations | Numbers taking Highers only | | |
|---|---|---|---|
| | 2005 | 2007 | 2009 |
| B | 3,897 | 3,738 | 3,838 |
| BC | 2,106 | 2,023 | 2,315 |
| BCP | 1,267 | 1,379 | 1,468 |
| BH | 106 | 80 | 114 |
| BHC | 61 | 60 | 78 |
| BHCP<br>BHP | 20 | 36 | 40 |
| BP | 335 | 369 | 462 |
| C | 1,461 | 1,394 | 1,360 |
| CP | 2,058 | 1,868 | 2,078 |
| H | 1,650 | 1,481 | 1,770 |
| HC | 642 | 767 | 852 |
| HCP | 412 | 462 | 527 |
| HP | 121 | 150 | 162 |
| P | 3,287 | 2,913 | 3,158 |
| Grand total | 17,423 | 16,720 | 18,222 |

*Source:* Scottish Government.

that biology (B plus H alone) accounted for almost a third of all core sciences Higher candidates. Combinations involving biology (biology and human biology) have proved consistently the most popular, accounting for 61%, 63% and 64% of all core sciences combinations candidature in 2005, 2007 and 2009, respectively (if agglomerating data for both biological subjects together). By contrast, a steady 43% of core sciences Higher candidates took physics combinations during this period, while the percentage of those taking combinations involving chemistry rose overall from 34% to 35%.

Key message S3. The majority of individuals taking core sciences Highers in 2005, 2007 and 2009 took combinations that included biology and/or human biology.

## S.6 Overall numbers of students taking core sciences together with mathematics

As table S.7 shows,[62] there were some considerable changes in core sciences with mathematics subject combinations taken at Higher in the period investigated. Compared with growth of 4% and 5% in overall student numbers taking Higher and the number of core sciences students taking Higher respectively, there was a drop in the numbers studying core sciences at Higher without any mathematics Higher between 2005 and 2009. The number who studied core sciences subjects with mathematics increased by 8.1% in the same period. Around 70% of students taking any core sciences Higher also studied a mathematics Higher in each of the years investigated.

Of the core sciences and mathematics combinations, P(M) was consistently the most popular individual subject combination, followed by CP(M) and BC(M). The numbers of students taking physics with mathematics dropped slightly, mostly attributed to a drop in the number of boys taking that subject combination. A slight rise in the numbers taking BC(M) was mainly attributed to growth in the state-funded sector. A significant proportion also took biology or human biology together with chemistry, physics and mathematics. The top five core sciences with mathematics combinations remained unchanged in terms of popularity across the years studied, although this is the case without combining data on those taking biology or human biology with chemistry, physics and mathematics.

Table S.8 shows the core sciences (with or without mathematics) subject combinations taken by students at Advanced Higher.

The patterns of change in subject combinations at Advanced Higher were similar to those found at Higher. The numbers taking core sciences subjects with mathematics rose 46% between 2005 and 2009, relative to 14% and 6% rises in the numbers taking Advanced Highers overall and core sciences with or without mathematics at Advanced Higher respectively. This meant that over 40% of students taking core sciences also took mathematics at Advanced Higher. Whilst biology as a single subject remained the most popular subject combination at Advanced Higher, P(M) and BC have shown strong growth (over 30% growth in the number of students taking these subject combinations), forming the bulk of the increases noted in table S.5 on the representation of core sciences among students taking Advanced Highers. This may reflect ongoing changes in university entrance for the top STEM university courses in recent years.

Key message S4. The proportion of students studying core sciences together with mathematics at Higher and Advanced Higher level has increased.

# C Science and mathematics subject combinations: gender and institution

This section considers how the popularity of science and mathematics subject combinations in Highers and Advanced Highers varies according to gender and the type of educational establishment in which they may be taken.

62 A complete version of this table, containing data for all possible core sciences combinations, is provided in the electronic appendix (table AS.1).

*Table S.7. Numbers of students taking core sciences combinations (with or without mathematics) at Higher (top 10), ranked by popularity (2005, 2007, 2009).*

| Subject combination | 2005 | % of students taking core sciences Highers | % all students taking Highers | Subject combination | 2007 | % of students taking core sciences Highers | % all students taking Highers | Subject combination | 2009 | % of students taking core sciences Highers | % all students taking Highers |
|---|---|---|---|---|---|---|---|---|---|---|---|
| P(M) | 2,797 | 16.1% | 7.9% | P(M) | 2,436 | 14.6% | 7.4% | P(M) | 2,663 | 14.6% | 7.3% |
| B | 2,356 | 13.5% | 6.7% | B | 2,232 | 13.3% | 6.7% | B | 2,157 | 11.8% | 5.9% |
| CP(M) | 1,950 | 11.2% | 5.5% | CP(M) | 1,740 | 10.4% | 5.3% | CP(M) | 1,956 | 10.7% | 5.3% |
| BC(M) | 1,628 | 9.3% | 4.6% | BC(M) | 1,598 | 9.6% | 4.8% | BC(M) | 1,840 | 10.1% | 5.0% |
| B(M) | 1,541 | 8.8% | 4.4% | B(M) | 1,506 | 9.0% | 4.5% | B(M) | 1,681 | 9.2% | 4.6% |
| BCP(M) | 1,217 | 7.0% | 3.5% | BCP(M) | 1,304 | 7.8% | 3.9% | BCP(M) | 1,399 | 7.7% | 3.8% |
| H | 1,144 | 6.6% | 3.2% | H | 986 | 5.9% | 3.0% | H | 1,122 | 6.2% | 3.1% |
| C(M) | 1,004 | 5.8% | 2.8% | C(M) | 917 | 5.5% | 2.8% | C(M) | 945 | 5.2% | 2.6% |
| H(M) | 506 | 2.9% | 1.4% | HC(M) | 602 | 3.6% | 1.8% | HC(M) | 665 | 3.6% | 1.8% |
| P | 490 | 2.8% | 1.4% | H(M) | 495 | 3.0% | 1.5% | H(M) | 648 | 3.6% | 1.8% |
| Total no. of students taking core sciences combinations only | 5,427 | 31.1% | 15.4% | Total no. of students taking core sciences combinations only | 5,145 | 30.8% | 15.5% | Total no. of students taking core sciences combinations only | 5,252 | 28.8% | 14.3% |
| Total no. of students taking core sciences with mathematics | 11,996 | 68.9% | 34.0 | Total no. of students taking core sciences with mathematics | 11,575 | 69.2% | 35.0% | Total no. of students taking core sciences with mathematics | 12,970 | 71.2% | 35.4% |
| Total no. of students taking core sciences Highers | 17,423 | 100.0% | 49.4 | Total no. of students taking core sciences Highers | 16,720 | 100.0% | 50.5% | Total no. of students taking core sciences Highers | 18,222 | 100.0% | 49.7% |
| Total no. of students taking Highers | 35,257 | | 100.0% | Total no. of students taking Highers | 33,105 | | 100.0% | Total no. of students taking Highers | 36,654 | | 100.0% |

*Source:* Scottish Government.

*Table S.8. Numbers of students taking core sciences combinations (with or without mathematics) at Advanced Higher (2005, 2007, 2009).*

| Subject combination | 2005 | % of students taking core sciences | % all students taking Advanced Highers | Subject combination | 2007 | % of students taking core sciences | % all students taking Advanced Highers | Subject combination | 2009 | % of students taking core sciences | % all students taking Advanced Highers |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B | 820 | 24.0% | 8.0% | B | 766 | 21.0% | 7.5% | B | 835 | 20.4% | 7.1% |
| P(M) | 497 | 14.5% | 4.9% | BC | 602 | 16.5% | 5.9% | P(M) | 632 | 15.4% | 5.4% |
| BC | 463 | 13.5% | 4.5% | P(M) | 513 | 14.0% | 5.0% | BC | 623 | 15.2% | 5.3% |
| C | 415 | 12.1% | 4.1% | C | 403 | 11.0% | 3.9% | C | 385 | 9.4% | 3.3% |
| P | 327 | 9.6% | 3.2% | P | 308 | 8.4% | 3.0% | C(M) | 333 | 8.1% | 2.8% |
| C(M) | 278 | 8.1% | 2.7% | C(M) | 292 | 8.0% | 2.8% | P | 319 | 7.8% | 2.7% |
| CP(M) | 198 | 5.8% | 1.9% | CP(M) | 225 | 6.2% | 2.2% | CP(M) | 284 | 6.9% | 2.4% |
| CP | 138 | 4.0% | 1.3% | BC(M) | 189 | 5.2% | 1.8% | BC(M) | 253 | 6.2% | 2.2% |
| BC(M) | 108 | 3.2% | 1.1% | CP | 134 | 3.7% | 1.3% | B(M) | 168 | 4.1% | 1.4% |
| B(M) | 77 | 2.3% | 0.8% | B(M) | 114 | 3.1% | 1.1% | CP | 115 | 2.8% | 1.0% |
| BCP | 59 | 1.7% | 0.6% | BCP | 65 | 1.8% | 0.6% | BCP | 79 | 1.9% | 0.7% |
| BP | 22 | 0.6% | 0.2% | BCP(M) | 18 | 0.5% | 0.2% | BP(M) | 29 | 0.7% | 0.2% |
| BCP(M) | 11 | 0.3% | 0.1% | BP | 15 | 0.4% | 0.1% | BP | 24 | 0.6% | 0.2% |
| BP(M) | 7 | 0.2% | 0.1% | BP(M) | 12 | 0.3% | 0.1% | BCP(M) | 20 | 0.5% | 0.2% |

*(Continued)*

*Table S.8 (Continued).*

| Subject combination | 2005 | % of students taking core sciences | % all students taking Advanced Highers | Subject combination | 2007 | % of students taking core sciences | % all students taking Advanced Highers | Subject combination | 2009 | % of students taking core sciences | % all students taking Advanced Highers |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total no. of students taking core sciences only | 2,244 | 65.6% | 21.9% | Total no. of students taking core sciences only | 2,293 | 62.7% | 37.3% | Total no. of students taking core sciences only | 2,380 | 58.1% | 20.3% |
| Total no. of students taking core sciences with mathematics | 1,176 | 34.4% | 11.5% | Total no. of students taking core sciences with mathematics | 1,363 | 37.3% | 13.3% | Total no. of students taking core sciences with mathematics | 1,719 | 41.9% | 14.7% |
| Total no. of students taking core sciences combinations with/without mathematics | 3,420 | 100.0% | 33.4% | Total no. of students taking core sciences combinations with/without mathematics | 3,656 | 100.0% | 35.6% | Total no. of students taking core sciences combinations with/without mathematics | 4,099 | 100.0% | 35.0% |
| Total no. of students taking Advanced Highers | 10,240 | | 100.0% | Total no. of students taking Advanced Highers | 10,263 | | 100.0% | Total no. of students taking Advanced Highers | 11,708 | | 100.0% |

*Source:* Scottish Government.

## S.7 Overall numbers taking core sciences by gender (Highers)

Table S.9 provides a breakdown of the figures in table S.3 (on core sciences participation in different qualifications by gender) by core sciences subject combination at Higher.

The numbers of males and females taking core sciences Highers in Scotland rose by 7% and 2%, respectively. However, the proportion of males taking core sciences rose from 53% to 55%, whilst the equivalent proportion of females fell from 47% to 46% in the period investigated. Regarding core sciences subject combinations, the combinations involving physics were popular among males and biology and human biology were dominant among females. Chemistry was linked to the more popular subject in their respective gender. For example, females taking individual combinations of B and BC accounted for over 70% of all students taking those combinations in each of the years studied. This is a long established pattern with girls preferring to study biology and boys preferring to study physics.

Whilst physics alone remained the most popular subject combination among males over recent years, it is calculable from table S.10 that there was a proportional drop of 4.5% in male students taking this. In contrast, males were increasingly inclined towards choosing BC. Whilst biology and chemistry as single subjects dropped in popularity, it is calculable from table S.10 that there was a 29% increase in the numbers of males taking BC within their core sciences subjects at Higher. For females, the numbers for subject combinations has remained relatively stable over the period studied, with the only major change being more females taking human biology within their core sciences selection. There was a proportional rise of 1.9% in the number of females taking combinations including human biology (a rise of 9.8% in overall numbers).

The five most popular combinations of core sciences and mathematics Highers disaggregated by gender are displayed in tables S.10 and S.11 (and complete versions are published in tables AS.2 and AS.3). Proportionally more males took their core sciences Highers with a mathematics Higher, at around 77% compared to females at just over 60% between 2005 and 2009.

There were clear gender patterns which run parallel to the patterns seen in table S.9 on core sciences subject combinations at Higher, with males inclined towards combinations with physics and females more inclined towards biology and human biology. There were some distinctive patterns appearing associated with mathematics. While P and CP have been the most popular core sciences combinations among males, over 70% of males took mathematics at Higher in addition to these core sciences combinations. In contrast, only 45% of female students taking biology as their sole core science also took mathematics at Higher. Despite the rise in females taking mathematics with their core sciences, B alone remained the most popular subject combination. However, over 70% of females who took BC (alone) as their core science combination at Higher also took Higher mathematics.

## S.8 Overall numbers taking core sciences by gender (Advanced Highers)

The combinations of core sciences subject combinations at Advanced Higher are outlined in table S.12. There were more males taking core sciences at Advanced Higher than females, and there has been larger growth in the numbers of males taking core sciences Advanced Highers than in females (28% vs 12%). P alone was the most popular combination amongst males, but there was a relative decline in the proportion of male students who studied P alone. There was a steady rise in the number of males taking core sciences combinations involving biology at Advanced Higher, showing a proportional growth of 7.5 percentage points between 2005 and 2009, and an increase in the overall numbers of males taking these combinations of over 65%. B alone was most popular in females but as with physics in males, there was a drop in its relative popularity of 3.5 percentage points amongst females. Instead, there was a rise of 36% in the numbers of females taking combinations involving BC (BC and BCP).

Core sciences and mathematics combinations at Advanced Higher are disaggregated by gender in tables S.13 and S.14. Over the period studied, there was a consistent gap between male and female students in respect of the proportions who took core sciences with mathematics. The proportion of males who took core sciences and who also took mathematics at Advanced Higher went up from 44% to 50%. However, the gap between males and females was closing, with a third of females taking core sciences with mathematics at Advanced Higher in 2009 (compared to 24% in 2005).

P alone and P(M) were the most popular core sciences combinations amongst males, with at least 35% of all males taking core sciences combinations at Advanced Higher in each of the years investigated. Of the subject combinations involving core sciences with mathematics in males, P(M) accounted for over 45% of the numbers in each year studied. The main change occurred with the rise in popularity of subject combinations involving biology. B alone and BC showed a rise in the overall numbers of 8.7%. Biology alone and BC were consistently the most popular amongst females, accounting for over half of all core sciences combinations with mathematics in each year investigated. Notably, the top three subject combinations amongst females involved core sciences without mathematics (table S.14).

Key message S5. A greater number of male students study core sciences at Higher/Advanced Higher than female students. As in the rest of the UK, males were more inclined to study core sciences combinations that include physics, whilst females were more inclined towards biological sciences. Chemistry was often involved in the most popular core sciences subject combinations in both genders.

*Table S.9. Numbers of female and male students taking core sciences combinations at Higher (2005, 2007, 2009).*

| | 2005 | | | | 2007 | | | | 2009 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Subject combination | Females | | Males | | Females | | Males | | Females | | Males | |
| B | 2,930 | 31.5% | 967 | 11.9% | 2,752 | 31.5% | 986 | 12.4% | 2,839 | 29.9% | 999 | 11.4% |
| BC | 1,524 | 16.4% | 582 | 7.2% | 1,407 | 16.1% | 616 | 7.7% | 1,618 | 17.0% | 697 | 8.0% |
| BCP | 667 | 7.2% | 600 | 7.4% | 668 | 7.6% | 711 | 8.9% | 666 | 7.0% | 802 | 9.2% |
| BH | 85 | 0.9% | 21 | 0.3% | 61 | 0.7% | 19 | 0.2% | 87 | 0.9% | 27 | 0.3% |
| BHC | 53 | 0.6% | 8 | 0.1% | 43 | 0.5% | 17 | 0.2% | 55 | 0.6% | 23 | 0.3% |
| BHCP / BHP | 14 | 0.1% | 6 | 0.1% | 18 | 0.2% | 18 | 0.2% | 19 | 0.2% | 21 | 0.2% |
| BP | 155 | 1.7% | 180 | 2.2% | 169 | 1.9% | 200 | 2.5% | 189 | 2.0% | 273 | 3.1% |
| C | 676 | 7.3% | 785 | 9.6% | 644 | 7.4% | 750 | 9.4% | 664 | 7.0% | 695 | 8.0% |
| CP | 442 | 4.8% | 1,616 | 19.9% | 363 | 4.2% | 1,504 | 18.9% | 409 | 4.3% | 1,669 | 19.1% |
| H | 1,317 | 14.2% | 333 | 4.1% | 1,191 | 13.6% | 290 | 3.6% | 1,373 | 14.5% | 397 | 4.5% |
| HC | 467 | 5.0% | 175 | 2.2% | 555 | 6.3% | 212 | 2.7% | 597 | 6.3% | 255 | 2.9% |
| HCP | 227 | 2.4% | 185 | 2.3% | 218 | 2.5% | 244 | 3.1% | 258 | 2.7% | 269 | 3.1% |
| HP | 70 | 0.8% | 51 | 0.6% | 77 | 0.9% | 73 | 0.9% | 65 | 0.7% | 97 | 1.1% |
| P | 660 | 7.1% | 2,627 | 32.4% | 578 | 6.6% | 2,335 | 29.3% | 651 | 6.9% | 2,507 | 28.7% |
| Grand total | 9,287 | 100.0% | 8,136 | 100.0% | 8,744 | 100.0% | 7,975 | 100.0% | 9,490 | 100.0% | 8,731 | 100.0% |

*Source:* Scottish Government.

*Table S.10. Number of male students taking core sciences subject combinations (with or without mathematics) at Higher (top five preferences, 2005, 2007, 2009).* [(a)]

| Subject combination | 2005 | % of males taking core sciences with/without mathematics | Subject combination | 2007 | % of males taking core sciences with/without mathematics | Subject combination | 2009 | % of males taking core sciences with/ without mathematics |
|---|---|---|---|---|---|---|---|---|
| P(M) | 2,218 | 27.3% | P(M) | 1,944 | 24.4% | P(M) | 2,096 | 24.0% |
| CP(M) | 1,536 | 18.9% | CP(M) | 1,386 | 17.4% | CP(M) | 1,567 | 17.9% |
| B | 626 | 7.7% | BCP(M) | 678 | 8.5% | BCP(M) | 766 | 8.8% |
| BCP(M) | 579 | 7.1% | B | 629 | 7.9% | B | 603 | 6.9% |
| C(M) | 531 | 6.5% | C(M) | 470 | 5.9% | BC(M) | 529 | 6.1% |
| Numbers taking core sciences only | 1,886 | 23.2% | Numbers taking core sciences only | 1,905 | 23.9% | Numbers taking core sciences only | 1,950 | 22.3% |
| Numbers taking core sciences with mathematics | 6,250 | 76.8% | Numbers taking core sciences with mathematics | 6,070 | 76.1% | Numbers taking core sciences with mathematics | 6,781 | 77.7% |
| Numbers taking core sciences with/without mathematics | 8,136 | 100.0% | Numbers taking core sciences with/without mathematics | 7,975 | 100.0% | Numbers taking core sciences with/without mathematics | 8,731 | 100.0% |
| Total size of male Highers cohort | 15,441 | | Total size of male Highers cohort | 14,788 | | Total size of male Highers cohort | 15,958 | |

*Source:* Scottish Government.

(a) This table shows the five most popular combinations among males taking core science Highers with (or without) mathematics. Table AS.2 in the electronic appendix provides a complete version of this table, enabling matching to data in table S.9.

*Table S.11. Number of female students taking core sciences subject combinations (with or without mathematics) at Higher (top five preferences, 2005, 2007, 2009).* [(a)]

| Subject combination | 2005 | % of females taking core sciences with/ without mathematics | Subject combination | 2007 | % of females taking core sciences with/ without mathematics | Subject combination | 2009 | % of females taking core sciences with/ without mathematics |
|---|---|---|---|---|---|---|---|---|
| B | 1,730 | 18.6% | B | 1,603 | 18.3% | B | 1,554 | 16.4% |
| BC(M) | 1,205 | 13.0% | B(M) | 1,149 | 13.1% | BC(M) | 1,311 | 13.8% |
| B(M) | 1,200 | 12.9% | BC(M) | 1,130 | 12.9% | B(M) | 1,285 | 13.5% |
| H | 918 | 9.9% | H | 795 | 9.1% | H | 870 | 9.2% |
| BCP(M) | 638 | 6.9% | BCP(M) | 626 | 7.2% | BCP(M) | 633 | 6.7% |
| Numbers taking core sciences only | 3,541 | 38.1% | Numbers taking core sciences only | 3,240 | 37.1% | Numbers taking core sciences only | 3,301 | 34.8% |
| Numbers taking core sciences with mathematics | 5,746 | 61.9% | Numbers taking core sciences with mathematics | 5,504 | 62.9% | Numbers taking core sciences with mathematics | 6,189 | 65.2% |
| Numbers taking core sciences with/ without mathematics | 9,287 | 100.0% | Numbers taking core sciences with/ without mathematics | 8,744 | 100.0% | Numbers taking core sciences with/ without mathematics | 9,490 | 100.0% |
| Total size of female Highers cohort | 19,816 | | Total size of female cohort | 18,316 | | Total size of female cohort | 20,693 | |

*Source:* Scottish Government.

(a) This table shows the five most popular combinations among females taking core science Highers with (or without) mathematics. Table AS.3 in the electronic appendix provides a complete version of this table, enabling matching to data in table S.9.

*Table S.12. Numbers of female and male students taking core sciences combinations at Advanced Higher (2005, 2007, 2009)*[a].

| | 2005 | | | | 2007 | | | | 2009 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Female | | Male | | Female | | Male | | Female | | Male | |
| B | 679 | 39.9% | 218 | 12.7% | 633 | 37.7% | 247 | 12.5% | 693 | 36.4% | 310 | 14.1% |
| BC | 407 | 23.9% | 164 | 9.6% | 496 | 29.6% | 295 | 14.9% | 560 | 29.4% | 316 | 14.4% |
| BCP | 35 | 2.1% | 35 | 2.0% | 37 | 2.2% | 46 | 2.3% | 39 | 2.0% | 60 | 2.7% |
| BP | 12 | 0.7% | 17 | 1.0% | 17 | 1.0% | 10 | 0.5% | 20 | 1.0% | 33 | 1.5% |
| C | 324 | 19.0% | 369 | 21.5% | 278 | 16.6% | 416 | 21.0% | 341 | 17.9% | 377 | 17.2% |
| CP | 89 | 5.2% | 247 | 14.4% | 67 | 4.0% | 292 | 14.8% | 80 | 4.2% | 319 | 14.5% |
| P | 157 | 9.2% | 667 | 38.8% | 149 | 8.9% | 672 | 34.0% | 172 | 9.0% | 779 | 35.5% |
| **Grand total** | **1,703** | 100.0% | **1,717** | 100.0% | **1,677** | 100.0% | **1,978** | 100.0% | **1,905** | 100.0% | **2,194** | 100.0% |

*Source:* Scottish Government.

(a) Note: human biology is not offered at Advanced Higher.

*Table S.13. Numbers of males taking core sciences subject combinations (with or without mathematics) at Advanced Higher, ranked by popularity (top five, 2005, 2007, 2009).*

| Subject combination | 2005 | % of males taking core sciences combinations with/without mathematics | Subject combination | 2007 | % of males taking core sciences combinations with/without mathematics | Subject combination | 2009 | % of males taking core sciences combinations with/without mathematics |
|---|---|---|---|---|---|---|---|---|
| P(M) | 397 | 23.1% | P(M) | 415 | 21.0% | P(M) | 507 | 23.1% |
| P | 270 | 15.7% | P | 257 | 13.0% | P | 272 | 12.4% |
| C | 220 | 12.8% | C | 241 | 12.2% | B | 259 | 11.8% |
| B | 200 | 11.6% | B | 215 | 10.9% | CP(M) | 230 | 10.5% |
| CP(M) | 152 | 8.9% | BC | 213 | 10.8% | BC | 219 | 10.0% |
| Numbers taking core sciences only | 956 | 55.7% | Numbers taking core sciences only | 1,074 | 54.3% | Numbers taking core sciences only | 1,106 | 50.4% |
| Numbers taking core sciences with mathematics | 761 | 44.3% | Numbers taking core sciences with mathematics | 904 | 45.7% | Numbers taking core sciences with mathematics | 1,088 | 49.6% |
| Numbers taking core sciences with/without mathematics | 1,717 | 100.0% | Numbers taking core sciences with/without mathematics | 1,978 | 100.0% | Numbers taking core sciences with/without mathematics | 2,194 | 100.0% |
| Total size of male cohort | 4,680 | | Total size of male cohort | 4,778 | | Total size of male cohort | 5,354 | |

*Source:* Scottish Government.

*Table S.14. Numbers of females taking core sciences subject combinations (with or without mathematics) at Advanced Higher, ranked by popularity (top five, 2005, 2007, 2009).*

| Subject combination | 2005 | % of females taking core sciences combinations with/without mathematics | Subject combination | 2007 | % of females taking core sciences combinations with/without mathematics | Subject combination | 2009 | % of males taking core sciences combinations with/without mathematics |
|---|---|---|---|---|---|---|---|---|
| B | 620 | 36.4% | B | 551 | 32.9% | B | 576 | 30.2% |
| BC | 335 | 19.7% | BC | 389 | 23.2% | BC | 404 | 21.2% |
| C | 195 | 11.5% | C | 161 | 9.6% | C | 177 | 9.3% |
| C(M) | 129 | 7.6% | C(M) | 117 | 7.0% | C(M) | 164 | 8.6% |
| P(M) | 100 | 5.9% | BC(M) | 107 | 6.4% | BC(M) | 156 | 8.2% |
| Numbers taking core sciences only | 1,288 | 75.6% | Numbers taking core sciences only | 1,218 | 72.6% | Numbers taking core sciences only | 1,274 | 66.9% |
| Numbers taking core sciences with mathematics | 415 | 24.4% | Numbers taking core sciences with mathematics | 459 | 27.4% | Numbers taking core sciences with mathematics | 631 | 33.1% |
| Numbers taking core sciences with/without mathematics | 1,703 | 100.0% | Numbers taking core sciences with/without mathematics | 1,677 | 100.0% | Numbers taking core sciences with/without mathematics | 1,905 | 100.0% |
| Total size of female cohort | 5,560 | | Total size of female cohort | 5,484 | | Total size of female cohort | 6,353 | |

*Source:* Scottish Government.

## S.9 Numbers of students taking core sciences: institutional differences

Table S.15 shows the core sciences combinations taken at Higher disaggregated by institution type. (Data for the FE sector and other institutions are included in the electronic appendix, table AS.4.) When comparing independent and state-funded schools, the distribution of core sciences combinations taken by students is broadly equivalent, with B, BC and P amongst the most individual popular subject combinations at Higher in the years studied in both sectors. The main difference was that students in the state-funded sector tended to study single core sciences rather than core sciences in combination. This is most apparent with biology and chemistry, in which it is calculable that in 2009 only 21% of students in the state-funded sector taking core sciences Highers chose combinations including biology with chemistry as opposed to 32% of independent school students.

Tables S.16 and S.17 indicate the most studied core sciences and mathematics combinations at Higher by institution type. Overall, the most popular core sciences and mathematics combinations are broadly similar between independent and state-funded schools. The numbers taking combinations in independent schools show more fluctuation owing to the relatively small size of the pupil cohort in the independent sector in Scotland. The only notable difference between the independent and state-funded sectors was that BCP(M) formed a larger proportion of subject combinations within the independent sector, which may be significant in terms of promoting entry to medicine and related higher education courses.

Key message S6. Students from the independent sector are more likely to study a combination of core sciences (as opposed to a single core science) compared with students from the state sector.

# D. Attainment in Higher core sciences and mathematics subject combinations

While information on the numbers taking science and mathematics Highers provides an indication of the size of the 'pool of talent' available to study for first degrees in science, technology, engineering or mathematics (STEM), a more refined understanding of this pool may be gained from considering attainment data.

Entry into many higher education STEM first degree courses is dependent on students gaining combinations of A–C grades, particularly in core sciences and/or mathematics subjects, and these are the main focus here. This section examines the proportion of the pool that has

*Table S.15. Numbers of students taking core sciences subject combinations at Higher by institution type (2005, 2007, 2009).*

<table>
<tr><th rowspan="2">Subject combination</th><th colspan="3">Independent</th><th rowspan="2">Subject combination</th><th colspan="3">State-funded</th></tr>
<tr><th>2005</th><th>2007</th><th>2009</th><th>2005</th><th>2007</th><th>2009</th></tr>
<tr><td>B</td><td>305</td><td>308</td><td>282</td><td>B</td><td>3,088</td><td>3,007</td><td>2,959</td></tr>
<tr><td>BC</td><td>225</td><td>221</td><td>249</td><td>BC</td><td>1,676</td><td>1,640</td><td>1,804</td></tr>
<tr><td>BCP</td><td>194</td><td>225</td><td>223</td><td>BCP</td><td>961</td><td>1,069</td><td>1,126</td></tr>
<tr><td>BH</td><td rowspan="4">8</td><td rowspan="2">7</td><td rowspan="2">5</td><td>BH</td><td>56</td><td>54</td><td>50</td></tr>
<tr><td>BHC</td><td>BHC</td><td>35</td><td>39</td><td>40</td></tr>
<tr><td>BHCP</td><td rowspan="2">12</td><td rowspan="2">11</td><td>BHCP</td><td rowspan="2">5</td><td rowspan="2">17</td><td rowspan="2">20</td></tr>
<tr><td>BHP</td><td>BHP</td></tr>
<tr><td>BP</td><td>49</td><td>43</td><td>39</td><td>BP</td><td>253</td><td>303</td><td>355</td></tr>
<tr><td>C</td><td>85</td><td>114</td><td>76</td><td>C</td><td>1,214</td><td>1,154</td><td>1101</td></tr>
<tr><td>CP</td><td>192</td><td>153</td><td>179</td><td>CP</td><td>1,761</td><td>1,638</td><td>1770</td></tr>
<tr><td>H</td><td>56</td><td>79</td><td>95</td><td>H</td><td>1,002</td><td>972</td><td>1116</td></tr>
<tr><td>HC</td><td>63</td><td>70</td><td>66</td><td>HC</td><td>476</td><td>575</td><td>647</td></tr>
<tr><td>HCP</td><td>55</td><td>57</td><td>52</td><td>HCP</td><td>310</td><td>369</td><td>411</td></tr>
<tr><td>HP</td><td>5</td><td>8</td><td>6</td><td>HP</td><td>96</td><td>120</td><td>130</td></tr>
<tr><td>P</td><td>253</td><td>220</td><td>252</td><td>P</td><td>2,787</td><td>2,537</td><td>2656</td></tr>
<tr><td>Grand total</td><td>1,490</td><td>1,517</td><td>1,535</td><td>Grand total</td><td>13,720</td><td>13,494</td><td>14,185</td></tr>
</table>

*Source:* Scottish Government.

*Table S.16. Numbers of students taking core sciences and mathematics subject combinations at Higher (top five, independent sector, 2005, 2007, 2009).*

| Subject combination | 2005 | % of students taking core sciences with/ without mathematics | Subject combination | 2007 | % of students taking core sciences with/ without mathematics | Subject combination | 2009 | % of students taking core sciences with/ without mathematics |
|---|---|---|---|---|---|---|---|---|
| P(M) | 227 | 15.2% | BCP(M) | 209 | 13.8% | P(M) | 221 | 14.4% |
| B | 198 | 13.3% | P(M) | 204 | 13.4% | BCP(M) | 213 | 13.9% |
| CP(M) | 189 | 12.7% | BC(M) | 191 | 12.6% | BC(M) | 205 | 13.4% |
| BC(M) | 185 | 12.4% | B | 182 | 12.0% | CP(M) | 169 | 11.0% |
| BCP(M) | 181 | 12.1% | CP(M) | 149 | 9.8% | B | 166 | 10.8% |
| Numbers taking core sciences only | 356 | 23.9% | Numbers taking core sciences only | 352 | 23.2% | Numbers taking core sciences only | 354 | 23.1% |
| Numbers taking core sciences with mathematics | 1,134 | 76.1% | Numbers taking core sciences with mathematics | 1,165 | 76.8% | Numbers taking core sciences with mathematics | 1,181 | 76.9% |
| Numbers taking core sciences with/without mathematics | 1,490 | 100.0% | Numbers taking core sciences with/without mathematics | 1,517 | 100.0% | Numbers taking core sciences with/without mathematics | 1,535 | 100.0% |
| Total no. taking cores sciences and/or mathematics | 1,765 | | Total no. taking cores sciences and/or mathematics | 1,758 | | Total no. taking cores sciences and/or mathematics | 1,819 | |
| Total no. taking Highers | 2,323 | | Total no. taking Highers | 2,226 | | Total no. taking Highers | 2,383 | |

*Source:* Scottish Government.

*Table S.17. Numbers of students taking core sciences and mathematics subject combinations at Higher (top five, state-funded sector, 2005, 2007, 2009).*

| Subject combination | 2005 | % of students taking core sciences with/without mathematics | Subject combination | 2007 | % of students taking core sciences with/without mathematics | Subject combination | 2009 | % of students taking core sciences with/without mathematics |
|---|---|---|---|---|---|---|---|---|
| P(M) | 2,377 | 17.3% | P(M) | 2,114 | 15.7% | P(M) | 2,246 | 15.8% |
| B | 1,844 | 13.4% | B | 1,790 | 13.3% | CP(M) | 1,676 | 11.8% |
| CP(M) | 1,673 | 12.2% | CP(M) | 1,522 | 11.3% | B | 1,632 | 11.5% |
| BC(M) | 1,298 | 9.5% | BC(M) | 1,280 | 9.5% | BC(M) | 1,450 | 10.2% |
| B(M) | 1,244 | 9.1% | B(M) | 1,217 | 9.0% | B(M) | 1,327 | 9.4% |
| Numbers taking core sciences only | 3,949 | 28.8% | Numbers taking core sciences only | 3,938 | 29.2% | Numbers taking core sciences only | 3,703 | 26.1% |
| Numbers taking core sciences with mathematics | 9,771 | 71.2% | Numbers taking core sciences with mathematics | 9,556 | 70.8% | Numbers taking core sciences with mathematics | 10,482 | 73.9% |
| Numbers taking core sciences with/without mathematics | 13,720 | 100.0% | Numbers taking core sciences with/without mathematics | 13,494 | 100.0% | Numbers taking core sciences with/without mathematics | 14,185 | 100.0% |
| Total no. taking cores sciences and/or mathematics | 16,969 | | Total no. taking cores sciences and/or mathematics | 16,412 | | Total no. taking cores sciences and/or mathematics | 17,244 | |
| Total nos. taking Highers | 26,603 | | Total nos. taking Highers | 25,830 | | Total nos. taking Highers | 26,921 | |

*Source:* Scottish Government.

gained good Highers in combinations of two core sciences and mathematics among students taking five (or more) Highers (five being the modal number of Highers taken (cf. table S.2)). Although students gaining grades A–C in a single core science or mathematics subject may subsequently pursue STEM studies at higher education level, generally it is expected that students wishing to study for a STEM first degree will have gained passes in at least two sciences and mathematics Highers (notwithstanding their attainment in other subjects).

## S.10 Numbers of students taking five or more Highers and obtaining grades A–C in two or more core sciences and mathematics

### S.10.1 Overview

Table S.18 provides summary data on the numbers of students taking five or more Highers and gaining A–C grades in two or more core sciences and mathematics subjects. It shows that between 2005 and 2009 the percentage of these students gaining grades A–C increased very slightly overall, while remaining at *ca*. 81%. It is calculable, too, that while the total numbers of students taking core sciences and/or mathematics increased 3.5%, the proportion of students gaining straight A and A–C grades in at least two core sciences and mathematics subjects rose 17% and 15%, respectively, over this time-period. It may also be calculated from table S.18 that the percentage of all students taking five Highers and at least two core sciences and mathematics that were (i) either just taking a single science or (ii) not being awarded A–C grades in two or more core sciences and mathematics subjects rose slightly between 2005 and 2009, but remained at *ca*. 19%.

### S.10.2 Comparison by institution type

Table S.19 breaks the figures in table S.18 down by institution type and compares these with the total number of students taking Highers in each type of institution. (Contextual data on the size, in terms of numbers, of the educational sectors are provided in table S.1.) It is clearly evident from table S.21 that state-funded schools account for the majority of students obtaining the minimum requirements for (potential) entry into higher education STEM courses. As a percentage of the total Highers cohort, it is calculable from table S.20 that the proportion of students in state-funded schools gaining A–C grades in two or more core sciences and mathematics Highers remained steady at *ca*. 65% between 2005 and 2009.

The proportion of students from independent schools generally considered suitable for STEM higher education studies decreased slightly, the proportion of these students gaining A–C grades in at least two core sciences and mathematics subjects falling overall by 0.5 percentage points during 2005–09.

The numbers gaining the generally expected minimum requirement for STEM higher education entry remained very low among students from FE sector colleges, while there was a very slight increase among those who took Highers in more than one type of institution ('multiple' institutions).

### S.10.3 Comparison by subject combination (aggregated data for all institution types)

The data in table S.18 may also be disaggregated by core sciences/or mathematics combinations to show the numbers of students taking at least five Highers and gaining A, A or B and A–C grades in at least two core sciences and mathematics combinations (table S.20),

*Table S.18. Numbers of students taking five or more Highers and gaining grades A–C in two or more core sciences and mathematics subjects (2005, 2007, 2009).*

| | 2005 | | 2007 | | 2009 | |
|---|---|---|---|---|---|---|
| Grades | Students | % | Students | % | Students | % |
| All A | 1,392 | 24.5% | 1,496 | 26.1% | 1,632 | 25.2% |
| A–B | 2,896 | 51.0% | 3,077 | 53.8% | 3,466 | 53.6% |
| A–C | 4,586 | 80.7% | 4,688 | 81.9% | 5,261 | 81.3% |
| Other[(a)] | 1,096 | 19.3% | 1,036 | 18.1% | 1,211 | 18.7% |
| Total numbers taking five Highers including two or more core sciences and mathematics | 5,682 | 100.0% | 5,724 | 100.0% | 6,472 | 100.0% |
| Total numbers taking core sciences and/or mathematics | 21,396 | | 20,249 | | 22,138 | |

*Source:* Scottish Government.

(a) 'Other' denotes candidates who were not awarded a grade A, B or C in *all* their science or mathematics Highers.

*Table S.19. Numbers of students taking five or more Highers and gaining grades A–C in two or more core sciences and mathematics subjects, split by institution type (2005, 2007, 2009).*

| Type of institution | Grade | 2005 Students | 2005 % of total students | 2007 Students | 2007 % of total students | 2009 Students | 2009 % of total students |
|---|---|---|---|---|---|---|---|
| State-funded schools | All A | 1,014 | 17.8% | 1,080 | 18.9% | 1,226 | 18.9% |
| | A–B | 2,285 | 40.2% | 2,386 | 41.7% | 2,701 | 41.7% |
| | A–C | 3,677 | 64.7% | 3,787 | 66.2% | 4,221 | 65.2% |
| | Other | 896 | 15.8% | 894 | 15.6% | 1,013 | 15.7% |
| Total no. of students taking two or more core sciences and mathematics combinations in state-funded schools | | **4,573** | **80.5%** | **4,681** | **81.8%** | **5,234** | **80.9%** |
| Independent schools | All A | 332 | 5.8% | 364 | 6.4% | 332 | 5.1% |
| | A–B | 479 | 8.4% | 554 | 9.7% | 551 | 8.5% |
| | A–C | 633 | 11.1% | 664 | 11.6% | 688 | 10.6% |
| | Other | 58 | 1.0% | 44 | 0.8% | 56 | 0.9% |
| Total no. of students taking two or more core sciences and mathematics combinations in state-funded schools | | **691** | **12.2%** | **708** | **12.4%** | **744** | **11.5%** |
| Further education | All A | 6 | 0.1% | *X*[(a)] | 0.1% | 5 | 0.1% |
| | A–B | 8 | 0.1% | 10 | 0.2% | 16 | 0.2% |
| | A–C | 15 | 0.3% | 12 | 0.2% | 25 | 0.4% |
| | Other | 6 | 0.1% | *X* | 0.1% | 9 | 0.1% |
| Total no. of students taking two or more core sciences and mathematics combinations in state-funded schools | | **21** | **0.4%** | **15** | **0.3%** | **34** | **0.5%** |
| 'Multiple' institutions[(b)] | All A | 40 | 0.7% | 48 | 0.8% | 69 | 1.1% |
| | A–B | 124 | 2.2% | 127 | 2.2% | 198 | 3.1% |
| | A–C | 261 | 4.6% | 225 | 3.9% | 327 | 5.1% |
| | Other | 136 | 2.4% | 95 | 1.7% | 133 | 2.1% |
| Total no. of students taking two or more core sciences and mathematics combinations in state-funded schools | | **397** | **7.0%** | **320** | **5.6%** | **460** | **7.1%** |
| Grand total (cf. Table S.20) | | 5,682 | 100.0% | 5,724 | 100.0% | 6,472 | 100.0% |
| Total no. of students taking core sciences combinations and/or mathematics Highers | | 21,396 | | 20,249 | | 22,138 | |

*Source:* Scottish Government.

(a) Data suppressed.

(b) 'Multiple' denotes students who have completed their Highers in different educational sectors (eg state-funded schools and FE).

*Table S.20. Numbers of students taking five or more Highers and gaining A–C grades in at least two core sciences and mathematics (2005, 2007, 2009).*

| | All A | | | A–B | | | A–C | | | Other | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Subject combination | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 | 2005 | 2007 | 2009 |
| BC(M) | 269 | 309 | 328 | 639 | 705 | 789 | 1,147 | 1,138 | 1,303 | 357 | 325 | 363 |
| BCP(M) | 413 | 433 | 479 | 743 | 804 | 872 | 1,034 | 1,119 | 1,208 | 121 | 126 | 144 |
| BHC(M) | *X*[(a)] | 0 | *X* | 7 | *X* | 7 | 21 | 20 | 19 | 24 | 19 | 29 |
| BHCP(M) | *X* | 8 | 8 | *X* | 15 | 17 | *X* | 19 | 23 | *X* | *X* | *X* |
| BH(M) | 0 | 0 | 0 | *X* | *X* | *X* | 16 | *X* | *X* | 23 | 20 | 30 |
| BHP(M) | 0 | 0 | 0 | 0 | 0 | *X* | *X* | *X* | *X* | *X* | *X* | *X* |
| BP(M) | 37 | 29 | 39 | 96 | 104 | 132 | 198 | 199 | 259 | 61 | 84 | 96 |
| CP(M) | 472 | 459 | 503 | 960 | 911 | 1,014 | 1,455 | 1,343 | 1,458 | 312 | 220 | 286 |
| HC(M) | 73 | 100 | 116 | 189 | 236 | 280 | 320 | 406 | 469 | 108 | 140 | 151 |
| HCP(M) | 116 | 148 | 148 | 224 | 262 | 313 | 321 | 364 | 422 | 55 | 49 | 60 |
| HP(M) | 9 | 10 | 10 | 30 | 30 | 38 | 66 | 64 | 84 | 26 | 42 | 39 |
| Grand total | 1,392 | 1,496 | 1,632 | 1,504 | 3,077 | 3,466 | 3,194 | 4,688 | 5,261 | 1,096 | 1,036 | 1,211 |
| Total no. of students taking core sciences combinations and/or mathematics Highers | 21,396 | 20,249 | 22,138 | 21,396 | 20,249 | 22,138 | 21,396 | 20,249 | 22,138 | 21,396 | 20,249 | 22,138 |

*Source:* Scottish Government.

(a) Data suppressed.

compared with the total numbers of students taking core sciences and/or mathematics in each year.

Against the background of a 3.5% overall increase in the numbers taking core sciences and/or mathematics combinations between 2005 and 2009, table S.20 shows that there were overall increases in the numbers of candidates obtaining A–C grades in most combinations. Indeed, among those taking five or more Highers the proportion of students that gained A–C grades in at least two core sciences and mathematics rose from 14.9% to 23.8% between 2005 and 2009. However, this increase owes much to the fact that while the percentage of A–C grades among students grew 64.7% between 2005 and 2009, the numbers of students taking core sciences and/or mathematics Highers rose 3.5% in the same period. Indeed, table S.20 reveals that although there were increases of 14% and 17% in numbers gaining grades A–C in BC(M) and BCP(M), the numbers gaining A–C grades in CP(M)—the most popular combination of two core sciences and mathematics—grew by just 0.2% overall.

Overall, it is possible to calculate that of the students taking five Highers who took two or more core sciences and mathematics subjects including biological sciences in 2005, 2007 and 2009, increases of 23% and 12%, respectively, were recorded in the proportions obtaining straight A grades and A–C grades.

Similarly, of the equivalent students who took two or more core sciences and mathematics subjects including chemistry in 2005, 2007 and 2009, increases of 14% and 6%, respectively, were recorded in the proportions obtaining straight A grades and A–C grades.

Finally, in comparing the ‘other’ data with the grade information in table S.20, it is possible to calculate that as a percentage of all students taking core sciences and/or mathematics Highers, the proportion failing to obtain good grades in one or more of two core science and mathematics subjects grew slightly from 5% to 5.5% between 2005 and 2009. Overall during the same period there was a 10% increase in the numbers of such candidates failing to attain the grades that would generally be required for admission into higher education STEM first degree courses.

Key message S7. The proportion of students taking at least five Highers who gained A–C grades in at least two core sciences and mathematics rose from 14.9% to 23.8% between 2005 and 2009.

# 6 Glossary

| | |
|---|---|
| ACME | Advisory Committee on Mathematics Education |
| AS-level | Advanced Subsidiary level |
| A2-level | The second year of the A-level qualification, taken together with AS-levels. |
| BTEC | Business and Technology Education Council [qualification] |
| CPD | Continuing professional development |
| CTC | City Technology College |
| BIS | Department for Business, Innovation and Skills |
| DCELLS | Department for Children, Education, Lifelong Learning and Skills |
| DCSF | Department for Children, Schools and Families |
| DENI | Department for Education, Northern Ireland |
| DfE | Department for Education |
| DfES | Department for Education and Skills |
| FE | Further education |
| GCE | General Certificate of Education |
| GCSE | General Certificate of Secondary Education |
| HE | Higher education |
| HEFCE | Higher Education Funding Council for England |
| HEI | Higher education institution |
| HESA | Higher Education Statistics Agency |
| HND | Higher National Diploma |
| ICT | Information and communications technology |
| NAO | National Audit Office |
| NI | Northern Ireland |
| NQF | National Qualifications Framework |
| NVQ | National Vocational Qualification |
| Ofqual | Office of Qualifications and Examinations Regulation |
| ONS | Office for National Statistics |
| QAA | Quality Assurance Agency |
| QCDA | Qualifications and Curriculum Development Authority |
| SCORE | Science Community Representing Education |
| SCQF | Scottish Credit and Qualifications Framework |
| SFR | Statistical first release |
| SIVS | Strategically Important and Vulnerable Subjects |
| STEM | Science, technology, engineering and mathematics |
| SVQ | Scottish Vocational Qualification |
| UCAS | Universities and Colleges Admissions Service |
| VCE | Vocational Certificate of Education |

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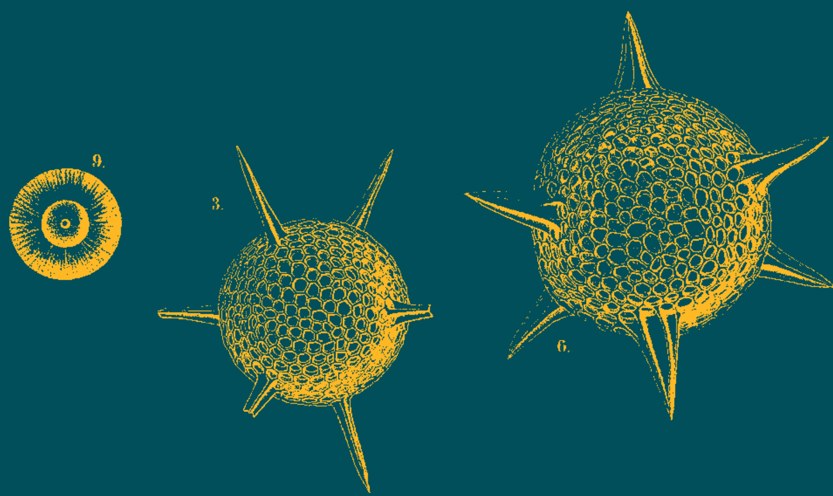



ISBN: 978-0-85403-872-5
Issued: February 2011 DES2096


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