Research Report DFE-RR178

Review of the National Curriculum in England

What can we learn from the English, mathematics and science curricula of high-performing jurisdictions?

Department for Education

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Executive Summary

Introduction

The Government is committed to ensuring that the new National Curriculum compares favourably with the curricula in the highest performing jurisdictions, and sets rigorous requirements for pupil attainment which measure up to the highest standards set internationally. The Government is also committed to slimming the National Curriculum so that it properly reflects the body of essential knowledge which all pupils should learn.

The purpose of this report is to explore and present initial findings on what can be learned from the analysis of curricula of high-performing jurisdictions, in order to inform the development of the new National Curriculum for English, mathematics and science. In particular, issues of breadth, specificity and challenge within each subject are examined in detail to assess what this may tell us in devising a new National Curriculum which measures up to the highest international standards.

This report forms part of a suite of evidence documents gathered as part of the National Curriculum review, including the Expert Panel report and summary report of responses to the call for evidence. Further analysis is underway to examine the education systems and cultural contexts of high-performing jurisdictions, in order to assess what other factors need to be taken into account when comparing the relative achievement of pupils from different jurisdictions.

The first two sections of the report focus on the methodology and the achievement of pupils in England compared to other jurisdictions in reading, mathematics and science. The remaining three sections focus on English, mathematics and science respectively – including the analysis of breadth, specificity and challenge of the curricula in high-performing jurisdictions in comparison to the National Curriculum in England.

Achievement in international comparisons

An important perspective on England's educational performance can be gained from analysis of the results from international comparative assessments such as the Programme for International Student Assessment (PISA), the Progress in International Reading Literacy Study (PIRLS) and the Trends in International Mathematics and Science Study (TIMSS).

In the most recent waves of PISA, PIRLS and TIMSS, England's performance was average, or higher than the average, at each age tested for reading, mathematics and science. However, to raise standards so that England is on a par with the highest-performing jurisdictions in the world, it is necessary to focus on areas for improvement. For this reason, the following findings concentrate exclusively on areas where there is the most scope to improve England's performance in these international assessments.

- **Reading:** Areas of particular priority for improvement in England are making straightforward inferences from specific ideas in a text in primary; and retrieving information from a text, integrating and interpreting information to demonstrate understanding and in interpreting continuous texts in secondary.

- ***Mathematics*****:** Areas of particular priority for improvement in England are *number* in both primary and secondary and *algebra* in secondary, although attainment is relatively low in most areas of mathematics compared with high-performing jurisdictions, including in mathematical processes such as recalling facts and solving problems.

- ***Science*****:** Unlike in reading and mathematics, attainment in science is relatively high, although areas of improvement can be identified across all sciences in primary and secondary. Weaknesses can also be identified in scientific processes and enquiry such as *using models and explanations* and *using scientific evidence*.

Curriculum comparisons

For English, mathematics and science, five comparator jurisdictions were selected, based on a synthesis of results from the recent waves of PISA, PIRLS and TIMSS, alongside the findings of other studies. The jurisdictions were selected separately for each subject, although there are some jurisdictions that are examined for more than one subject.

English	**Mathematics**	**Science**
New South Wales, Australia	Finland	Victoria, Australia
Alberta, Canada	Flemish Belgium	Alberta, Canada
New Zealand	Hong Kong	Hong Kong
Singapore	Singapore	Singapore
Massachusetts, USA	Massachusetts, USA	Massachusetts, USA

Curriculum aims are a key feature of high-performing jurisdictions, and there is also a degree of commonality in aims between jurisdictions for all three subjects. This indicates that curriculum aims aligned with those of high-performing jurisdictions should be considered for the new National Curriculum for each subject.

There is a relatively high degree of commonality in the domains of knowledge for all three subjects, particularly with regard to mathematics and science. This indicates that the high-level content of the National Curriculum is broadly in line with those of high-performing jurisdictions.

The curricula analysed maintain breadth within each subject, with little evidence that some jurisdictions define expectations around a narrow core of knowledge within any one subject or for any particular age group. This indicates that – in curricular terms at least – high-performing jurisdictions do not sacrifice breadth for depth or challenge within each of the subjects.

The main points of comparison for each subject are:

- ***English:*** The curricula for English are the most diverse in terms of the content specified and how this content is presented, although a common feature is an emphasis on different modes of communication (*reading*, *writing*, *speaking and listening*) and *literature*.

- ***Mathematics:*** Mathematics curricula invariably include the domains of *number*, *geometry and measures*, and *data and statistics* during the primary phase, and this is extended to the domains of *algebra* and *probability* during the secondary phase. Mathematical processes related to *mental and written fluency*, *problem solving*, and *mathematical reasoning* are also standard domains, although their presentation within each curriculum varies.

- ***Science:*** Science curricula invariably include the domains of *biology*, *chemistry* and *physics* both in primary and secondary, plus scientific processes and enquiry such as *experimental methods and practices*. There is more variation in how the content is presented – either integrated or separately by domain. *Earth science* content features in all curricula though not always as a separate domain.

Within each subject, there is a very wide range in the specificity of content across the curricula from different high-performing jurisdictions. For mathematics and science, greater specificity provides a clearer basis to assess what should be taught and therefore what pupils are expected to learn. This was more difficult for English, where greater specificity did not provide a clearer basis to assess challenge.

Where the level of challenge could be assessed:

- ***English:*** Although English curricula are more difficult to assess in terms of challenge, examples can be identified where the approach differs significantly from the approach used in the 1999 and 2007 National Curricula for England.

- ***Mathematics:*** Some mathematics curricula of high-performing jurisdictions are much more challenging than the 1999 and 2007 National Curriculum for England, in particular on *number* and *algebra*, though *data and statistics* is slightly more challenging in England.

- ***Science:*** Science curricula of one or two high-performing jurisdictions are more challenging than the 1999 National Curriculum, for example in some elements of *biology* and *physics*, though England is more challenging in other domains. However, the secondary 2007 National Curriculum for England is not specific enough to assess the level of challenge.

These initial findings on specificity and challenge indicate that if the National Curriculum for English, mathematics and science is each slimmed down, there would need to be sufficient detail to be clear about high expectations. In particular, the current secondary National Curriculum for England was radically slimmed down in 2007 and this lacks the required specificity with which to set high expectations.

A number of examples are provided in the report to show key differences between the National Curriculum and the curricula of high-performing jurisdictions. These illustrate where the new National Curriculum could be strengthened so that the content and expectations are on a par with the highest-performing jurisdictions.

Conclusions

These findings are subject to the limitations of the methodology used. In particular, these findings are to be reviewed in the light of an ongoing analysis of the education systems and cultural contexts of high-performing jurisdictions and how the intended curriculum impacts on the enacted curriculum as implemented by teachers in the classroom in each jurisdiction.

However, even this initial analysis makes clear that the National Curriculum can be much more ambitious in terms of expectations and standards for English, mathematics and science without sacrificing curricular breadth within these subjects. It is more uncertain whether this ambition is achievable by slimming down the current National Curriculum for these subjects, especially mathematics and science. These issues will therefore need to be examined further in considering the design of the new National Curriculum.

Section 1 – Comparing achievement and the role of the curriculum

1.1 Introduction

As part of its commitment to learning from other jurisdictions[1] to improve pupil achievement in England's schools, the Government is reviewing the National Curriculum to ensure that it is informed by the content, standards and expectations of the highest-performing jurisdictions internationally. Comparative studies have demonstrated that pupils in other jurisdictions are performing at a significantly higher level in key aspects of reading, mathematics and science. The Government is also committed to slimming down the National Curriculum so that it properly reflects the body of essential knowledge which all pupils should learn. The Government wants to avoid prescribing pedagogy through the National Curriculum so that teachers are given greater professional freedom over how they teach their pupils.

The purpose of this report is therefore to explore and present initial findings from an analysis of curricula of high-performing jurisdictions, in order to inform the development of the new National Curriculum for English, mathematics and science. In particular, issues of breadth, specificity and challenge within each subject are examined in detail to assess what this might tell us in the context of devising a new National Curriculum which measures up to the highest international standards.

The report is divided into five sections:

- This section sets out the rationale and methodology used for the statistical analysis of pupil attainment across high-performing jurisdictions, and the content analysis of the statutory curricula of a sub-set of these jurisdictions, alongside some of the limitations of the methodology.

- Section 2 provides a summary of the findings from the most recent comparative studies – namely the Programme for International Student Assessment (PISA) 2009, the Progress in International Reading Literacy Study (PIRLS) 2006 and the Trends in International Mathematics and Science Study (TIMSS) 2007 - and assesses the performance of pupils in England compared with pupils in other jurisdictions in reading, mathematics and science.

- In Sections 3 to 5, the content of the statutory curricula are examined in more detail for English, mathematics and science respectively. The purpose of these sections is to:

[1]Throughout this report the term "jurisdiction" has been used for brevity. This term relates to countries, territories, provinces, regions or states that have central responsibility for public education, including the statutory curriculum. The term encompasses both the public education system and the wider society served by the education system.

- identify a subset of high-performing comparator jurisdictions in each of reading, mathematics and science;

- analyse the curriculum content of the comparator jurisdictions in order to provide insights into the commonalities and differences in the curriculum content;

- focus specifically on the breadth, specificity and, where possible, the level of challenge and/or sequencing of content within comparable age-phases; and

- illustrate some of the specific differences in challenge between curricula, with a focus on content that appears more challenging in high-performing jurisdictions.

1.2 Rationale

In England, the introduction of the National Curriculum is considered to have made a lasting impact on pupils' achievement, through – for example:

- setting higher overall expectations of young people (see Barber, 2002[2]; Hopkins, 2001[3]; and Tabberer, 1997[4]);

- reduced inappropriate repetition of content (see Chitty, 2004[5]; and Evangelou et al, 2008[6]); and

- more balanced coverage of content in the primary phase, particularly in science (see Harlen, 2008[7]).

The National Curriculum has been revised regularly since it was introduced, but without a clear focus on international comparisons. As set out in Case for Change[8] published alongside the White Paper The Importance of Teaching [9], highly effective education systems have been increasingly examining the likely needs of the future, and adopting a systematic approach to curriculum reform. This approach has included thorough examination of evidence about the needs of young people, benchmarking against other curricula internationally and taking care to avoid too frequent changes to the curriculum, instead establishing a cycle in which the curriculum may be thoroughly reviewed perhaps once a decade. In addition, setting high

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[2] Barber, M. (2002). *Crossing the bridge.* Association for Achievement and Improvement through Assessment.
[3] Hopkins, D. (2001). *School improvement for real.* London: Routledge.
[4] Tabberer, R. (1997). *Primary Education: expectations and provision.* National Foundation for Educational Research.
[5] Chitty. C. (2004). *Educational Policy in Britain.* London: Palgrave Macmillan.
[6] Evangelou, M. Taggart, B. Sylva, K. Melhuish, E. Sammons, P. and Siraj-Blatchford, I. (2008). *Effective Pre-school, Primary and Secondary Education 3-14 Project (EPPSE 3-14): What Makes a Successful Transition from Primary to Secondary School?* DCSF-RR019.
[7] Harlen, W. (2008). *Science as a key component of the primary curriculum: a rationale with policy implications.* Perspectives on Education 1 (Primary Science), 2008:4–18.
[8] Department for Education (2010a). *The Case for Change.* DFE-00564-2010.
[9] Department for Education (2010b). *The Importance of Teaching – The Schools White Paper* 2010. DFE-CM-7980.

expectations – sometimes alongside some form of external assessment – can improve achievement overall (see NCES, 2007[10]).

In the context of this greater consideration of international comparisons, the statistics clearly indicate that attainment in England could be substantially improved. Findings from the most recent waves of PISA, PIRLS and TIMSS broadly suggest that England's performance remains average, or higher than the average, at each age tested for reading, mathematics and science. However, with more and more jurisdictions joining between PISA 2000 and PISA 2009, England's relative ranking has gone down from 7th to 25th in reading, 8th to 28th in mathematics and from 4th to 16th in science[11].

In order to improve pupil attainment, Tim Oates[12] argues that a coherent and conceptually well defined statutory curriculum is a necessary though not sufficient condition. He also argues that a great deal can be learned from an analysis of the content, standards and expectations of high-performing jurisdictions so long as consideration is taken of both educational and societal and cultural contextual factors. There is also a growing evidence base about the impact of the statutory curriculum on educational performance, including performance in international comparison studies such as PISA, PIRLS and TIMSS.

Indeed, the statutory curriculum has a significant impact on the way teachers plan their school curriculum and what is actually taught (see Schmidt & Prawar, 2006[13]), and studies show that national control of the curriculum can result in higher test performance in international comparative assessments such as TIMSS (see Schmidt et al, 2001[14]). Internationally, curriculum reform is considered by policy makers to be one of the key levers for effecting change in what happens in the classroom and thereby improving outcomes (see Mourshed, Chijiloke and Barber, 2011[15]; Pepper, 2008[16]; Sargent et al 2010[17]). There is also a small but growing evidence base of content analysis of international curricula in English, mathematics and science, for example the work of Ruddock and Sainsbury (2008)[18].

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[10] National Center for Education Statistics (2007). *Mapping 2005 state proficiency standards onto the NAEP scales* (NCES 2007–482). U.S. Department of Education, National Center for Education Statistics, Washington, DC: US Government Printing Office.

[11] For an analysis of some of the limitations of comparisons over time, see Jerrim, J. (2011). *England's "plummeting" PISA test scores between 2000 and 2009: Is the performance of our secondary school pupils really in relative decline?* London: Department of Quantitative Social Science, Institute of Education, University of London.

[12] Oates, T (2010). *Could do better: Using international comparisons to refine the National Curriculum in England* Cambridge: Cambridge Assessment.

[13] Schmidt W. & Prawat R. (2006). *Curriculum coherence and national control of education: issue or non-issue?* Journal of Curriculum Studies, vol3.8 no.6 pp 641-658.

[14] Schmidt, W. H., McKnight, C. C., Houang, R. T., Wang, H.-C., Wiley, D. E., Cogan, L. S. and Wolfe, R. G. (2001). *Why Schools Matter: A Cross-National Comparison of Curriculum and Learning* San Francisco, CA: Jossey-Bass.

[15] Mourshed, M., Chikioke, C. and Barber, M. (2011). *How the world's most improved school systems keep getting better*, McKinsey & Company.

[16] Pepper, D. (2008). *Primary curriculum change: directions of travel in 10 countries*. London: Qualifications and Curriculum Authority.

[17] Sargent, C, Anne Byrne, A., O'Donnell, S. and White E. (2010), *Curriculum review in the INCA countries*, INCA thematic probe: June 2010.

[18] Ruddock, G. and Sainsbury, M. (2008). *Comparison of the core primary curriculum in England to those of other high performing countries.* DCSF Research Report DCSF-RW048.

The evidence suggests that reform of the National Curriculum can have an impact on raising standards, so long as other reforms are put in place to ensure that the curriculum can be delivered effectively by teachers and the accountability system puts sufficient focus on the quality of teaching[19]. In this context, the rationale for focusing on the curricula of high-performing jurisdictions is that – alongside other factors – each of these curricula is part of an education system that works in practice. The key features of curricula associated with world class assessment results can therefore be assessed, and this is what this report sets out to achieve.

1.3 Methodology

The methodology used to produce this report is based on both a statistical analysis of data from recent waves of PISA, PIRLS and TIMSS and on content analysis of comparator curricula documents.

The statistical analysis included an analysis of the performance of pupils in England compared to pupils in high-performing jurisdictions in reading, mathematics and science. This analysis presents data from PISA, PIRLS and TIMSS studies, comparing the average scale scores of the high-performing comparator jurisdictions to those of England. The data are used to compare assessment scores that were statistically significantly different from those of England, focusing on those that were higher and lower than England, and those which had improved or deteriorated compared to their own score in the previous assessment wave. In addition, a more fine-grained analysis of pupil performance examines attainment in different domains of reading, mathematics and science. The statistical analysis is set out in Sections 2.4 to 2.6.

For the content analysis, all curricula reviewed were compared with the current National Curriculum for English, mathematics and science[20]. Curricula were analysed on a domain by domain basis in order to compare coverage and sequencing of content, adopting the methodology used in Ruddock and Sainsbury[17]. Wider research evidence has also been used to supplement the analyses in order to highlight key issues related to curriculum choices and the extent to which they relate to pedagogy. In terms of particular subjects, the framework of analysis for different domains of knowledge was as follows:

- For English, the analysis focused on the domains of *reading, writing, speaking, listening* and *language structure*; each was sub-divided into respective sub-domains.

- For mathematics, the analysis focused on the domains of *number, fractions, algebra, statistics* and *probability*, alongside domains related to *mathematical processes*.

[19] Department for Education (2010a). *The Case for Change.* DFE-00564-2010.
[20] The current primary level National Curriculum (Key Stages 1 and 2) was released in 1999 alongside the secondary National Curriculum (Key Stages 3 and 4). The secondary level National Curriculum was subsequently revised in 2005 for Key Stage 4 science and 2007 for Key Stage 3 and 4 English and mathematics and Key Stage 3 science.

- For science, the analysis focused on the sub-domains within *biology, chemistry* and *physics* alongside domains related to *scientific processes* and *enquiry*[21].

On the basis of the content analysis, some specific examples have been identified where the curricula of other jurisdictions were more challenging than the National Curriculum for England. These instances have been selected as illustrative examples and are not intended to be generally indicative of the level of challenge of that curriculum. For the reasons set out later in the report, comparing the level of challenge systematically as part of the analysis was not always possible.

Wherever possible, the analysis focused mainly on the statutory curricula in place during the late 1990s and/or 2000s. These were the curricula that would have defined expectations in schools for pupils who participated in PIRLS 2006, TIMSS 2007 or PISA 2009. Due to this historical approach, it should be noted that statutory curricula in some jurisdictions may have changed substantially since the curricula under consideration. Where there has been more recent reform, the analysis identifies the most substantive changes to the statutory curricula.

Thus, for England, the 1999 National Curriculum is likely to have had the most significant impact on the education of pupils in recent years, while the more recent 2007 National Curriculum for secondary was implemented between 2008 and 2011. The analysis therefore focuses primarily on the 1999 National Curriculum while only substantive changes since 2007 are identified. The analysis does not include wider non-statutory guidance and other related resources. For this reason, the National Strategies[22] frameworks and other non-statutory guidance in literacy, mathematics and secondary science introduced by the previous Government are not within the scope of this analysis.

Table 1.1 below sets out the comparator jurisdictions and the publication years of the statutory curricula that were introduced or revised over the 1990s and 2000s.

[21] The definition of domains and sub-domains was informed by the call for evidence response from Science Community Representing Education (SCORE) – see http://www.score-education.org/media/7650/scorencevidence.pdf. SCORE is a collaboration of organisations and comprises the Association for Science Education, Institute of Physics, Royal Society, Royal Society of Chemistry and Society of Biology.
[22] The National Strategies website with the main resources can be found here: http://webarchive.nationalarchives.gov.uk/20110809101133/http://www.nsonline.org.uk

Table 1.1: Comparator jurisdictions and the publication date of the curricula used for comparison

	Curricula Examined – Date of Publication		
Jurisdiction	**Mathematics**	**English**	**Science**
England (primary & secondary)	1999	1999	1999
England (secondary only)	2007	2007	2005,2007
Alberta		2000, 2003	1996, 2003, 2005
Finland	2004		
Flemish Belgium	2010[23]		
Hong Kong	1999, 2000		1998, 2002, 2007
Massachusetts	2000, 2004	2001	2006
New South Wales		2003, 2007[24]	
New Zealand		1994	
Singapore	2001	2001	2001, 2005
Victoria			2008[25]

Mapping curriculum content against different age groups is one of the most technically challenging aspects of the content analysis. Table 1.2 shows how the different year groups in the comparator jurisdiction education systems have been mapped against the year groups used in England. Throughout the report, the England equivalent terms are used to describe particular year groups (e.g. Year 7) or age phases (e.g. Years 1-2).

For Hong Kong, slightly different equivalence has been used for mathematics and science. For mathematics, the closest age equivalence between England and Hong Kong is used in order to capture accurately and fairly the detailed year-on-year content in the primary phase in Hong Kong. For science, the closest key stage equivalence is used as this gives a better match at secondary level. This is because the Hong Kong science curriculum is relatively limited in the primary phase compared to the secondary phase, while the content itself is set out by their key stages rather than year-on-year. The result of the science equivalence basis is that pupils in Hong Kong deemed to be at the same stage are actually an average of eight months older than those in England.

[23] No statutory curriculum was available earlier than 2010.
[24] The 1998 New South Wales K-6 syllabus was re-published in 2007 to include foundation statements for each stage.
[25] 2008 was a revised edition from the learning standards first published in 2005.

Table 1.2: Ages and phases across education systems in the comparator jurisdictions

Age	England		Alberta		Massa-chusetts		New Zealand		N.S. Wales & Victoria		Singapore *		Hong Kong (for Maths) †		Hong Kong (for Science) ‡		Flemish Belgium		Finland	
4–5	EYFS	R		Preschool		Preschool		Preschool		Preschool		Preschool		K		K		Preschool		Preschool
5–6	Key Stage 1	Y1		K		K	Level 1	Y1	Early St. 1	K		K		K	Primary school	P1		Preschool		Preschool
6–7		Y2	Elementary school	G1	Elementary school	G1		Y2	Stage 1	Y1	Primary school	P1	Primary school	P1		P2	Primary school	P1		Preschool
7–8	Key Stage 2	Y3		G2		G2	Level 2	Y3		Y2		P2		P2		P3		P2	Phase 1	G1
8–9		Y4		G3		G3		Y4	Stage 2	Y3		P3		P3		P4		P3		G2
9–10		Y5		G4		G4	Level 3	Y5		Y4		P4		P4		P5		P4	Phase 2	G3
10–11		Y6		G5		G5		Y6	Stage 3	Y5		P5		P5		P6		P5		G4
11–12	Key Stage 3	Y7		G6		G6	Level 4	Y7		Y6		P6		P6	Secondary school	S1		P6		G5
12–13		Y8	Junior high school	G7	High school	G7		Y8	Stage 4	Y7	Secondary school	S1	Secondary school	S1		S2	First stage	S1	Phase 3 **	G6
13–14		Y9		G8		G8	Level 5	Y9		Y8		S2		S2		S3		S2		G7
14–15	Key Stage 4	Y10		G9		G9		Y10	Stage 5	Y9		S3		S3		S4	Second stage	S3		G8
15–16		Y11	HS	G10		G10	L6	Y11		Y10		S4		S4		S5		S4		G9

═══ Phase transition (a point where most pupils would change school or start a different type of schooling)

▒▒▒ Non-compulsory phase of education

* The express curriculum route was analysed as the majority of students (80%) take this route rather than the technical or academic route.
† For mathematics, the closest **age** equivalence between England and Hong Kong is used in order to accurately and fairly capture the structured nature of maths content in the primary years.
‡ For science, the closest **key stage** equivalence is used as this gives a better match at secondary level, which is where most science teaching takes place in Hong Kong.

Sources: http://education.alberta.ca/admin/resources/guidetoed.aspx, http://www.indobase.com/study-abroad/countries/usa/usa-education-system.html, http://www.minedu.govt.nz/, http://www.australianexplorer.com/australian_school_systems.htm, http://www.inca.org.uk/1018.html, http://www.edb.gov.hk/FileManager/EN/Content_1511/2012_poaleaflet_e.pdf, http://www.ond.vlaanderen.be/publicaties/2005/educationinflandersbroadview.pdf, http://www.uta.fi/FAST/US2/PAPS/ss-edfus.html

1.4 Further analysis

The analysis presented in this report does not encompass any examination of the education systems and societal factors that are often cited as explaining pupil achievement in different jurisdictions (see Alexander, 2001[26] and 2010[27]; Green, 1997[28]; National Research Council, 2003[29]; Oates, 2007[30] and 2010[31]; Wilkinson & Pickett, 2009[32]). To address this gap and build on the initial findings in this report, the Department for Education is analysing a wide range of factors that relate to both the given education system and the society served by this education system for a range of comparator jurisdictions. The particular factors that are currently being examined by the Department are:

- The cultural and demographic contexts of comparator jurisdictions. These contexts have been reviewed, noting differences in the size of the population and its linguistic make-up; in income levels and inequality; in teacher pay and qualification levels; and the levels of home-school involvement reported by head teachers;

- The structure of schooling in the comparator jurisdictions' education systems. Structures have been examined, including their levels of centralisation/decentralisation; the existence of a tiered or comprehensive secondary school system; the size and governance of independent and government-dependent private school sectors; and the direction of recent reforms to school structures;

- Accountability and assessment systems in the comparator jurisdictions' education systems. These have been compared with reference to the use of mandatory universal or sample testing; the level of governance at which accountability assessments are made; the focus on pupil, school or district-level performance; and the importance placed on differentiating pupil performance by different jurisdictions; and

- How the statutory curriculum is implemented in schools. This includes factors such as teaching time; breadth of the wider curriculum and the

[26] Alexander R.J. (2001). *Culture and Pedagogy: international comparisons in primary education* Oxford: Blackwell
[27] Alexander, R.J. (2010). *"World class schools" – noble aspiration or globalised hokum*. Compare: a Journal of Comparative Education Vol. 40 Issue 6 pp801-817.
[28] Green, A. (1997). *Education, Globalization and the Nation State*. London: Macmillan
[29] National Research Council. (2003). *Understanding Others, Educating Ourselves: Getting More from International Comparative Studies in Education*. Committee on a Framework and Long-term Research Agenda for International Comparative Education Studies. C. Chabbott and E. J. Elliott, editors. Board on International Comparative Studies in Education, Board on Testing and Assessment, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.
[30] Oates, T. (2007), *The constraints on delivering public goods – a response to Randy Bennett's 'What does it mean to be a non-profit educational measurement organization in the 21st Century?'* International Association for Educational Assessment Annual Conference, Azerbaijan, September 2007.
[31] Oates, T (2010). *Could do better: Using international comparisons to refine the National Curriculum in England* Cambridge: Cambridge Assessment
[32] Wilkinson, R. and Pickett, K. (2009). *The Spirit Level: why equality is better for everyone*, London: Allen Lane.

differences between the intended and the actual curriculum in most state-funded schools.

Ultimately, in considering the development of the new National Curriculum, there is a need to articulate the relationship between the *intended* curriculum – as set out in any statutory curriculum – and the *enacted* curriculum - as experienced by pupils. This involves identifying a range of factors, including the critical role of school leaders and the extent to which teachers are given the skills, flexibility and incentives to innovate and develop a school curriculum within which the intended curriculum is only a part.

Section 2 – Achievement in international comparison studies

2.1 Introduction

The transnational comparison of pupil attainment in this report is based on the data from the PISA, PIRLS and TIMSS studies (see Appendix 1 for background). Pupil attainment in different jurisdictions can be used as a means of identifying some as high-performing jurisdictions when compared with others, and for benchmarking system performance against what has been achieved internationally.

As the PISA, PIRLS and TIMSS studies are international in scope, cover large, randomly sampled groups of pupils and are administered to cohorts of specific age ranges, they are considered to be a reliable and robust comparison tool for performance against the subject areas tested in any particular wave.

However, as the studies are based on sample surveys, they do not test all the pupils in each participating jurisdiction, but instead assess a subset of each total pupil population. A further consideration is that different cohorts of pupils are sampled in the various assessments. However, the sampling strategy for each assessment sets out rigorous procedures to ensure that the samples tested have acceptable levels of representativeness[33]. Reporting of the results discloses any cases where sampling procedures within a particular participating jurisdiction failed to meet these standards.

Further caution is needed in comparing performance over time and between studies. For example, Jerrim[34] highlights changes in sampling methods over successive waves of PISA (e.g. from age based to year group based sampling), school and pupil response bias, and changes in the period of the year during which the survey is undertaken. In terms of comparison between studies, although the PISA, PIRLS and TIMSS studies all include an assessment of reading, mathematics and science, different kinds of knowledge are measured, meaning that the results are not directly comparable between PISA and PIRLS for reading or between PISA and TIMSS for mathematics or science. For example, TIMSS aims to discover what pupils have been taught and how much they know, while PISA aims to discover what pupils can do with the knowledge they have. There are other differences between PISA and the other studies, as highlighted by Ruddock *et al.*(2006)[35] who wrote:

> *It is the quantity of reading that marks PISA out, not the complexity of the language, which is similarly unfamiliar in both the*

[33] See OECD (2010a). *PISA 2009 Results: What Students Know and Can Do – Student Performance in Reading, Mathematics and Science* (Volume I) pp22 Paris, OECD Publishing.
[34] Jerrim, J. (2011). *England's "plummeting" PISA test scores between 2000 and 2009: Is the performance of our secondary school pupils really in relative decline?* London: Department of Quantitative Social Science, Institute of Education, University of London
[35] Ruddock, G. Clausen-May, T. Purple, C. and Ager, R. (2006). *Validation Study of the PISA 2000, PISA 2003 and TIMSS 2003 International Studies of Pupil Attainment*. (p123). DfES Research Report RR772

international studies. The high reading demand of questions in PISA is often accompanied by a relatively lower demand in the mathematics or science required. This reflects the lower level of mathematics or science that pupils can apply in new contexts as opposed to very familiar ones.

Despite the fact that the TIMSS study focuses more on what pupils know rather than how they use this knowledge, TIMSS has published research that shows that there was no bias in test results caused by differences in curriculum in the education systems (see Martin *et al*, 2008[36]). Yet, given the differences between the studies, it is not surprising that two surveys can return quite different results in comparing between studies within any one jurisdiction and age group.

In summary, PISA, PIRLS and TIMSS studies can only provide a measure of performance for the subjects they test and - within reading, mathematics and science - the domains within each subject which are measured through the tests (see Appendix 1 for more detail). It is therefore not possible to directly compare the results of the different studies because they are measuring different things, at different ages, and for different pupil populations.

2.2 Key findings

- An important perspective on England's educational performance can be gained from analysis of the results from international comparative assessments such as PISA, PIRLS and TIMSS.

- However, comparisons between different international assessments must be interpreted with care; each study provides information on pupil performance which focuses on different aspects of subject knowledge, measured at different ages, and for different cohorts of pupils.

Reading

- Areas of particular priority for improvement in England are making straightforward inferences from specific ideas in a text in primary; and retrieving information from a text, integrating and interpreting information to demonstrate understanding and in interpreting continuous texts in secondary.

- At age 10, Alberta and Singapore scored higher than England in *interpreting ideas* and *making straightforward inferences* at a statistically significant level in the PIRLS 2006 study. At age 15, Singapore, New Zealand, Canada and Australia scored significantly higher than England in *retrieving, integrating and interpreting information* and *interpreting continuous texts* in the PISA 2009 study.

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[36] Martin, M.O; Mullis, I.V.S and Foy, P (with Olson, J.F; Erberber, E; Preuschoff, C and Galia, J) (2008). Appendix C of *TIMSS 2007 International Science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades.* Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College

Mathematics

- Areas of particular priority for improvement in England are *number* in both primary and secondary and *algebra* in secondary, although attainment is relatively low in most areas of mathematics compared with high-performing jurisdictions.

- At age 10, Singapore, Hong Kong and Massachusetts scored higher than England at a statistically significant level in all mathematics domains; while at age 14 the same jurisdictions out-performed England in every area except *data and chance*, where only Singapore and Massachusetts scored significantly higher in the TIMSS 2007 study.

Science

- Unlike in reading and mathematics, attainment in science is relatively high, although areas of improvement can be identified across all sciences in primary and secondary. Weaknesses can also be identified in scientific processes and enquiry such as using models and explanations and using scientific evidence.

- At age 10 and 14, Singapore and to a lesser extent Massachusetts scored higher than England in most science domains, including *biology*, *earth science* and in the processes of science such as *recalling facts* and *using models and explanations* as measured in the TIMSS 2007 studies. At age 15, Hong Kong, Canada and to a lesser extent Australia outperformed the UK in most science domains such as *earth and space*, *physical systems* and *using scientific evidence* as measured in the PISA 2006 study.

2.3 Pupil attainment comparisons

The summary of aggregate scores for reading, mathematics and science provides a more general overview of pupil attainment in England in comparison with other jurisdictions. Table 2.1 provides a summary of the test score comparisons from recent waves of PISA, PIRLS and TIMSS studies for all jurisdictions with scores that were higher than England's at a statistically significant level on at least one scale across reading, mathematics and science. The table highlights in green jurisdiction scores that are statistically significantly higher than England or in yellow where there has been improvement since a previous wave of a study. The table also highlights in orange jurisdiction scores that are statistically significantly lower than England or where there has been significant deterioration since a previous wave of the study. Horizontal arrows (↔) indicate scores that are not statistically significantly different from England or from the same jurisdiction's score in the previous assessment wave, while 'n/a' indicates that data were not available to make the comparison.

In addition, for the PISA studies, England's scores in reading, mathematics and science can be compared with other jurisdictions using the concept of years of progress[37]. Table 2.2 shows the attainment gap in terms of years of progress, effect size and PISA points for jurisdictions that performed statistically significantly better than England in PISA 2009.

Shanghai achieved the highest average scale scores across reading, mathematics and science in PISA 2009, and the attainment gap in terms of PISA points, effect size and years of progress for 15 year-old pupils in Shanghai and England is statistically significant in reading, mathematics and science. The attainment gap between reading scores for 15 year-old pupils in Shanghai and England was 62 points, which is equivalent to 1.5 years of progress. In mathematics, the gap was 108 PISA points, equivalent to 2.5 years of progress; and for science the gap was 61 PISA points, equivalent to 1.4 years of progress.

An example of where the picture differed between reading, mathematics and science can be seen in the achievement gap between pupils in England and Chinese Taipei. In mathematics, pupils in Chinese Taipei achieved an average scale score 51 points higher than pupils in England, equivalent to 1.2 years of progress. However for reading and science, the gap was not statistically significant.

In total, 15 year-olds in eight jurisdictions were found to have reading advantages equivalent to a year or more of progress when compared with English pupils (Shanghai, South Korea, Finland, Hong Kong, Singapore, Switzerland, Liechtenstein and Chinese Taipei). Three jurisdictions (Shanghai, South Korea and Finland) had advantages equivalent to at least one year's progress in mathematics. In science, only Shanghai had an advantage equivalent to more than one year's progress.

[37] In DfE analysis, a measure of years' progress was derived using key stage point scores, with the point score at Key Stage 3 being closest to the age of PISA participants (15 years old). Years' progress was then expressed in terms of effect size, which for Key Stage 3 was 0.4. For more detail see Education Standards Analysis and Research Division, Department for Education (2011). *PISA 2009 Study: How big is the gap? A comparison of pupil attainment in England with the top-performing countries*. DfE Research Report DFE-RR149.

Table 2.1: High-level comparisons of PISA, PIRLS and TIMSS scores compared with those of England

Subject	Reading				Maths						Science					
International Comparative Test	PIRLS 2006 age ≈ 10		PISA 2009 age ≈ 15		TIMSS 2007 age ≈ 10		TIMSS 2007 age ≈ 14		PISA 2009 age ≈ 15		TIMSS 2007 age ≈ 10		TIMSS 2007 age ≈ 14		PISA 2009 age ≈ 15	
Reference score for tests of statistically significant differences	Eng	2001 Test	Eng	2000 Test	Eng	2003 Test	Eng	2003 Test	Eng	2003 Test	Eng	2003 Test	Eng	2003 Test	Eng	2006 Test
Australia	n/a	n/a	▲	det	▼	imp	▼	↔	▲	det	▼	↔	▼	det	▲	↔
Belgium	n/a	n/a	▲	↔	n/a	n/a	n/a	n/a	▲	det	n/a	n/a	n/a	n/a	▼	↔
Belgium - Flemish	▲	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
British Columbia (Can)	▲	n/a	n/a	n/a	▼	n/a	↔	n/a	n/a	n/a	↔	n/a	▼	n/a	n/a	n/a
Canada	n/a	n/a	▲	↔	n/a	n/a	n/a	n/a	▲	↔	n/a	n/a	n/a	n/a	▲	↔
Canada - Alberta	▲	n/a	n/a	n/a	▼	n/a	n/a	n/a	n/a	n/a	↔	n/a	n/a	n/a	n/a	n/a
Denmark	▲	n/a	↔	↔	▼	n/a	n/a	n/a	▲	det	▼	n/a	n/a	n/a	▼	↔
Estonia	n/a	n/a	↔	n/a	n/a	n/a	n/a	n/a	▲	n/a	n/a	n/a	n/a	n/a	▲	↔
Finland	n/a	n/a	▲	↔	n/a	n/a	n/a	n/a	▲	↔	n/a	n/a	n/a	n/a	▲	det
Germany	▲	imp	↔	imp	▼	n/a	n/a	n/a	▲	imp	▼	n/a	n/a	n/a	↔	↔
Hong Kong (China)	▲	imp	▲	↔	▲	imp	▲	det	▲	↔	▲	imp	↔	det	▲	↔
Hungary	▲	imp	↔	imp	▼	det	↔	det	↔	↔	↔	↔	↔	↔	▼	↔
Iceland	▼	↔	↔	↔	n/a	n/a	n/a	n/a	▲	det	n/a	n/a	n/a	n/a	▼	↔
Italy	▲	imp	▼	↔	▼	↔	▼	↔	▼	imp	↔	imp	▼	↔	▼	imp
Japan	n/a	n/a	▲	↔	▲	↔	▲	↔	▲	↔	↔	↔	▲	↔	▲	↔
Korea	n/a	n/a	▲	imp	n/a	n/a	▲	imp	▲	↔	n/a	n/a	▲	det	▲	imp
Liechtenstein	n/a	n/a	↔	imp	n/a	n/a	n/a	n/a	▲	↔	n/a	n/a	n/a	n/a	↔	↔
Luxembourg	▲	n/a	▼	n/a	n/a	n/a	n/a	n/a	↔	↔	n/a	n/a	n/a	n/a	▼	↔
Macao (China)	n/a	n/a	▼	n/a	n/a	n/a	n/a	n/a	▲	↔	n/a	n/a	n/a	n/a	↔	↔
Netherlands	▲	det	▲	n/a	↔	↔	n/a	n/a	▲	det	▼	↔	n/a	n/a	↔	↔
New Zealand	▼	↔	▲	↔	▼	↔	n/a	n/a	▲	↔	▼	det	n/a	n/a	▲	↔
Norway	▼	↔	▲	↔	▼	imp	▼	imp	↔	↔	▼	imp	▼	det	▼	imp
Ontario – Canada	▲	↔	n/a	n/a	▼	↔	↔	↔	n/a	n/a	↔	↔	▼	↔	n/a	n/a
Russian Federation	▲	imp	▼	↔	↔	↔	↔	↔	▼	↔	↔	imp	▼	imp	▼	↔
Shanghai (China)	n/a	n/a	▲	n/a	n/a	n/a	n/a	n/a	▲	n/a	n/a	n/a	n/a	n/a	▲	n/a
Singapore	▲	imp	▲	n/a	▲	↔	▲	det	▲	n/a	▲	imp	▲	↔	▲	n/a
Slovenia	▼	imp	▼	n/a	▼	imp	▼	imp	▲	n/a	▼	imp	↔	imp	↔	det
Sweden	▲	det	↔	det	▼	n/a	▼	det	↔	det	▼	n/a	▼	det	▼	↔
Switzerland	n/a	n/a	↔	↔	n/a	n/a	n/a	n/a	▲	↔	n/a	n/a	n/a	n/a	↔	↔
Taipei (China)	↔	n/a	↔	n/a	▲	imp	▲	imp	▲	n/a	▲	imp	▲	det	↔	det
United States	↔	↔	↔	↔	▼	imp	↔	↔	↔	↔	↔	↔	▼	↔	▼	imp
US - Massachusetts	n/a	n/a	n/a	n/a	▲	n/a	▲	n/a	n/a	n/a	▲	n/a	▲	n/a	n/a	n/a

Key:

▲	*Listed country has test score statistically significantly higher than England*
▼	*Listed country has test score statistically significantly lower than England*
↔	*Listed country has test score that is not statistically significantly different from England / its own score at the*
imp	*Listed country has test score that is statistically significantly higher than its own score at the previous test*
det	*Listed country has test score that is statistically significantly lower than its own score at the previous test*
n/a	*Data for the comparison not available*
Name	*Comparator education system, as listed in the following section*

Sources: Mullis, I.V.S. Martin, M.O. Kennedy, A.M. and Foy, P. (2007). *PIRLS 2006 International Report: IEA's Progress in International Reading Literacy Study in Primary Schools in 40 Countries*. Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston. OECD (2010a). *PISA 2009 Results: What Pupils Know and Can Do – Pupil Performance in Reading, Mathematics and Science* (Volume I). Paris, OECD Publishing. Mullis, I.V.S. Martin, M.O. and Foy, P. (with Olson, J.F. Preuschoff, C. Erberber, E. Arora, A. and Galia, J.) (2008). *TIMSS 2007 International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*. Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College. Martin, M.O. Mullis, I.V.S. and Foy, P. (with Olson, J.F. Erberber, E. Preuschoff, C. and Galia, C.) (2008). *TIMSS 2007 International Science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*. Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.

Table 2.2: Attainment gap between England and jurisdictions outperforming England in PISA 2009 study

	Reading assessment			**Mathematics assessment**			**Science assessment**		
	Attainment gap…			**Attainment gap…**			**Attainment gap…**		
Comparison jurisdiction2	*Effect size*	…in PISA points	…in years' progress	*Effect size*	…in PISA points	…in years' progress	*Effect size*	…in PISA points	…in years' progress
Shanghai	*0.6*	62	1.5	*1.1*	108	2.5	*0.6*	61	1.4
South Korea	*0.5*	45	1.1	*0.6*	54	1.3	*0.3*	24	0.6
Finland	*0.4*	42	1.0	*0.5*	48	1.1	*0.4*	40	0.9
Hong Kong-China	*0.4*	39	0.9	*0.7*	62	1.5	*0.4*	35	0.8
Singapore	*0.3*	32	0.7	*0.7*	70	1.6	*0.3*	28	0.7
Canada	*0.3*	30	0.7	*0.4*	34	0.8	*0.2*	15	0.4
New Zealand	*0.3*	27	0.6	*0.3*	27	0.6	*0.2*	18	0.4
Japan	*0.3*	26	0.6	*0.4*	37	0.9	*0.3*	26	0.6
Australia	*0.2*	21	0.5	*0.2*	22	0.5	*0.1*	14	0.3
Netherlands	*0.1*	14	0.3	*0.4*	33	0.8	*0.1*	9	0.2
Belgium	*0.1*	12	0.3	*0.2*	23	0.5	-	-	-
Norway	*0.1*	9	0.2	*0.1*	6	0.1	-	-	-
Estonia	*0.1*	7	0.2	*0.2*	20	0.5	*0.1*	14	0.3
Switzerland	*0.1*	6	0.1	*0.4*	42	1.0	*0.0*	3	0.1
Iceland	*0.1*	6	0.1	*0.2*	14	0.3	-	-	-
Liechtenstein	*0.1*	5	0.1	*0.5*	44	1.0	*0.1*	6	0.1
Germany	*0.0*	3	0.1	*0.2*	20	0.5	*0.1*	7	0.2
Chinese Taipei	*0.0*	1	0.0	*0.5*	51	1.2	*0.1*	7	0.2
Denmark	*0.0*	1	0.0	*0.1*	11	0.3	-	-	-
Macao-China	-	-	-	*0.3*	33	0.8	-	-	-
Slovenia	-	-	-	*0.1*	9	0.2	-	-	-

1. Shaded cells indicate the gap between England's average score and that of the comparison jurisdiction is statistically significant.
2. Jurisdictions are listed in descending order by size of attainment gap in the reading assessment, those listed in **bold** are OECD member states.
- Average score was not higher than England's in this strand.

Source: OECD, PISA 2009 Database and National Pupil Database 2010

Source: Education Standards Analysis and Research Division, Department for Education (2011). *PISA 2009 Study: How big is the gap? A comparison of pupil attainment in England with the top-performing countries*. DfE Research Report DFE-RR14

In Sections 2.4-2.6, pupil attainment in different domains of reading, mathematics and science is examined in more detail. In each case, the scales are set so that 500 is the mean (or very close to the mean), while the standard deviation – average distance from the mean – is 100. The error bars used on the charts show 95% confidence intervals – if it were possible to survey the whole population instead of just a sample, the result would very probably fall within these intervals. However, the mean and standard deviation depend entirely on the performance of the participating jurisdictions, and, since each survey has different participants, it is not possible to compare scale scores between different studies. In particular, PISA study scaling is based on the mean and standard deviation of OECD jurisdictions, while PIRLS and TIMSS use the mean and standard deviation of *all* participating jurisdictions.

2.4 International comparisons in reading

In the most recent waves of PISA and PIRLS, England's performance was average or higher than the average at each age tested for reading. The detailed findings set out below on different aspects of reading give a more fine-grained picture of pupils' achievement compared to other jurisdictions (see Appendix 1 for more details on how reading is measured). There are no large-scale international studies that assess other aspects of language or literacy such as writing.

Within reading, the three aspects of reading where there is most room for improvement in England are: *making straightforward inferences* in the primary curriculum from PIRLS 2006, and *access and retrieve*, *integrate and interpret* and the use of *continuous texts* in the secondary curriculum from PISA 2009. These findings are examined in more detail below:

Reading at age 10: PIRLS 2006

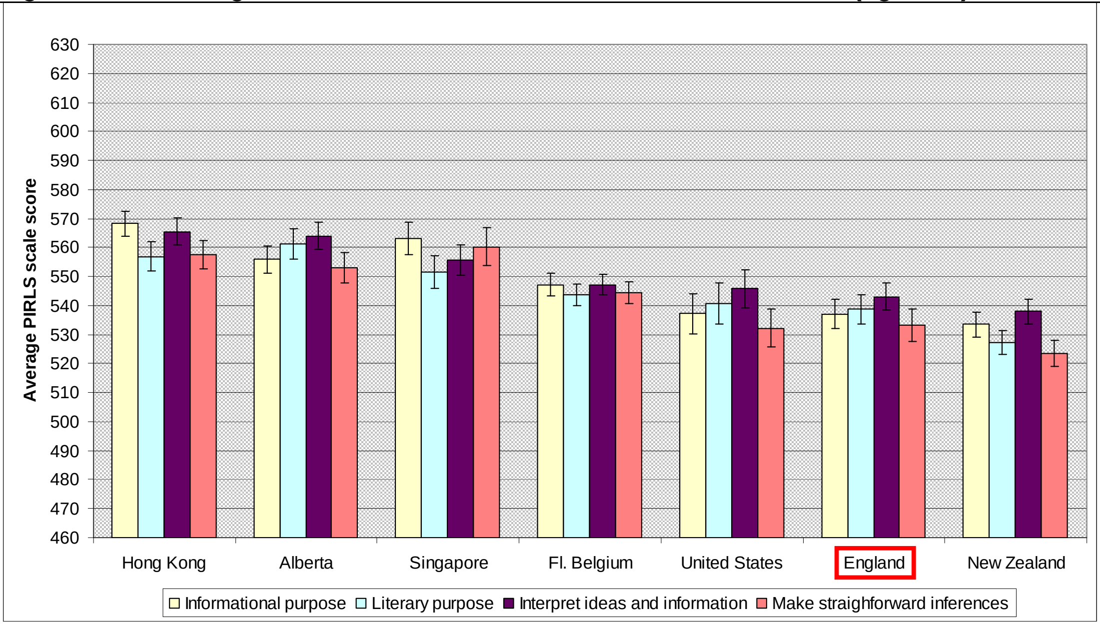
The PIRLS 2006 study tested reading for two different purposes: *literary* and *informational,* alongside testing for two different domains of reading:

- *interpreting ideas and information* involves whole-text and contextual understanding and response; and
- *making straightforward inferences* involves basic understanding of specific ideas in the texts.

As can be seen in Figure 2.3, pupils in Alberta and Singapore scored significantly higher than pupils in England in the tasks relating to *reading for informational purposes*. In addition, pupils also scored significantly higher in tasks relating to *reading for literary purposes* in Alberta and Singapore, although pupils in England scored significantly higher than those in New Zealand in this type of task. Scores for the US in both these domains were not significantly different from those for England.

In addition, pupils in Singapore and Alberta scored significantly higher in the *making straightforward inferences* domain; the score for pupils in the US was not significantly different from that of England. In the domain of *interpret ideas and information*, pupils in Alberta and Singapore achieved scores significantly higher than pupils in England. The scores for pupils in the US and New Zealand did not differ significantly to those for pupils in England in this domain.

Figure 2.3: Reading attainment for different domains in PIRLS 2006 (aged 10)



Note: Jurisdictions are shown in descending order of average reading achievement. Source: http://nces.ed.gov/surveys/international/ide/

Reading at age 15: PISA 2009

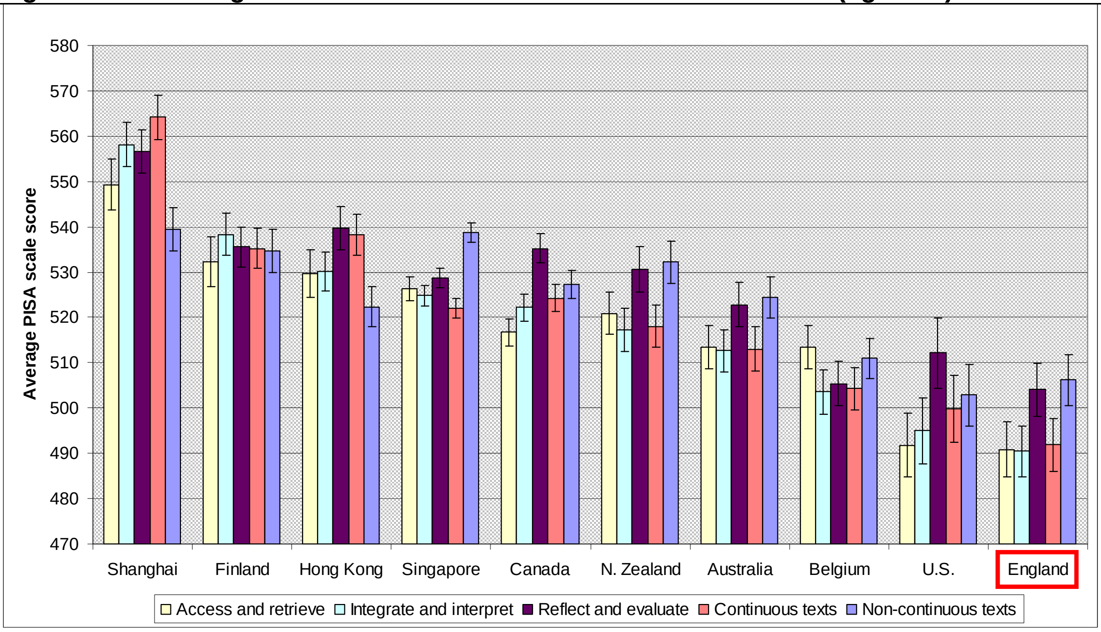
PISA 2009 tested for three different domains in relation to two different text formats – continuous and non-continuous. The three domains tested the ability to:

- access and retrieve information;
- *integrate and interpret* information in order to demonstrate understanding of the text; and
- *reflect on and evaluate* the text based on wider knowledge.

As can be seen in Figure 2.4, among Anglophone jurisdictions, pupils in Singapore, Canada, Australia and New Zealand scored significantly higher than 15 year old pupils in England on tasks relating to *accessing and retrieving information, integrating and interpreting information*, and *reflecting and evaluating*. Scores for pupils in the US for the three domains were not significantly different from those for pupils in England.

In addition, pupils in Singapore, Canada, Australia and New Zealand scored significantly higher than pupils in England on tasks relating to both *continuous and non-continuous texts*. As before, the scores for pupils in the US were not statistically significantly different from those achieved by pupils in England.

Figure 2.4: Reading attainment for different domains in PISA 2009 (aged 15)



Note: Jurisdictions are shown in descending order of average reading achievement. Source: http://nces.ed.gov/surveys/international/ide/

2.5 International comparisons in mathematics

In the most recent waves of the PISA and TIMSS studies, England's performance was average or higher than the average at each age tested for mathematics. The more detailed findings set out below on different aspects of mathematics gives a more fine-grained picture of pupils' achievement compared to other jurisdictions (see Appendix 1 for more details on how mathematics is measured).

Within mathematics, the domains where there is most room for improvement in England are *number* in both the primary and secondary curricula and *algebra* in the secondary curriculum, although attainment is relatively low in most of the domains of mathematics assessed. The findings are examined in more detail below.

Mathematics at age 10: TIMSS 2007

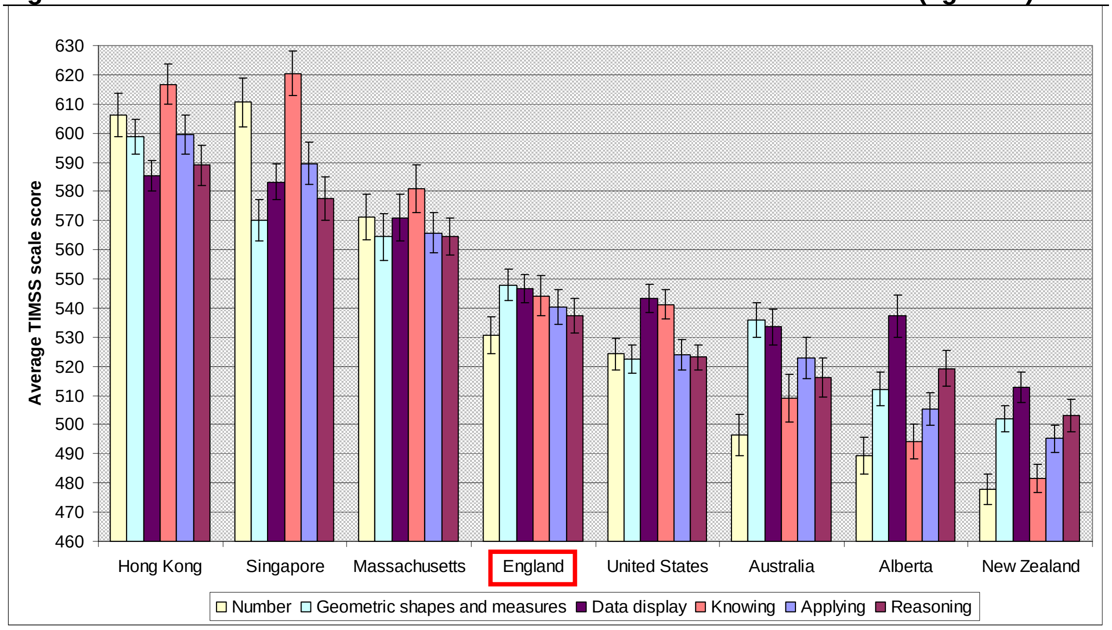
In mathematics at age 10, the TIMSS content domains were *number*, *algebra*, *geometric shapes and measures*, and *data display*. TIMSS 2007 also divided tasks into the cognitive domains of *knowing, applying* and *reasoning*. In mathematics:

- *knowing* means recalling facts and basic computation;
- *applying* means solving routine problems; and
- *reasoning* means solving non-routine problems.

As can be seen in Figure 2.5, there was a statistically significant difference between England and the higher-performing jurisdictions of Singapore, Hong Kong and Massachusetts in all of the six domains presented. England's scale score for the content domain of *number* (531) is lower than its other respective scores, suggesting greater weakness in this domain compared to geometric shape and measures or data display. At age 10, *number* typically involves tasks such as recognising multiples and factors of numbers; adding and subtracting fractions and decimals, number sentences and sequences. A relatively low score in *number* is shared by most of the English-speaking comparator jurisdictions with the exception of Massachusetts and the wider United States.

In the three cognitive domains, England's scores are quite similar to one another, while in Hong Kong, Singapore and Massachusetts pupils are much stronger in the cognitive domain of *knowing* in comparison with *applying* and *reasoning*.

Figure 2.5: Mathematics attainment for different domains in TIMSS 2007 (aged 10)



Note: Jurisdictions are shown in descending order of average mathematics achievement.
Source: http://nces.ed.gov/surveys/international/ide/

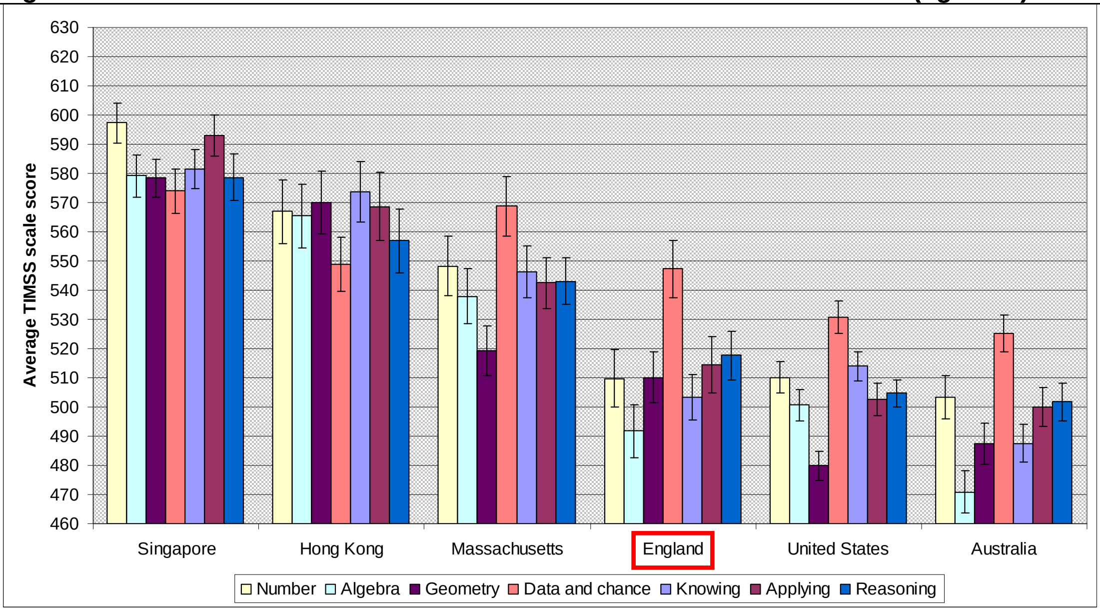
Mathematics at age 14: TIMSS 2007

In mathematics at age 14, the four content domains are *number*, *algebra*, *geometry*, and *data and chance* alongside the three cognitive domains of *knowing*, *applying* and *reasoning*.

As can be seen in Figure 2.6, in five of the seven domains, there was a statistically significant difference between England and each of the higher performing jurisdictions of Singapore, Hong Kong and Massachusetts. These were *number*, *algebra, knowing*, *applying* and *reasoning*. In *geometry* Singapore and Hong Kong significantly outperform England and Massachusetts while in *data and chance*, Singapore and Massachusetts significantly outperform England and Hong Kong.

In England, pupils' attainment in the domains of *number*, *algebra*, *geometry* and *data and chance* shows very high variation between domains compared to Singapore and Hong Kong, with the greatest difference between *data and chance* – where performance was relatively high - and *algebra.* This relatively low performance in *algebra* was on a par with the US but some way above Australia.

Figure 2.6: Mathematics attainment for different domains in TIMSS 2007 (aged 14)



Note: Jurisdictions are shown in descending order of average mathematics achievement.
Source: http://nces.ed.gov/surveys/international/ide/

2.6 International comparisons in science

Unlike in reading and mathematics, in the most recent waves of the PISA and TIMSS studies, England's performance was higher than the average at each age tested for science although a number of jurisdictions were higher performing at a statistically significant level. The more detailed findings set out below on different aspects of science gives a more fine-grained picture of pupils' achievement compared to other jurisdictions (see Appendix 1 for more details on how science is measured).

Within science, overall improvement is desirable in *biology*, *physics* and *chemistry* – alongside the *earth sciences*. No specific domains stand out as requiring particular improvement in either primary or secondary. Some weaknesses can be identified in scientific processes and enquiry such as using models and explanations and using scientific evidence. The findings are examined in more detail below.

Science at age 10: TIMSS 2007

The TIMSS age 10 content domains for science are *life science*, *physical science* and *earth science*. This means that chemistry and physics are combined in TIMSS (under *physical science*), while *earth science* is a separate domain.

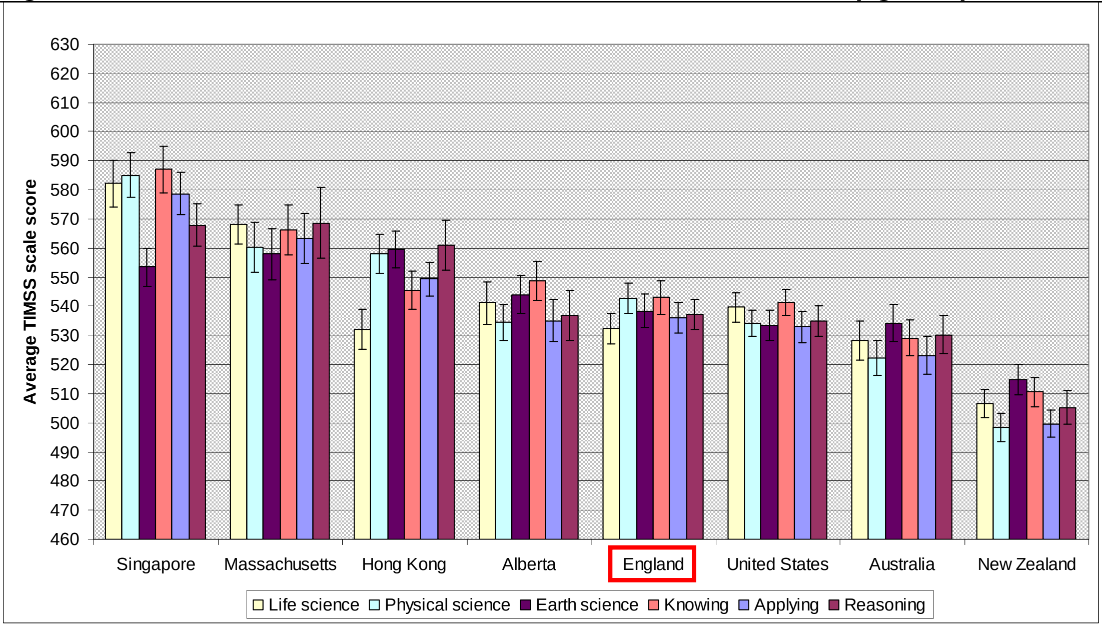
TIMSS 2007 science also divided tasks into the cognitive domains of *knowing*, *applying* and *reasoning.* In science:

- *knowing* means recalling facts and basic procedures;
- *applying* means using models and explaining; and
- *reasoning* means analysing, designing and planning.

As can be seen from Figure 2.7, pupils aged 10 in Singapore and Massachusetts scored significantly higher than pupils in England in the domain of *life science*. However, pupils in England achieved a score in this domain that was not significantly different from that achieved by pupils in Australia and Alberta. In the *physical science* domain, pupils in Singapore, Hong Kong and Massachusetts achieved significantly higher scores compared to pupils in England; however England achieved scores that were significantly higher than both Australia and Alberta in this domain. In the domain of *earth science*, once again Hong Kong, Singapore and Massachusetts achieved a score that was significantly higher than that achieved by England; pupils in Alberta and Australia achieved scores that were not significantly different from those achieved by pupils in England.

In tasks relating to the *knowing* domain, pupils in Singapore and Massachusetts scored significantly higher than pupils in England. The scores for pupils in Alberta and Hong Kong did not differ significantly to those for pupils in England, and pupils in England scored significantly higher than pupils in Australia in this domain. In *applying*, the scores for Singapore, Hong Kong and Massachusetts were significantly higher than those of England, while there was no significant difference between England and Alberta. Pupils in England achieved a score that was significantly higher than pupils in Australia for this domain. In *reasoning*, pupils in Hong Kong, Singapore and Massachusetts scored significantly higher compared to pupils in England, while scores for pupils in Alberta and Australia were not significantly different from those for pupils in England.

Figure 2.7: Science attainment for different domains in TIMSS 2007 (aged 10)



Note: Jurisdictions are shown in descending order of average science achievement. Source: http://nces.ed.gov/surveys/international/ide/

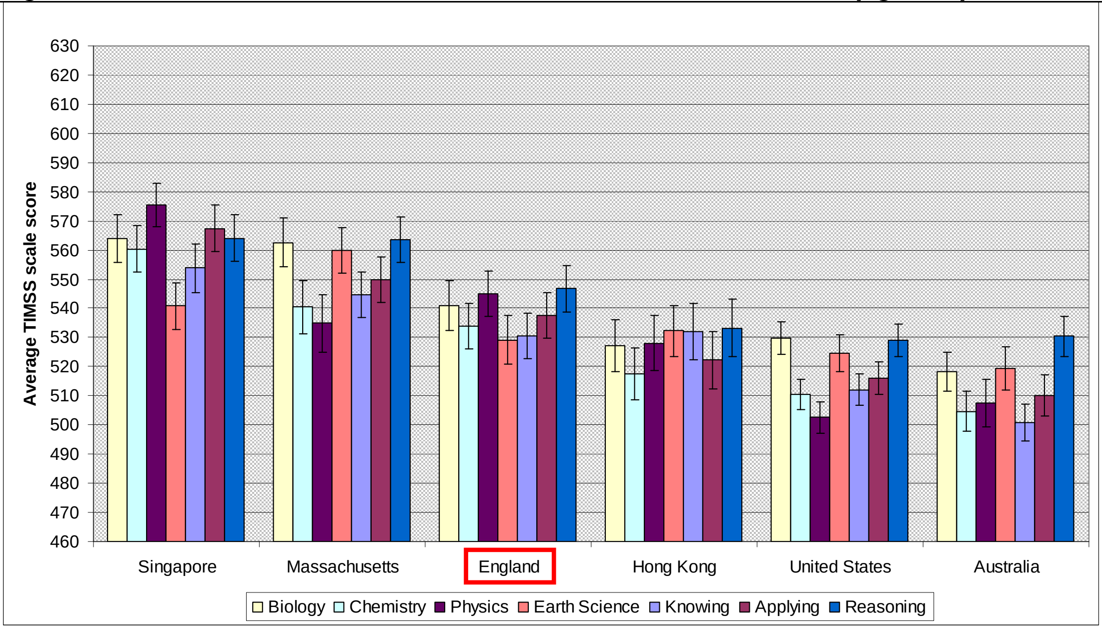
Science at age 14: TIMSS 2007

TIMSS 2007 age 14 science has content domains of *biology*, *chemistry*, *physics* and *earth science* alongside the cognitive domains of *knowing*, *applying* and *reasoning*. *Earth science* includes content that would belong in geography in England.

The data in Figure 2.8 show that pupils in Singapore and Massachusetts scored significantly higher in *biology* compared to pupils in England. However, pupils in England achieved scores that were significantly higher than those for pupils in Australia in this domain. In *chemistry* and *physics*, only pupils in Singapore scored significantly higher than pupils in England; pupils in Australia and the US achieved scores significantly lower than pupils in England, and pupils in Massachusetts achieved scores that were not significantly different from those achieved by pupils in England. Massachusetts achieved scores that were significantly higher than that of England in *earth science*, while Hong Kong, Singapore and Australia achieved scores that did not differ significantly to those of England.

In tasks that assessed the *knowing* domain, pupils in Singapore achieved scores that were significantly higher than those of pupils in England. However, England achieved a score significantly higher than Australia and the US, and a score that did not differ significantly to that achieved by Hong Kong. Once again, Singapore achieved scores that were significantly higher than England in the *applying* and *reasoning* domains. However, England achieved scores that were significantly higher than both Hong Kong and Australia in these domains.

Figure 2.8: Science attainment for different domains in TIMSS 2007 (aged 14)



Note: Jurisdictions are shown in descending order of average science achievement. Source: http://nces.ed.gov/surveys/international/ide/

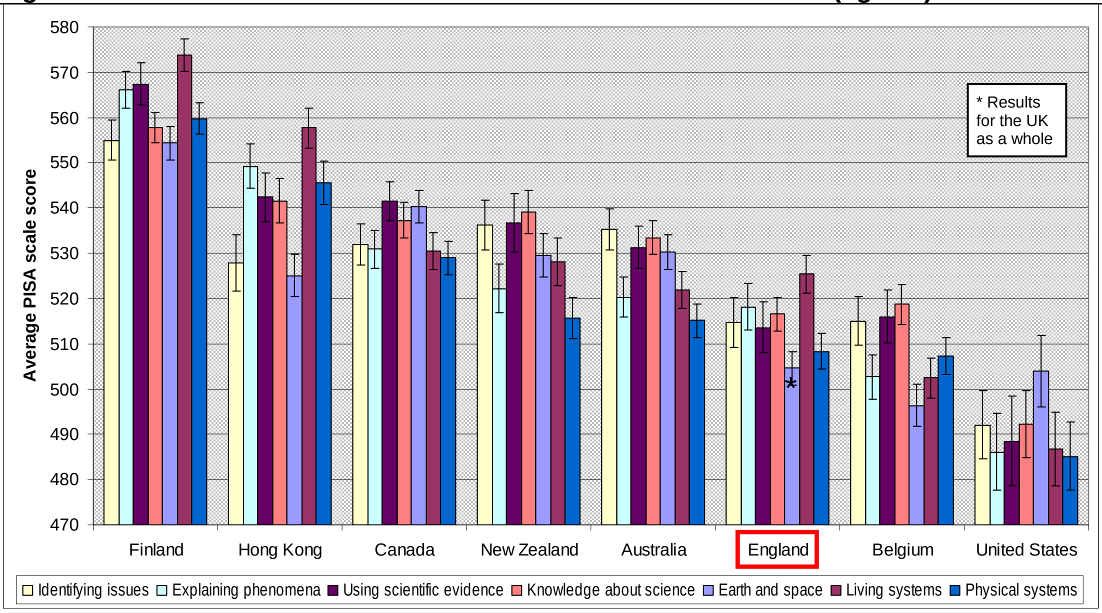
Science at age 15: PISA 2006

In PISA 2006, the content domains were *knowledge about science*, *earth and space*, *living systems*, and *physical systems* while the cognitive domains were *identifying scientific issues*, *explaining phenomena*, and *using scientific evidence*. The OECD did not publish separate scores on these knowledge sub-domains for England, so the following analysis uses UK scores as a proxy.

As can be seen in Figure 2.9, in the *knowledge about science* and *earth and space* domains, Hong Kong, Canada and Australia achieved scores that were higher than the UK at a statistically significant level. For *physical systems*, Hong Kong and Canada achieved scores higher than those achieved by the UK while for living systems, Hong Kong scores higher than those achieved by the UK

In *identifying scientific issues* and *using scientific evidence*, Hong Kong, Canada and Australia achieved scores that were higher than the UK at a statistically significant level. In *explaining phenomena*, pupils in Hong Kong and Canada scored significantly higher than pupils in the UK. Finland was the highest-performing jurisdiction across all domains.

Figure 2.9: Science attainment for different domains in PISA 2996 (age 15)



Note: Jurisdictions are shown in descending order of average science achievement. Source: http://nces.ed.gov/surveys/international/ide/

Section 3 – Curriculum comparisons for English

3.1 Introduction

This section sets out the selection of five comparator jurisdictions based on the findings of the international comparison studies, followed by the initial findings from the analysis of the statutory English curricula of these jurisdictions and England's National Curriculum. The Anglophone jurisdictions are: Alberta, Canada; Massachusetts, USA; New South Wales, Australia; New Zealand; and Singapore[38].

Anglophone jurisdictions have been selected for the main curriculum analysis for two reasons:

- Fairer comparisons can be made between jurisdictions where English is the first or main language;

- Compared to other languages the English language has a relatively irregular written form, including a complex orthography (*i.e.* an unclear relationship between sounds and spellings).

The analysis was also extended to some non-Anglophone jurisdictions, in order to assess how different jurisdictions define expectations around the reading of literature in their curricula.

The purpose of comparing the curricula has been to identify whether there are any similarities and differences between the statutory curricula, which could be used to inform the development of the National Curriculum in England. The content analysis focuses on the level of the statutory curricula for English in high-performing jurisdictions compared to the 1999 and 2007 National Curricula for England. As stated in Section 1.3, the analysis does not include wider non-statutory guidance and other related resources. For this reason, the National Strategies' *Frameworks for teaching* - non-statutory guidance for the teaching of literacy, introduced by the previous Government - are not within the scope of this analysis.

The focus has been on the organisation, breadth, specificity and, where possible, the level of challenge and sequencing of content within comparable age-phases (see Appendix A for more detail). The analysis examines the aims and domains common to the English curricula in the different jurisdictions. A number of examples are provided that illustrate where England's curriculum is less challenging or less specific than the statutory curricula of high-performing jurisdictions.

3.2 Key findings

- The curricula for English across jurisdictions examined are organised

[38]Although English is not the mother-tongue of most inhabitants of Singapore, it is the official medium of instruction in schools. See http://www.contactsingapore.org.sg/investors/live/language/

very differently, although a structure based on the four modes of speaking, listening, reading and writing is the most common.

- Differences in the level of challenge across domains and sub-domains were particularly difficult to assess, in part because of the variety in the structure and level of specificity of each curriculum, and in part because of the non-linear nature of the subject. It is evident that the degree of specificity is not a clear indicator of the level of challenge and also evident that increasing the level of challenge for older pupils is difficult to achieve without also increasing the level of specificity.

- Specificity varies amongst jurisdictions and between the domains and sub-domains within the curricula of those jurisdictions. Alberta has a considerably more detailed curriculum than the others analysed. New South Wales is also very specific, whilst Massachusetts and England 1999 are similar in terms of the level of specificity. England 2007 and New Zealand are both notable for their broader, less detailed statements, New Zealand particularly so.

Reading

- The jurisdictions analysed take a similar approach to *word reading* during the primary years, focusing on securing knowledge of grapheme-phoneme correspondences to decode words. This is commonly expected alongside other word reading strategies.

- The breadth and specificity of *comprehension* is broadly similar across the jurisdictions, although England has a greater emphasis on the *author's craft* in literature. Alberta, Singapore and Massachusetts have a greater focus on *reading for research* than the other curricula analysed.

- There is significant variation in the specification of literature. Three of the six Anglophone jurisdictions analysed (England, Alberta and Massachusetts) and eight European jurisdictions (Denmark, Estonia, France, Latvia, Lithuania, Malta, Portugal and Poland) provide guidance on reading material as part of the curriculum, which is set out by author, by title or by both author and title.

Writing

- *Composition* has approximately the same prominence and level of detail in each of the jurisdictions, but the emphasis on the different skills needed for composition varies greatly.

- *Planning, evaluating, editing* and *proof-reading* are covered very differently across the jurisdictions, with New Zealand and Singapore having less detail than the other curricula.

- There is considerable variation in content and some variation in challenge with regard to *grammar, punctuation* and *spelling*. The

Singapore and Massachusetts curricula set out *grammar* requirements in the greatest level of detail and with the greatest level of challenge. Alberta is unique in continuing *spelling* strategies into the secondary phase.

Speaking and listening

- *Speaking* and *listening* are represented either as separate domains in English (England, New Zealand, New South Wales primary) or integrated within other domains such as *language* (Massachusetts) or wider all-encompassing domains (Alberta, Singapore and New South Wales secondary).

- Alongside England, Alberta and New South Wales have the greatest breadth of content for *speaking* and *listening* than in other jurisdictions. *Speaking* and *listening* has prominence within the Singapore primary curriculum, but is the least challenging at secondary of all the other curricula analysed.

- At primary, *speaking* and *listening* relates to a wide range of activity including: developing vocabulary, effective participation in discussion, oral presentation and asking and answering questions. At secondary, *speaking* and *listening* mainly relates to presenting complex information to a range of audiences, debating, adapting presentations for different audiences and processing complex information.

3.3 Selecting comparator jurisdictions

The curriculum analysis first involved the selection of a small number of high-performing jurisdictions in *reading* to benchmark against England. Identifying comparator jurisdictions was in part based on a synthesis of the results from these international comparisons and also on whether an education system for the given jurisdiction is organised at a national or sub-national (state, province, region) level. Given this, it was sometimes necessary to draw on other studies to identify regions with the highest performing pupils within a particular nation. The jurisdictions covered in each survey are set out in Table 3.1.

Table 3.1: Jurisdictions covered in recent waves of PISA and PIRLS studies

		Australia	Alberta	Flemish Belgium	Finland	Hong Kong	Massachusetts	New Zealand	Singapore
Reading	PIRLS 2006 *age 10*		☑	☑		☑	☑ (USA)	☑	☑
	PISA 2009 *age 15*	☑	☑ (Can.)	☑ (Belg.)	☑	☑	☑ (USA)		☑

The PIRLS 2006 assessments were administered in 45 jurisdictions in total, including two language communities within Belgium (French and Flemish), and five provinces within Canada. The sample size was approximately 220,000 pupils[39]. The mean age of participants was 10.5, with a minimum age of 9.5 years. The three top performing education systems in the 2006 PIRLS study were the Russian Federation (565), Hong Kong (564) and Alberta, Canada (560). England had an average score of 539, which was significantly above the scale[40] average of 500[41].

The main focus of the PISA 2009 age 15 assessments was reading. Results from the assessment reported the highest reading score for Shanghai[42] (556), followed by Korea (539) and Finland (536)[43]. England achieved a mean reading score of 495, which was not statistically significantly different from the OECD average score of 493[44].

Massachusetts did not participate in the PISA 2009 or PIRLS 2006 reading assessments; however, it did perform very strongly within the US on NAEP national reading assessments[45].

Among all the jurisdictions taking part in the above studies, it is possible to identify five Anglophone jurisdictions with the highest achieving pupils in reading. The selected jurisdictions are:

- Alberta;
- Massachusetts;
- New South Wales;
- New Zealand; and
- Singapore.

3.4 Curriculum analysis for English - an overview

The curriculum documents analysed are those that were being taught in schools prior to and at the time of the PISA and PIRLS assessments. The

[39] Joncas, M. (2007). *PIRLS 2006 Sampling Weights and Participation Rates*. In Martin, M.O. Mullis, I.V.S. and Kennedy, A.M. (eds.) (2007). *PIRLS 2006 Technical Report*. Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.
[40] The supporting metric for the PIRLS 2006 scale was established by setting the average of the mean scores for participants in PIRLS 2001 at 500, with a standard deviation of 100. Foy, P. Galia, J. and Li, I. (2007). *Scaling the PIRLS 2006 Reading Assessment Data*. In Martin, M.O. Mullis, I.V.S. and Kennedy, A.M. (eds.) (2007). *PIRLS 2006 Technical Report*. Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.
[41] Mullis, I.V.S. Martin, M.O. Kennedy, A.M. and Foy, P. (2007). *PIRLS 2006 International Report: IEA's Progress in International Reading Literacy Study in Primary Schools in 40 Countries*. Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.
[42] Pupil scores in PISA 2009 were scaled to fit the metric for pupil scores in PISA 2000 in order to facilitate comparisons between years. Scores for PISA 2000 were normally distributed with a mean of 500 and a standard deviation of 100. See *PISA 2009 Study: How big is the gap? A comparison of pupil attainment in England with the top-performing countries (2011).* DfE Research Report DFE-RR149.
[43] OECD (2010a). *PISA 2009 Results: What Students Know and Can Do – Student Performance in Reading, Mathematics and Science (Volume I).* Paris: OECD Publishing.
[44] Bradshaw, J. Ager, R. Burge, B. and Wheater, R. (2010). *PISA 2009: Achievement of 15-Year-Olds in England*. Slough: NFER.
[45] National Center for Education Statistics (2011). *The Nation's Report Card: Reading 2011* (NCES 2012–457). Washington DC: Institute of Education Sciences, US Department of Education

2007 National Curriculum for England has also been reviewed to understand how the curricula of high-performing jurisdictions compare with the curriculum currently being taught in England's secondary schools.

Comparing the curriculum documents for the six jurisdictions revealed significant variation in how English subject curricula are organised (see Appendix A - Table A1). Massachusetts, Singapore and New South Wales are organised into two-year groupings; New Zealand organised into outcome levels approximating to two years per level; England set out in key stages; and Alberta is set out year by year.

With the exception of Alberta, the curricula are clearly organised into domains that broadly align with the four modes of communication: *speaking, listening, reading* and *writing*, although the terms used to describe these modes differ between jurisdictions.

It is worth noting that more recent curriculum reforms also show no tendency towards one favoured model: New Zealand is moving away from a curriculum organised around the three domains of *speaking and listening*, *reading* and *writing*; whilst the others remain fairly similar. Table 3.2 sets out how curricula analysed for this report are organised and any changes as a result of recent reforms.

Table 3.2: Organisation of English curricula

	Organisation of curriculum analysed for this report	Organisation of latest or forthcoming curriculum
New South Wales	**2007[46] (Years 1 to 7):** • Talking & listening • Reading • Writing **2003 (Years 8 to10):** Through responding to and composing a wide range of texts in context and through close study of texts, students will develop skills, knowledge and understanding in order to: • speak, listen, read, write, view and represent • use language and communicate appropriately and effectively • think in ways that are imaginative, interpretive and critical • express themselves and their relationships with others and the world • learn and reflect on their learning through their study of English.	**Adopts federal curriculum from 2014:** • Speaking and listening • Reading and viewing • Writing and representing
Alberta	**2000:** Students will listen, speak, read, write, view and represent to: • explore thoughts, ideas, feelings and experiences • comprehend and respond critically to oral, print and other media texts • manage ideas and information • enhance the clarity and artistry of communication • respect, support and collaborate with others	n/a
New Zealand	**1994:** • Oral language • Written language • Visual language	**2010:** • Listening, reading, and viewing • Speaking, writing, and presenting
Singapore	**2001:** • Language for information • Language for literary response and expression • Language for social interaction	**2010:** • Listening and viewing • Reading and viewing • Speaking and representing • Writing and representing • Grammar • Vocabulary
Massachusetts	**2001:** • Language • Reading and literature • Composition • Media	**2011:** • Reading • Writing • Speaking and listening
England	**1999:** • Speaking and listening • Reading • Writing	**2007 (secondary):** • Speaking and listening • Reading • Writing

[46] The 1998 New South Wales K-6 syllabus was re-published in 2007 to include foundation statements for each stage

Breadth

As highlighted by Ruddock and Sainsbury[47], it is difficult to compare the breath of content coverage across English curricula due to a number of factors which are detailed elsewhere in this report but outlined briefly here. Firstly, the level of specificity varies widely between jurisdictions. Secondly there is a general tendency for specificity to decrease in the secondary phase. Lastly, there is no common layout of content, either in terms of the structure of domains and sub-domains, or the sequencing of content into age phases or levels.

As set out in Table 3.2, each jurisdiction covers the domains of reading, writing, speaking and listening, giving each domain significant weight from Years 1 to 11. There are, however, differences in the breath of coverage across jurisdictions:

- *Word reading* is covered in each curriculum, with significant prominence and breadth during early primary. This focuses on securing decoding skills, with some variations in the specification of strategies to be taught alongside the use of phonics. The breadth of study varies considerably between jurisdictions for *reading comprehension*, with differences occurring in the more specific or sophisticated textual comprehension approaches taken by England (1999) and Alberta.

- All curricula specify the *reading of literary and non-literary texts*, with the majority outlining the range of specific text types or genres for study. England, for example, sets out the range of literary and non-fiction texts in the *breadth of study*, while Singapore specifies types of text under its three main curriculum headings. Differences in coverage of reading are particularly apparent in the specification of *reading for information and research*, where Alberta, Singapore and Massachusetts are the most comprehensive.

All curricula specify the *composition of fiction, non-fiction and poetic writing*, but differ in whether they set out specific types of text as, for example, set out in the *breadth of study* for England (e.g. stories, poems, playscripts, autobiographies, screenplays, diaries). There is significant variation in the amount of coverage for *planning, evaluating, editing and proof reading* amongst curricula, ranging from considerable coverage (Alberta) to very little (Singapore). The amount of content for *grammar* also varies significantly at both primary and secondary. Other than New Zealand which has no discernible detail, the other curricula cover the similar grammar fundamentals, except for Singapore, which covers significantly more grammar than the other jurisdictions.

The coverage of *speaking and listening* also varies, having a greater breadth of content in the Alberta and New South Wales curricula than in other jurisdictions.

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[47] Ruddock, G. and Sainsbury, M. (2008). *Comparison of the core primary curriculum in England to those of other high performing countries*. DCSF Research Report DCSF-RW048.

Specificity

The level of specificity varies considerably amongst the curricula analysed. The analysis has shown that the degree of specificity depends on three factors: the detail provided for each learning outcome; the amount of content that is repeated from earlier stages; and the use of teaching examples.

Alberta stands out as having the most detailed curriculum, with very specific learning statements set out year by year across five inter-related *general outcomes*. The New South Wales primary curriculum has a high level of specificity, separating the headline domains into *learning to* and *learning about,* which are then divided into further sub-domains. New South Wales has slightly less content in its secondary curriculum than it does for primary.

Massachusetts has a level of specificity akin to England 1999 and Singapore. The Massachusetts curriculum has examples of classroom practice after many of the outcome statements. Massachusetts and Singapore stand out in having separate and detailed *grammar* sections. However, Singapore has less detail in *planning* and in *editing writing* than many of the other jurisdictions examined.

The statements in the 2007 secondary National Curriculum for England are fairly unspecific by comparison, although there are more supporting guidance notes within the document than found in other curricula. The New Zealand curriculum is set out as very broad attainment levels, with very few statements per level. The impact of this is that there is very little information for teachers on, for example, what strategies should be used to teach pupils to decode or how to write for specific purposes.

Across all of the curricula analysed, the greatest variation in level of specificity is found in the primary phase. There is a tendency for *all* curricula to become less specific for the secondary phase.

Challenge

Differences in the level of challenge across domains and sub-domains were particularly difficult to assess, in part because of the variety in the structure and level of specificity of each curriculum, and in part because of the non-linear nature of the subject. The level of challenge in English is related more to expected outcomes than to the particular concepts. This means that the level of challenge cannot easily be judged from curriculum documents alone. For example, it is difficult to judge the level of challenge in reading without a specification of the texts to be read in each year or over longer age phases. Similarly, the level of challenge for writing is also dependent on the complexity of the task, as well as the attention to language conventions and meeting the needs of the reader. Grammar, and to a lesser extent spelling, have been the two areas where it has been easier to make direct comparisons about levels of challenge.

It has also been evident from the analysis that the degree of specificity is not a clear indicator of the level of challenge and that increasing the level of challenge for older pupils is difficult to achieve without also increasing the level of specificity. Alberta appears more challenging overall than the other curricula at Years 10 and 11, although in part this may be due to the degree to which the process of *analysing, interpreting and composing text* is broken down within the curriculum.

3.5 Curriculum aims

All the curriculum documents examined begin by explaining the importance of English, both as a curriculum subject and for personal development. The value of language development as a first principle of English is outlined in all the jurisdictions' curriculum documentation, for example:

- **New Zealand:** "Language development is essential to intellectual growth. It enables us to make sense of the world around us. The ability to use spoken and written language effectively, to read and to listen and to discern critically messages […] is fundamental to both learning and to effective participation in society and the workforce."[48]

- **Alberta:** "The ability to use language effectively enhances student opportunities to experience personal satisfaction and to become responsible, contributing citizens and lifelong learners"[49] and "As well as being a defining feature of culture, language is an unmistakable mark of personal identity and is essential for forming interpersonal relationships, extending experiences, reflecting on thought and action, and contributing to society" [50].

- **New South Wales:** "Language is central to students' intellectual, social and emotional development and has an essential role in all key learning areas. The learning experiences provided in this syllabus will assist students to become competent in English and to use language effectively in a range of contexts"[51] and "Competence in English will enable students to learn about the role of language in their own lives, and in their own and other cultures. They will then be able to communicate their thoughts and feelings, to participate in society, to make informed decisions about personal and social issues, to analyse information and viewpoints, to use their imaginations and to think about the influence of culture on the meanings made with language" [52].

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[48] New Zealand Ministry of Education (1994). *English in the New Zealand Curriculum* http://www.minedu.govt.nz/~/media/MinEdu/Files/EducationSectors/Schools/EnglishInTheNewZealandCurriculum.pdf
[49] Alberta Learning (2000) *English Language Arts* (p1) http://education.alberta.ca/media/450519/elak-9.pdf
[50] Alberta Learning (2000) *English Language Arts* (p1) http://education.alberta.ca/media/450519/elak-9.pdf
[51] New South Wales Department of Education (2007) *English K-6 Syllabus* (p6) http://k6.boardofstudies.nsw.edu.au/files/english/k6_english_syl.pdf
[52] New South Wales Department of Education (2007) *English K-6 Syllabus* (p6) http://k6.boardofstudies.nsw.edu.au/files/english/k6_english_syl.pdf

Beyond these high-level statements, all the curricula analysed have curriculum aims for English (see Table A1, Appendix A). These are set out in different ways, including very detailed statements (e.g. Massachusetts), long narratives explaining the significance the domains (e.g. Alberta), and principles underpinning the teaching of the subject (e.g. Singapore). Broadly, the curricula emphasise similar priorities and principles around the importance of language, effective written and spoken communication, the value of literature, and the impact of proficient language use on the individual and society.

Taken together, the aims across all the comparator curricula can be articulated as follows:

- From early primary, securing development of word reading skills quickly, whilst pupils learn to enjoy and understand books that they hear read to them;

- Spelling, punctuating and using grammar accurately as part of writing clearly, confidently and imaginatively;

- Reading widely and enjoying reading; developing curiosity, understanding and critical appreciation of the world through texts read;

- Developing confidence, independence and a personal style through proficient and accurate use of language;

- Engaging with history, society and literary heritage through the study of literature from different periods and cultures and of different genres;

- Communicating effectively through writing, debate, discussion and presentation and using language conventions; and

- Understanding language conventions and developing a rich vocabulary.

In terms of a cross-curricular approach to language and literacy, amongst the Anglophone jurisdictions analysed, only England specifies a set of overarching aims that includes the English language. Alberta and Singapore both have separate documents that set out their vision for education but these make no reference to language[53] [54]. The handbook for the England National Curriculum 1999[55] makes explicit reference to the importance of English across the curriculum in the key skill of *communication* embedded across all subjects. The foreword states:

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[53] Government of Alberta (2011) *Guide to Education: ECS to Grade 12* http://education.alberta.ca/media/6542444/guidetoed_2011-2012.pdf
[54] Ministry of Education Singapore (2009) *Desired Outcomes of Education* (p1) http://www.moe.gov.sg/education/desired-outcomes/
[55] Department for Education and Employment and Qualifications and Curriculum Authority (1999) *English : The National Curriculum for England Key stages 1-4* http://webarchive.nationalarchives.gov.uk/20101221004558/http://curriculum.qcda.gov.uk/uploads/English%201999%20programme%20of%20study_tcm8-12054.pdf

"The focus of this National Curriculum, together with the wider school curriculum, is therefore to ensure that pupils develop from an early age the essential literacy and numeracy skills they need to learn…"

3.6 Domains

The variety amongst the curricula makes an assessment of coverage difficult, as reported by Ruddock and Sainsbury[56] for primary curricula. By analysing the detailed content, however, it has been possible to identify common domains and sub-domains[57] which capture all the key elements of the curriculum. These are:

- Reading
  - Reading strategies
  - Comprehension
  - Literature
  - Research
- Writing
  - Planning writing
  - Composition
  - Evaluating, editing and proof-reading
  - Grammar, spelling and punctuation.
- Speaking and listening

With these domains and sub-domains, it has been possible to assess coverage and identify the extent to which there is commonality or variation across the curricula analysed.

Reading

Our analysis found that *reading* is broadly split into four areas across the curricula which cover:

- ***Reading strategies***: the skills and strategies needed to decode the written word and to have a literal comprehension at the word and sentence level.

- ***Comprehension***: once word reading skills have been acquired, *comprehension* relates to the skills and strategies needed for understanding and analysing the meaning and nuances of whole texts. It also relates to understanding the impact of language and structure and developing personal preferences.

- ***Literature***: the range of literary works (e.g. novels, plays, short stories,

[56] Ruddock, G. and Sainsbury, M. (2008). *Comparison of the core primary curriculum in England to those of other high performing countries*. DCSF Research Report DCSF-RW048.
[57] Handwriting and English language variation were also domains common to all jurisdictions and have been included in the summary analysis in the Tables A3 and A4 at Appendix A, but not referenced in this analysis summary.

and poems) that pupils are expected to read and study.

- ***Research***: the range of strategies needed to search for information and to summarise and analyse the results of such research.

Reading strategies

All the curricula analysed were developed before systematic phonics teaching in early reading had such a high national and international profile. Table A2 (Appendix A) maps content in this area in more detail.

One of the most well-known studies into the impact of phonics was the 2006 United States National Reading Panel report[58]. It found that "*this type of phonics instruction (i.e. systematic synthetic phonics) benefits both students with learning disabilities and low-achieving students who are not disabled*", going on to observe that such teaching "*was significantly more effective in improving low socio-economic status (SES) children's alphabetic knowledge and word reading skills than instructional approaches that were less focused on these initial reading skills*". Systematic phonics teaching also benefited the spelling ability of good readers.

An Australian study, published a year earlier, found similarly[59]: *"The incontrovertible finding from the extensive body of local and international evidence-based literacy research is that for children during the early years of schooling (and subsequently if needed) to be able to link their knowledge of spoken language to their knowledge of written language, they must first master the alphabetic code.*" The study referred to the need to teach this knowledge "*explicitly, systematically, early and well*".

In the UK, the Clackmannanshire study in Scotland[60], the Rose Review of early reading[61] and various reports by Ofsted, especially *Reading by six* in 2010[62], all furnished additional, similar evidence. Ofsted reported that *"the best primary schools in England teach virtually every child to read"* and that in the twelve successful schools visited for the 2010 report "*the diligent, concentrated and systematic teaching of phonics*" was central to the success of the schools that were achieving high standards in reading by the end of Year 2.

Prior to the prevalence of systematic phonics, the teaching of reading drew heavily on a view that pupils should be taught to use a combination of approaches, sometimes referred to as 'cueing systems' or 'strategies', to make sense of what they were reading. All of the curricula analysed specify

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58 The US National Reading Panel (2006). R*eport of the National Reading Panel: Teaching Children to Read.* http://www.nichd.nih.gov/publications/nrp/findings.cfm

59 Australian Government, Department of Education, Science and Training (2005). *Teaching Reading.* http://www.dest.gov.au/nitl/documents/report_recommendations.pdf

60 Scottish Executive, Education Department (2005). *A Seven Year Study of the Effects of Synthetic Phonics Teaching on Reading and Spelling Attainment.* http://www.scotland.gov.uk/Resource/Doc/933/0044071.pdf

61 Rose, J (2006). *Independent review of the teaching of early reading: final report*. DfES report (0201-2006DOC-EN) http://media.education.gov.uk/assets/files/pdf/i/independent%20review.pdf

62 Ofsted (2010). *Reading by Six: how the best schools do it.* Manchester: Ofsted

this combination of approaches, requiring pupils to use phonological knowledge (the sounds of spoken language), grammatical knowledge, visual cues, and semantic cues to make sense of the written word. For example, the New Zealand curriculum states:

> "*The [reading] process includes using semantics, syntax, visual cues, context, and background knowledge, and combining these to construct meaning. Dame Marie Clay says of the reading development of children that they continue 'to gain in this complex processing throughout their formal education…"*[63]*,*

Similarly the Alberta curriculum states that:

> *"Students use a variety of strategies and cueing systems as they interact with oral, print and other media texts*"[64].

The extracts from England 1999 and New South Wales in Table 3.3 exemplify the similarities in approach between the jurisdictions:

Table 3.3: Example of reading strategies in England (1999) and New South Wales (2007)

England 1999 – Years 1 and 2	**New South Wales 2007 Stage 1 - Year 2**
Reading strategies Pupils should be taught to read with fluency, accuracy, understanding and enjoyment: **Word recognition and graphic knowledge** They should be taught phonemic awareness and phonic knowledge to decode and encode words, including to: • hear, identify, segment and blend phonemes in words in the order in which they occur • sound and name the letters of the alphabet • identify syllables in words • recognise that the same sounds may have different spellings and that the same spellings may relate to different sounds • read on sight high-frequency words and other familiar words • recognise words with common spelling patterns • recognise specific parts of words, including prefixes, suffixes, inflectional endings, plurals • link sound and letter patterns, exploring rhyme, alliteration and other sound patterns	**Draws on an increasing range of skills and strategies when reading and comprehending texts** **Graphological and phonological information** • recognises upper-case letters • automatically recognises irregular words such as 'come', 'are', 'laugh' • exchanges sounds–letters to make a new word • blends words ending and beginning with double consonants and consonant digraphs to work out unknown words • blends long vowel sounds with consonants and consonant blends • blends 'consonant-vowel-vowel-consonant' (cvvc) words, words with vowel digraphs (e.g. 'rain – train'), double vowel sounds (e.g. 'ee') and other common digraphs (e.g. 'ar', 'ay') • draws on knowledge of letter–sound relationships when trying to read unknown words, e.g. sounds out, attempts to break words into syllables • responds to punctuation when reading aloud, e.g. full stop, question mark, comma, exclamation mark, contractions.

[63] New Zealand Ministry of Education (1994). *English in the New Zealand Curriculum.* (p141) http://www.minedu.govt.nz/~/media/MinEdu/Files/EducationSectors/Schools/EnglishInTheNewZealandCurriculum.pdf
[64] Alberta Learning (2000) *English Language Arts.* http://education.alberta.ca/media/450519/elak-9.pdf (p17)

In addition to the word reading strategies and contextual understanding common to both the England and New South Wales curricula, New South Wales requires pupils to be taught about and to recognise specific grammatical details in order to aid understanding of the text. Grammatical understanding in the England National Curriculum, on the other hand, is limited to word order and whole text structure. This is shown in the extracts from the curriculum documents in Table 3.4 below.

Table 3.4: Example of grammar and reading strategies in England (1999) and New South Wales (2007)

England 1999 – Years 1 and 2	**New South Wales 2007 Stage 1 - Year 2**
To read with fluency, accuracy, understanding and enjoyment, pupils should be taught to use a range of strategies to make sense of what they read. **Grammatical awareness** They should be taught to use grammatical understanding and their knowledge of the content and context of texts to: • understand how word order affects meaning • decipher new words, and confirm or check meaning • work out the sense of a sentence by re-reading or reading ahead **Contextual understanding** • focus on meaning derived from the text as a whole • use their knowledge of book conventions, structure, sequence and presentational devices • draw on their background knowledge and understanding of the content	Draws on an increasing range of skills and strategies when reading and comprehending texts. **Grammatical Information** • identifies a clause in printed texts • identifies a sentence in printed texts • identifies words in texts which have similar meaning • recognises nouns and noun groups and pronouns in printed texts • identifies noun–pronoun, subject–verb links in written texts • identifies words that indicate where, why, when and how actions take place • identifies conjunctions in printed texts

Comprehension

There is significant variation in the specificity of reading comprehension across jurisdictions, as shown in the map of content in Table A2 (Appendix A).

During early primary, to demonstrate their understanding of texts read for themselves and heard read aloud, the common requirement is for pupils to re-tell or recall facts from an information text or a story, and to discuss the key features. In comparison to the other jurisdictions, Massachusetts and Alberta appear to be more challenging in early primary. In Alberta, pupils in Year 1 are expected to analyse text structure, relate their personal experiences to their reading and develop their own preferences for reading material. Massachusetts also sets out a high level of challenge at this stage, requiring pupils to identify similarities in plot, setting and character among the works of an author or illustrator.

In the secondary phase, breadth and challenge increase through widening the range of texts that pupils are expected to read and study. Each jurisdiction requires pupils to use an increasingly sophisticated range of skills and techniques to analyse text content and features. The Massachusetts curriculum is more detailed than the National Curriculum and sets out basic expectations for *understanding a text*, with further, more specific expectations set out for *making connections, genre, theme* across fiction, non-fiction and poetry. The analysis and interpretation of texts at Years 10 and 11 of the Alberta curriculum is broken down into significant detail, thus making the different elements of comprehension appear more challenging than the other curricula.

Our analysis of approaches to reading comprehension supports other recent findings that, at primary and lower secondary, The National Curriculum focuses more on the intentions and choices of the author, whereas other curricula focus more on understanding what has been read[65] [66]. Table 3.5 illustrates this difference between England and Singapore.

Table 3.5: Example of reading comprehension in England (1999) and Singapore (2001)

England 1999 – Years 7 to 11	Singapore 2001 –Year 9

Understanding texts
 	
To develop understanding and appreciation of texts, pupils should be taught:
 	
Reading for meaning
 	
Understanding the author's craft
 	
• how language is used in imaginative, original and diverse ways
• to reflect on the writer's presentation of ideas and issues, the motivation and behaviour of characters, the development of plot and the overall impact of a text
• to distinguish between the attitudes and assumptions of characters and those of the author
• how techniques, structure, forms and styles vary
• to compare texts, looking at style, theme and language, and identifying connections and contrasts.
	Listen to/read/view a variety of texts and demonstrate understanding of content in oral or written form
	• Make predictions about storyline / content, characters using
	    • contextual clues
	    • prior knowledge
	• Identify gist / main idea(s) through looking at characters, events, setting, plot
	• Recall details about characters, events, setting, plot
	• Infer and draw conclusions about characters, their actions and motives, events, setting
	• Infer meaning using
	    • contextual clues
	    • prior knowledge
	    • knowledge of familiar cultures in Singapore, Asia and the rest of the world
	
	Listen to/ read/ view a variety of texts and demonstrate in oral or written form the ability to acquire and use knowledge for a variety of purposes
	
	• Give reasons to support a response / point of view / an opinion
	• Organise and summarise information: list, sequence, compare, contrast, classify information
	• Evaluate texts for reasonableness of ideas and persuasive language
	• Explore possible factors relating to motives of characters / events in a story: causes, consequences, reasons
	• Abstract ideas / themes from a text

[65] Ruddock, G. and Sainsbury, M. (2008). *Comparison of the core primary curriculum in England to those of other high performing countries.* DCSF Research Report DCSF-RW048.
[66] Ofsted (2009) *English at the Crossroads: An Evaluation of English in Primary and Secondary Schools 2005/08.* London: Ofsted

Reading literature

The *reading and study of literature* are features of all the curricula analysed, with *non-fiction reading* also set out in some. The organisation of reading lists varies with no common model; they may be set out by author, by title or by both author and title. This variety is apparent in the specification of literature within the original six Anglophone jurisdictions considered (see Appendix A - Table A2) and also among the non-Anglophone jurisdictions with high-performing or improving reading scores in international comparisons (see Eurydice 2011[67]).

Among the comparator Anglophone jurisdictions, England, Alberta and Massachusetts all specify literature as part of their curriculum. Among the non-Anglophone jurisdictions, eight European jurisdictions (Denmark, Estonia, France, Latvia, Lithuania, Malta, Portugal and Poland) also provide lists of texts or authors. The analysis also showed that curricula with no specified reading lists commonly specify the genres of works to be read. While fiction is at the core of all lists, some also include non-fiction works while England, Massachusetts and Poland also list poets and playwrights.

Almost all of the reading lists reviewed took the form of guidance or exemplars, with teachers given the autonomy to select particular texts. Although reading lists, where provided, are expected to form the basis of study, each jurisdiction appears to give schools or teachers the flexibility to make judgements about the suitability of the texts listed, and the option to choose alternatives. Most jurisdictions set out their reading lists for both primary and secondary with the exception of England which is secondary only.

The only jurisdictions with a statutory requirement to read specific titles or the works of a particular author were Denmark and England. In Denmark, the requirement relates to the works of 15 Danish authors while in England the only required author is Shakespeare during the secondary phase.

These requirements in England and Denmark exemplify a more common purpose of the reading lists analysed, namely to ensure that pupils have access to a national literary heritage. The reading lists of the curricula analysed often set out national literature separately; for example, Alberta uses an icon to indicate Canadian texts.

Most jurisdictions with reading lists provided these banded into age-phases of more than one year, with teachers given the freedom to decide on the most appropriate texts, except for the Alberta curriculum which recommends texts of increasing complexity each year.

The following sections exemplify in more detail how each of the jurisdictions considered sets out reading lists.

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[67] Eurydice (2011). *Teaching Reading in Europe: Contexts, Policies and Practices*. http://eacea.ec.europa.eu/education/eurydice/documents/thematic_reports/130EN.pdf

England (1999) and (2007)

In the England (1999) curriculum, the *breadth of study* stipulates the ranges of literature, non-fiction and non-literary texts that should be included as part of the curriculum (see Table 3.6a). At secondary, there is a requirement for pupils to study two plays by Shakespeare, plus two major writers and four major poets published before 1914, from a specified list; exemplar authors are provided for other genres.

England's current secondary curriculum (2007), provides a list of authors, playwrights and poets which are categorised into: *contemporary writers*; *authors from the English literary heritage;* and *authors from different cultures and traditions* (see Table 3.6b). Two plays by Shakespeare are the only statutory requirement.

Table 3.6a: Example of the reading list in the National Curriculum (1999)

	Range of texts
Years 1-2	**Literature** • stories and poems with familiar settings and those based on imaginary or fantasy worlds • stories, plays and poems by significant children's authors • retelling of traditional folk and fairy stories • stories and poems from a range of cultures • stories, plays and poems with patterned and predictable language • stories and poems that are challenging in terms of length of vocabulary • texts where the use of language benefits from being read aloud and reread **Non-fiction and non-literary** • print and ICT-based information texts, including those with continuous texts and relevant illustrations • dictionaries, encyclopaedias and other reference materials
Years 3-6	**Literature** • a range of modern fiction by significant children's authors • long established children's fiction • a range of good-quality modern poetry • classic poetry • texts drawn from a variety of cultures and traditions • myths, legends and traditional stories • playscripts **Non-fiction and non-literary** • diaries, autobiographies, biographies, letters • print and ICT-based reference and information materials • newspapers, magazines, articles, leaflets, brochures, advertisments.
Years 7-11	**Literature** • plays, novels, short stories and poetry from the English literary heritage, including: i. two plays by Shakespeare, one of which should be studies in Years 7-9 ii. a drama by major playwrights, with the following examples: *William Congreve, Oliver Goldsmith, Christopher Marlowe, Sean O'Casey, Harold Pinter, J B Priestley, Peter Shaffer, GB Shaw, R B Sheridan, Oscar Wilde.* iii. works of fiction by two major writers published before 1914, selected from the following list: *Jane Austen, Charlotte Bronte, Emily Bronte, John Bunyan, Wilkie Collins, Joseph Conrad, Daniel Defoe, Charles Dickens, Arthur Conan Doyle, George Eliot, Henry Fielding, Elizabeth Gaskell, Thomas Hardy, Henry James, Mary Shelley, Robert Louis Stevenson, Jonathan Swift, Anthony Trollope, H G Wells* iv. two works of fiction by major writers published after 1914, with the following examples: *E M Forster, William Golding, Graham Greene, Aldous Huxley, James Joyce, DH Lawrence, Katherine Mansfield, George Orwell, Muriel Spark, William Trevor, Evelyn Waugh.* v. poetry by four major poets published before 1914, selected from the follow*ing* list:

	Range of texts
	Matthew Arnold, Elizabeth Barrett Browning, William Blake, Emily Bronte, Robert Browning, Robert Burns, Lord Byron, Geoffrey Chaucer, John Clare, Samuel Taylor Coleridge, John Donne, John Dryden, Thomas Gray, George Herbert, Robert Herrick, Gerard Manley Hopkins, John Keats, Andrew Marvell, John Milton, Alexander Pope, Christina Rossetti, William Shakespeare (sonnets), Percy Bysshe Shelley, Edmund Spenser, Alfred Lord Tennyson, Henry Vaughan, William Wordsworth, Sir John Wyatt vi. poetry by four major poets published after 1914, with the following examples : *W H Auden, Gillian Clarke, Keith Douglas, T S Eliot, U A Fanthorpe, Thomas Hardy, Seamus Heaney, Ted Hughes, Elizabeth Jennings, Philip Larkin, Wilfred Owen, Sylvia Plath, Stevie Smith, Edward Thomas, R S Thomas, W B Yeats* • recent and contemporary drama, fiction and poetry written for young people and adults, with the following examples: *Drama: Alan Ayckbourn, Samuel Beckett, Alan Bennett, Robert Bolt, Brian Friel, Willis Hall, David Hare, Willie Russell, RC Sherriff, Arnold Wesker* *Fiction: J G Ballard, Berlie Doherty, Susan Hill, Laurie Lee, Joan Lingard, Bill Naughton, Alan Sillitoe, Mildred Taylor, Robert Westall* *Poetry: Simon Armitage, James Berry, Douglas Dunn, Liz Lochhead, Adrian Mitchell, Edwin Muir, Grace Nichols, Jo Shapcott* • drama, fiction and poetry by major writers from different cultures and traditions, with the following examples: *Drama: Athol Fugard, Arthur Miller, Wole Soyinka, Tennessee Williams* *Fiction: Chinua Achebe, Maya Angelou, Willa Cather, Anita Desai, Nadine Gordimer, Ernest Hemingway, HH Richardson, Doris Lessing, R K Narayan, John Steinbeck, Ngugi wa Thiong'o* *Poetry: E K Brathwaite, Emily Dickinson, Robert Frost, Robert Lowell, Les Murray, Rabindranath Tagore, Derek Walcott* **Non-fiction and non-literary texts** • Literary non-fiction • Print and ICT-based information and reference texts • Media and moving image text Examples of non-fiction and non-literary texts: *Personal record and viewpoints on society: Peter Ackroyd, James Baldwin, John Berger, James Boswell, Vera Brittain, Lord Byron, William Cobbett, Gerald Durrell, Robert Graves, Samuel Johnson, Laurie Lee, Samuel Pepys, Flora Thompson, Beatrice Webb, Dorothy Wordsworth* *Travel writing: Jan Morris, Freya Stark. Laurens Van Der Post* *Reportage: James Cameron, Winston Churchill, Alistair Cooke, Dilys Powell* *The natural world: David Attenborough, Rachel Carson, Charles Darwin, Steve Jones*

Table 3.6b: Example of the reading list in the Secondary National Curriculum (2007)

	Range of texts
Years 7-9	**Literature** • stories, poetry and drama drawn from different historical times, including contemporary writers. With the following examples of contemporary writers: *Douglas Adams, Richard Adams, David Almond, Simon Armitage, Bernard Ashley, Jean M Auel, Malorie Blackman, Alan Bennett, Henrietta Branford, Charles Causley, Brian Clark, Frank Cottrell Boyce, Berlie Doherty, Carol Ann Duffy, Alan Garner, Alan Gibbons, Morris Gleitzman, Willis Hall, Adrian Henri, Susan Hill, Anthony Horowitz, Janni Howker, Jackie Kay, Elizabeth Laird, Joan Lingard, Roger McGough, Michelle Magorian, Jan Mark, Adrian Mitchell, Michael Morpurgo, Brian Patten, Peter Porter, Philip Pullman, Celia Rees, Philip Reeve, Michael Rosen, Willy Russell, Louis Sachar, Marcus Sedgewick, Dodie Smith, Robert Swindells and Robert Westall.* • texts that enable pupils to understand the appeal and importance over time of texts from the English literary heritage, with the following examples: *WH Auden, Robert Bolt, TS Eliot, Robert Frost, William Golding, Graham Greene, Seamus Heaney, Ted Hughes, Elizabeth Jennings, Philip Larkin, DH Lawrence, Ursula Le Guin, Jack London, George Orwell, Wilfred Owen, Sylvia Plath, Siegfried Sassoon, George Bernard Shaw, RC Sherriff, Dylan Thomas, RS Thomas and John Wyndham* • texts that enable pupils to appreciate the qualities and distinctiveness of texts from different cultures and traditions, with the following examples: *John Agard, Maya Angelou, Kwesi Brew, Anita Desai, Deborah Ellis, Athol Fugard, Jamila Gavin, Nadine Gordimer, Gaye Hicyilmaz, Beverly Naidoo, Grace Nichols, C Everard Palmer, Bali Rai, John Steinbeck, Meera Syal, Mildred D Taylor, Mark Twain, Adeline Yen Mah and Benjamin Zephaniah.*

	• at least one play by Shakespeare. **Non-fiction and non-literary:** • forms such as journalism, travel writing, essays, reportage, literary non-fiction and multimodal texts including film • purposes such as to instruct, inform, explain, describe, analyse, review, discuss and persuade.
Years 10-11	**Literature** • stories, poetry and drama drawn from different historical times, including contemporary writers. With the following examples of contemporary writers*: Douglas Adams, Richard Adams, Fleur Adcock, Isabel Allende, Simon Armitage, Alan Ayckbourn, JG Ballard, Pat Barker, Alan Bennett, Alan Bleasdale, Bill Bryson, Angela Carter, Bruce Chatwin, Brian Clark, Gillian Clarke, Robert Cormier, Jennifer Donnelly, Keith Douglas, Roddy Doyle, Carol Ann Duffy, UA Fanthorpe, John Fowles, Brian Friel, Mark Haddon, Willis Hall, David Hare, Tony Harrison, Susan Hill, SE Hinton, Jackie Kay, Harper Lee, Laurie Lee, Andrea Levy, Joan Lingard, Penelope Lively, Liz Lochhead, Mal Peet, Peter Porter, Philip Pullman, Willy Russell, Jo Shapcott and Zadie Smith.* • texts that enable students to understand the nature, significance and influence over times of text from the English literary heritage, with the following examples: *Kingsley Amis, WH Auden, TS Eliot, EM Forster, Robert Frost, William Golding, Graham Greene, Seamus Heaney, Ted Hughes, Aldous Huxley, Elizabeth Jennings, James Joyce, Philip Larkin, DH Lawrence, Katherine Mansfield, Sean O'Casey, George Orwell, Wilfred Owen, Harold Pinter, Sylvia Plath, JB Priestley, Siegfried Sassoon, Peter Shaffer, George Bernard Shaw, RC Sherriff, Stevie Smith, Muriel Spark, Dylan Thomas, Edward Thomas, RS Thomas, William Trevor, Evelyn Waugh, Arnold Wesker, John Wyndham and WB Yeats.* • texts that enable students to make connections between experiences across times and literary traditions • texts that enable students to analyse the values and assumptions of writing from different cultures and traditions, relating and connecting them to their own experience, with the following examples*: Chinua Achebe, John Agard, Monica Ali, Moniza Alvi, Maya Angelou, Isaac Bashevis Singer, James Berry, Edward Braithwaite, Anita Desai, Emily Dickinson, F Scott Fitzgerald, Athol Fugard, Jamila Gavin, Nadine Gordimer, Doris Lessing, Arthur Miller, Les Murray, Beverley Naidoo, RK Narayan, Grace Nichols, Ruth Prawer Jhabvala, Bali Rai, Wole Soyinka, John Steinbeck, Meera Syal, Mildred D Taylor, Mark Twain, Derek Walcott, Walt Whitman, Tennessee Williams, Adeline Yen Mah and Benjamin Zephaniah. The study of texts by these authors should be based on whole texts and presented in ways that will engage students* • at least one play by Shakespeare. **Non fiction and non-literary texts** • forms such as journalism, travel writing, essays, reportage, literary non-fiction, print media and multimodal texts including film and television • purposes such as to instruct, inform, explain, describe, analyse, review, discuss and persuade.

Massachusetts (2001)

Massachusetts' specification covers both primary and secondary, setting out its list in blocks of years from Reception to Year 13. There are two lists: the first specifies authors, illustrators, and works which reflect common American literary and cultural heritage; the second lists authors of literature from around the world. Both are split further into more specific genres for each block of years[68]. Some specific examples are included in Table 3.7 for Years 6 to 9.

[68] Massachusetts Department for Education (2001) *Massachusetts English Language Arts Curriculum Framework.* http://www.doe.mass.edu/frameworks/ela/0601.pdf

Table 3.7: Example of reading list in Massachusetts (2001)

	Suggested authors, illustrators and works reflecting our common literary and cultural heritage	Suggested authors and illustrators of contemporary American literature and world literature
Reception –Year 3	**For reading, listening, and viewing** **The Bible as literature** **Picture book authors and illustrators** **Poets**	**Contemporary literature of the United States**
Years 4–5	**Traditional literature** **The Bible as literature** **American authors and illustrators** **British authors** **Poets**	
Years 6–9	**Traditional literature** • Grimm's fairy tales, French fairy tales, Tales by Hans Christian Andersen and Rudyard Kipling, Aesop's fables *[list continues]* **The Bible as literature** • Old Testament, Genesis, Ten Commandments, Psalms and Proverbs • New Testament: Sermon on the Mount, Parables **American authors or illustrators** • Louisa May Alcott, Lloyd Alexander, Natalie Babbitt, L. Frank Baum, Nathaniel Benchley, Carol Ryrie Brink, Elizabeth Coatsworth *[list continues]* **British and European authors or illustrators** • James Barrie, Lucy Boston, Frances Burnett, Lewis Carroll, Carlo Collodi, Daniel Defoe, Charles Dickens, Arthur Conan Doyle *[list continues]* **Poets** • Stephen Vincent and Rosemarie Carr Benet, Lewis Carroll, John Ciardi, Rachel Field *[list continues]*	
Years 10–13	**Traditional and Classical literature** **The Bible as literature** **American Literature** • Historical documents of literary and philosophical significance • Important writers of the 18^{th} and 19^{th} centuries • Important writers of the first half of the 20^{th} century • Playwrights • Poets • Immigration experience **British and European Literature** • Poetry, Drama, Essays and Fiction	**Contemporary American Literature** • Fiction • Poetry • Essay/ non-fiction (contemporary and historical) • Drama **Historical and Contemporary World Literature** • Fiction • Poetry • Essay/ non-fiction • Drama • Religious Literature

Alberta (2005)[69]

The Alberta curriculum includes supplementary guidance that sets out novels and non-fiction titles year by year for Years 5 to 11. The list is annotated, providing a short quotation from the text, along with suggested themes and literary features for study. Canadian texts are identified with a '(C)' throughout the document (see Table 3.8). The titles have been selected for their suitability for pupils' ages, abilities and social maturity, and other criteria as appropriate for their year group. Table 3.8 sets out an extract from the reading list for Year 9 pupils, along with an annotation for one of the texts, 'Holes'[70].

Table 3.8: Example of reading list in Alberta (2005)

English Language Arts Novels and Nonfiction—Grade 8	
• Artemis Fowl • The Dark Is Rising • Dragonwings • Freak the Mighty • The Giver • **Holes** • Invitation to the Game (C) • Journey to the River Sea • Kensuke's Kingdom • Looking Back: A Book of Memories • The Master Puppeteer • Redwork (C)	• The Seeing Stone • Shadow in Hawthorn Bay (C) • Shane • Shipwrecked! The True Adventures of a Japanese Boy • A Single Shard • The True Confessions of Charlotte Doyle • The Tuesday Café (C) • Under the Blood-Red Sun • Walk Two Moons • What They Don't Know (C) • Winners (C)
Example: HOLES, Louis Sachar In **Holes**, Stanley Yelnats finds himself plunked down in Camp Green Lake, a work-camp for juvenile delinquents, after being wrongfully accused of theft. Stanley discovers there is no lake, just a gigantic, dry wasteland where daytime temperatures hover around 95 degrees in the shade. All of the boys are sent out each day in the heat to dig holes. The warden, it seems, is convinced that there is buried treasure on the site. When Stanley digs up a tiny cartridge with the initials 'KB' on it, enclosed in the shape of a heart, he's sure he has found a clue. Stanley learns that one hundred and ten years ago, Katherine Barlow, the schoolteacher, refused an offer of marriage from the son of the richest man in the country. Instead, she fell in love with Sam, a negro. There was a law in Texas forbidding their romance, so the gentle schoolmarm became the notorious outlaw Kissin' Kate Barlow. Holes subtly addresses the themes of justice and friendship through a humorous, descriptive and accessible style that has wide appeal for students.	
"*One thing was certain: They weren't just digging to build character. They were definitely looking for something. And whatever they were looking for, they were looking in the wrong place. Stanley gazed out across the lake, toward the spot where he had been digging yesterday when he found the gold tube. He dug the hole into his memory*." p. 71	
This novel has support videos available through ACCESS: All About the Book: A Kid's Video Guide to "Holes," 2002 [21 min. BPN 2076103], Good Conversation: A Talk with Louis Sachar, 1999 [21 min. BPN 2075912] and Holes (feature film) [120 min. BPN 2079101]. **Awards:** ALA Best Books for Young Adults, 1978	

[69] The reading list for Alberta was last updated in 2005.
[70] Alberta Education (2005) *English Language Arts: authorized novels and non-fiction annotated list.* *http://education.alberta.ca/teachers/program/english/resources/ela-list.aspx*

Denmark[71]

There are two distinct elements to Denmark's reading list: a list of suggested texts for primary and secondary phases, and a literary reading list which comprises texts from 15 Danish authors. It is expected that each of the texts from the reading list will be covered between Years 3 and 11 and is not age-specific, giving teachers the autonomy to use the texts as they feel appropriate, and to choose additional texts without restrictions.

Poland (2006)

In Poland, there is no compulsory reading list, although recommended authors or titles are listed as part of the core curriculum document. Where a title or author is not stipulated, there is often reference to genre, with the teacher required to select a suitable text to meet the criteria. Table 3.9 summarises the coverage of text titles as set out in the Polish core curriculum document for Years 9 to 11[72].

Table 3.9: Example of reading list in Poland (2006)

For the Polish language works include:

- The Bible
- A choice of myths
- Homer
- Sophocles
- Shakespeare
- Cervantes
- Song of Roland
- Dickens (two novels to choose from)
- De Saint-Exupéry
- Hemingway
- Chekhov

Polish literature includes:

- Miron Bialoszewski "A Diary of the Warsaw Uprising"
- Bogurodzica
- A choice of Renaissance and Baroque poetry
- Jan Kochanowski selected poems
- Krasicki selected poems
- Mickiewicz selected poems, "Dziady" part 2 and "Pan Tadeusz"
- Slowacki "Balladyna"
- Fredro "Zemsta"
- Prus and Zeromski ("Syzyfowe prace") (19th century writers)
- Modern Polish literature such as diaries, memoirs, correspondence, journalism, literature from the local area, texts from the daily press
- Popular literature (at least one text in each year).

Reading for research

Each curriculum varies in the degree to which it specifies *research activities*, as detailed in Table A2 (Appendix A). The majority of the jurisdictions cover

[71] Date publication unknown. (See Eurydice (2007). *National Literature Canon.* http://www.nfer.ac.uk/shadomx/apps/fms/fmsdownload.cfm?file_uuid=A981D4AF-C29E-AD4D-04C0-3715224EB1D0&siteName=nfer).
[72] Eurydice (2007). *National Literature Canon.* http://www.nfer.ac.uk/shadomx/apps/fms/fmsdownload.cfm?file_uuid=A981D4AF-C29E-AD4D-04C0-3715224EB1D0&siteName=nfer

the same ground, with pupils expected to select and read a range of reference or non-fiction texts to suit the purpose of the task.

At primary level, the focus is on pupils being able to organise the task of finding information (such as using reference materials and libraries), generating questions for research and summarising findings. At secondary, emphasis is given to search criteria for selecting texts, synthesising the information, and using and evaluating sources.

Alberta, Singapore and Massachusetts have the most detailed requirements for reading for research and information at both primary and secondary phases. In Alberta, detailed strategies are set out for learning to read for information as part of the *Managing ideas and information* General Outcome. Pupils are expected to plan and determine their information needs before selecting and processing a range of sources. Pupils are taught to interpret and analyse the text and then to evaluate the success of the strategies they used.

New South Wales and New Zealand have less detail in their curricula: New Zealand simply identifies the need to select and read a wide range of written informational texts, giving very little detail on strategies for selecting or reading these. New South Wales focuses on the use of technology, both for written and visual language texts.

England's 1999 and 2007 secondary curriculum documents make only minor reference to the process of reading for information in Years 7–11, and this is mostly in connection with electronic texts and other media sources. In comparison, the Alberta curriculum[73] is far more detailed, setting out requirements for reading as part of the research process. Table 3.10 shows the difference between the England (1999) and Alberta curricula.

Table 3.10: Example of reading for research in England (1999) and Alberta (2000)

England 1999 – Years 7-11	**Alberta 2000 – Year 8**
Printed and ICT-based information texts To develop their reading of print and ICT-based information texts, pupils should be taught to: • select, compare and synthesise information from different texts • evaluate how information is presented • sift the relevant from the irrelevant, and distinguish between fact and opinion, bias and objectivity • identify the characteristic features, at word, sentence and text level, of different types of texts. **Media and moving image texts** Pupils should be taught: • how meaning is conveyed in texts that include print, images and sometimes sounds • how choice of form, layout and presentation	**Focus attention** **Determine information needs** **Plan to gather information** **Use a variety of sources** • obtain information from a variety of sources, such as adults, peers, advertisements, magazines, lyrics, formal interviews, almanacs, broadcasts and videos, to explore research questions **Access information** • use a variety of tools and text features, such as headings, subheadings, topic sentences, summaries, staging and pacing, and highlighting, to access information • distinguish between fact and opinion, and follow the development of argument and opinion • scan to locate specific information quickly;

[73] Alberta combines reading, writing, speaking and listening across the English curricula, so these statements relate to the research process as a whole (both reading and writing) rather than being specific to reading.

contribute to effect (for example, font, caption, illustration in printed text, sequencing, framing, soundtrack in moving image text) • how the nature and purpose of media products influence content and meaning [for example, selection of stories for a front page or news broadcast] • how audiences and readers choose and respond to media.	summarize and record information useful for research purposes **Evaluate sources** • use pre-established criteria to evaluate the usefulness of a variety of information sources in terms of their structure and purpose **Organize information** • organize ideas and information by selecting or developing categories appropriate to a particular topic and purpose **Record information** **Evaluate information**

Writing

Our analysis found that *writing* can be broadly split into five sub-domains across the curricula which cover:

- ***Planning*****:** considering the content, audience and purpose of a piece of writing through planning and preparation;

- ***Composition*****:** putting thoughts and information into writing; bringing together technical, presentational and creative aspects of writing;

- ***Evaluating, editing and proof-reading*****:** reviewing and evaluating one's own and others' writing, identifying and making improvements to the content and structure of the text, and correcting any errors;

- ***Grammar, spelling and punctuation*****:** using grammatical conventions in writing at word, sentence and text level. *Grammar* predominantly covers writing sentences and speaking correctly through the knowledge of a range of grammatical conventions. *Punctuation* features largely within *grammar* (e.g. sentence construction, dialogue) and *spelling* (e.g. contractions);

- ***Handwriting*****:** developing the fine motor skills and techniques for correct formation of letters and digits and developing a fluent, cursive and individual style.

Table A3 (Appendix A) sets out the characteristics of *planning, composition and editing* in each jurisdiction. There was a notable variation in the breadth and specificity amongst jurisdictions for these domains, more so for writing than for reading.

Planning

New Zealand, Singapore and England (1999) and (2007) all give very little detail on *planning writing* at primary or secondary level.

The New South Wales primary curriculum has detailed content on specific organisational techniques for writing, such as using *"a framework to make* *notes, e.g. matrix, flowchart, semantic map*" in Years 2–3. The secondary curriculum is much less detailed, setting out different purposes for which pupils should use planning.

Massachusetts is also quite detailed in its requirements for planning a piece of writing, for example, one of the planning requirements for Year 6-7 is:

> *"Decide on the placement of descriptive details about setting, characters, and events in stories. For example, when writing their own mystery stories, students plan in advance where clues will be located*"

In addition, the primary curriculum gives significant weight to undertaking research in preparation for writing, with some specific research skills covered. The secondary curriculum is less prescriptive, requiring pupils to:

> *"Organize ideas for a critical essay about literature or a research report with an original thesis statement in the introduction, well constructed paragraphs that build an effective argument, transition sentences to link paragraphs into a coherent whole, and a conclusion'*[74].

Composition

The curricula analysed have similar levels of specificity for *composition* (see Appendix A -Table A3), with the exception of Alberta and New South Wales, which both have greater specificity. England 1999, New Zealand, Singapore and Massachusetts all describe the required outcomes at a general level. Singapore and Alberta both combine many of the writing outcomes with those of speech.

At lower primary, *composition* centres on constructing meaningful sentences and converting these into longer texts (both stories and expository texts) with a basic structure. During the remainder of the primary phase, curricula commonly focus on pupils writing at increasing length, for a specific purpose; using more complex sentence and organisational structures; using language for effect; and developing a 'personal voice'. Genres of writing to be covered are set out in different ways, with New Zealand being unique in categorising writing into *expressive, poetic* and *transactional* sub-domains, while the 1999 England curriculum sets out the different forms for writing separately at each key stage. For example, at Key Stage 2, composition should include narratives, poems, playscripts, reports, explanations, opinions, instructions, reviews and commentaries.

The difference in approach between England and Alberta is exemplified by the extracts from these curricula in Table 3.11. While England's National Curriculum sets out in very general terms what pupils should be taught, Alberta gives detailed suggestions of how better composition could be achieved, covering both the structure of the text (*e.g.* "*beginnings, middles and ends*") and its possible purpose (*e.g.* "*demonstrate clear relationships*

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[74] Massachusetts Department for Education (2001). *Massachusetts English Language Arts Curriculum Framework.*(p.66) http://www.doe.mass.edu/frameworks/ela/0601.pdf

between character and plot").

Table 3.11: Example of composition in England (1999) and Alberta (2000)

England 1999, Years 3–6	Alberta 2000, Year 6
Composition Pupils should be taught to: • choose form and content to suit a particular purpose (for example, notes to read or organise thinking, plans for action, poetry for pleasure) • broaden their vocabulary and use it in inventive ways • use language and style that are appropriate to the reader • use and adapt the features of a form of writing, drawing on their reading • use features of layout, presentation and organisation effectively.	**Create original text** *[building on requirements set out in earlier years]* **Year 6** • use texts from listening, reading and viewing experiences as models for producing own oral, print and other media texts • experiment with modelled forms of oral, print and other media texts to suit particular audiences and purposes • use structures encountered in texts to organize and present ideas in own oral, print and other media texts • use own experience as a starting point and source of information for fictional oral, print and other media texts

At secondary level, the emphasis in all curricula moves to more sophisticated writing for more complex purposes. Pupils are expected to use and apply their skills and knowledge to adapt standard text types to suit the audience and purpose, developing a more fluent, personal style. Each jurisdiction focuses on developing coherent, well-structured whole texts to which pupils can apply their knowledge of writing conventions and techniques. The Singapore curriculum gives significantly less detail for composing texts at the secondary phase. Massachusetts has more content relating to the different forms of writing than other curricula, whilst New Zealand emphasises the importance of pupils having the appropriate terminology to describe their writing.

Evaluating, editing and proof-reading

There is significant variation in the specification of *evaluating, editing and proof-reading*. Alberta has the highest level of specificity, for example requiring Year 5 pupils to "*identify and reduce fragments and run-on sentences*" and "*edit for subject-verb agreement*." Once again, in the secondary phase curricula become much more general; in Alberta, for example, pupils in Year 10 should "*revise to combine narration, description and exposition effectively*".

New Zealand and Singapore have very little content in relation to *evaluating, editing and proof reading*. In the case of Singapore, this is a notable omission in that it is at odds with the level of detail in the rest of the curriculum.

Massachusetts contrasts with England by specifying a list of sophisticated language features to be checked and revised. England does not do this at either primary or secondary, and furthermore does not mention checking for grammatical errors at all. Table 3.12 exemplifies Massachusetts' greater specificity and higher level of challenge (even after taking into account the one-year age difference).

Table 3.12: Example of planning, drafting and evaluating in England (1999) and Massachusetts (2001)

England 1999, Years 3–6	Massachusetts 2001, Years 6–7
Planning and drafting To develop their writing on paper and on screen, pupils should be taught to: […] • revise, change and improve the draft • proof-read and check the draft for spelling and punctuation errors, omissions and repetitions […] • discuss and evaluate their own and others' writing	**Revising** • Revise writing to improve level of detail and precision of language after determining where to add images, sensory detail, combine sentences, vary sentences and rearrange text. **Standard English Conventions** • Use additional knowledge of correct mechanics (apostrophes, quotation marks, comma use in compound sentences, paragraph indentations), correct sentence structure (elimination of fragments and run-ons), and correct standard English spelling (commonly used homophones) when writing, revising, and editing. **Evaluating Writing and Presentations** Year 4–5 • Form and explain personal standards or judgments of quality, display them in the classroom, and present them to family members. Year 6–7 • Use prescribed criteria from a scoring rubric to evaluate compositions, recitations, or performances before presenting them to an audience.

Grammar, spelling and punctuation

The extent of *grammar* and *punctuation* coverage varies considerably (see Appendix A - Table A3). New Zealand is notable for the absence of specific requirements for *grammar* and *punctuation* throughout its curriculum. England and New South Wales integrate *grammar* into other sections, while Massachusetts, Singapore and Alberta present *grammar* as a separate section of the curriculum.

The Singapore curriculum has a discrete and very detailed *grammar* strand which has a greater level of specificity and challenge than any of the other curricula analysed. For example, *connectors to do with time and sequence* and *modal auxiliaries* are introduced as learning outcomes for the end of Year 3 and are listed in relation to spoken and written texts.

The Massachusetts curriculum also sets out expectations of grammatical knowledge in some detail, and is more challenging than the England 1999 and 2007 secondary curricula. Table 3.13 illustrates how - at Years 10 and 11 - pupils in Massachusetts are expected to be able to use their knowledge of grammar to analyse sentence structure, including undertaking basic formal analysis using the transformational model.

Table 3.13: Example of grammar in England (1999) and Massachusetts (2001)

England 1999, Years 7–11	Massachusetts 2001, Years 10–11
Pupils should be taught the principles of sentence grammar and whole-text cohesion and use this knowledge in their writing. They should be taught: • word classes or parts of speech and their grammatical functions • the structure of phrases and clauses and how they can be combined to make complex sentences (for example, coordination and subordination) • paragraph structure and how to form different types of paragraph • the structure of whole texts, including cohesion, openings and conclusions in different types of writing (for example, through the use of verb tenses, reference chains) • - the use of appropriate grammatical terminology to reflect on the meaning and clarity of individual sentences (for example, nouns, verbs, adjectives, prepositions, conjunctions, articles).	• Identify simple, compound, complex, and compound-complex sentences. • Identify nominalized, adjectival, and adverbial clauses. • Recognize the functions of verbs: participles, gerunds, and infinitives. • Analyze the structure of a sentence *(traditional diagram, transformational model).* *For example, students analyze the clauses and phrases in the first two lines of Robert Louis Stevenson's poem, "My Shadow":* *"I have a little shadow that goes in and out with me,* *And what can be the use of him is more than I can see."* • Identify rhetorically functional sentence structure *(parallelism, properly placed modifiers).* • Identify correct mechanics *(semicolons, colons, hyphens),* correct usage *(tense consistency),* and correct sentence structure *(parallel structure).* • Describe the origins and meanings of common words and foreign words or phrases used frequently in written English, and show their relationship to historical events or developments *(glasnost, coup d'état).*

Alberta also has a separate section on *grammar*, although it is not particularly detailed on the specific grammar to be learnt. Most statements are fairly general, for example "*use a variety of strategies to make effective transitions between sentences and paragraphs in own writing"* (Year 6), or "*edit for subject-verb agreement*" (Year 5).

The picture for *spelling* is somewhat different from that of *grammar* (see Appendix A - Table A3), with Alberta being the most prescriptive, and Singapore and New Zealand giving very little detail. Alberta has greater coverage of *spelling* at secondary level than the other curricula, for example requiring pupils to "*identify and use variant spelling for particular effects, depending on audience, purpose, content and context*."

New South Wales (2007) and England's 1999 National Curriculum set out quite general spelling strategies for primary pupils and require pupils to broaden their knowledge and become more confident in spelling more complex and unfamiliar words. New Zealand makes little mention of spelling, specifying that it is one of the conventions pupils should use.

Speaking and listening

Speaking and *listening* are represented differently in each jurisdiction, either as separate domains (England, New Zealand, New South Wales primary) or integrated within other domains (Massachusetts, Alberta, Singapore and New

South Wales secondary). Table 3.14 shows the organisation of *speaking* and *listening* in each jurisdiction. Table A5 (Appendix A) has more detail on each of the curriculum documents.

Table 3.14: Speaking and listening in comparator jurisdictions

New South Wales 2007 (Years 1 to 7)	England 1999 (Years 1 to 11)
Learning to talk and listen **Talking and Listening** • Purpose • Audience, Subject Matter **Skills and Strategies** • Listening Skills • Interaction Skills • Oral Presentation Skills Learning about talking and listening **Context and Text** • Audience • Channel of Communication • Language Varieties **Language Structures and Features** • Text Structures and Features • Grammar • Expression **New South Wales 2003 (Years 8 to11)** Through responding to and composing a wide range of texts in context and through close study of texts, students will develop skills, knowledge and understanding in order to: • speak, listen, read, write, view and represent • use language and communicate appropriately and effectively • think in ways that are imaginative, interpretive and critical • express themselves and their relationships with others and the world • learn and reflect on their learning through their study of English. **Massachusetts 2001** **Language:** • Discussion • Questioning, Listening and Contributing • Oral Presentation • Vocabulary and concept development • Structures and Origins of Modern English (integrated with reading and writing) • Formal and Informal English (integrated with reading and writing)	• Speaking • Listening • Group discussion and interaction • Drama • Standard English (also in reading and writing domains) • Language Variation (also in reading and writing domains) **England 2007 (Years 7 to 11)** Speaking and Listening **Alberta 2000** *(Features in all 5 General Outcomes)* Students will listen, speak, read, write, view and represent to: • explore thoughts, ideas, feelings and experiences • comprehend and respond critically to oral, print and other media texts • manage ideas and information • enhance the clarity and artistry of communication • respect, support and collaborate with others **New Zealand 1994** **Listening Functions** • Interpersonal listening • Listening to Texts **Speaking Functions** • Interpersonal Speaking • Using Texts **Listening and Speaking Processes** • Exploring Language • Thinking Critically • Processing Information **Singapore 2001** • Language for Information • Language for Literary Response And Expression • Language for Social Interaction

The jurisdictions have a similar approach to *speaking* and *listening* at the primary and secondary phases. At primary level, the focus is generally on developing vocabulary, clear articulation, effective participation in discussion, oral presentations, and asking and answering questions. Developing comprehension through hearing and responding to texts read aloud is a significant part of all the curricula studied before word-reading is secure. Other than for Singapore, at secondary level the focus moves to presenting more complex information to a range of audiences, debating, adapting presentations for different audiences and processing complex information.

The approach taken by Alberta and, to a lesser extent, Singapore is distinctive, with the majority of outcomes and indicators in the Alberta curriculum applied to both *speaking* and *writing*. This gives *speaking* and *listening* almost equal prominence to *reading* and *writing*. For example, Table 3.15 shows how, in contrast to England, pupils in Alberta are expected to use dictionaries to support spoken as well as written language.

Table 3.15: Example of use of dictionaries and reference aids in England (1999) and Alberta (2000)

England 1999, Years 7–11	Alberta 2000, Year 7
Spelling Pupils should be taught to: […] • check their spelling for errors and use a dictionary when necessary • use different kinds of dictionary, thesaurus and spellchecker.	**Use references** • choose the most appropriate reference to confirm the spellings or locate the meanings of unfamiliar words in oral, print and other media texts

New South Wales sets out detailed primary learning outcomes for speaking and listening; for example, "*detects strategies that speakers use to influence an audience, e.g. emotive language, one-sided presentation of information, exaggerated claims"*.

The curricula of England, Massachusetts and Singapore are broadly similar in their level of detail, with New Zealand again the least specific. The level of challenge and progression in the Singapore curriculum for speaking and listening is below that of the other curricula, particularly at secondary, with little progression from primary to secondary and with outcomes for speaking for Year 11 almost the same as those for Year 7.

Section 4 – Curriculum comparisons for mathematics

4.1 Introduction

This section first sets out the selection of five comparator jurisdictions based on the findings of the international comparison studies, followed by the initial findings from the content analysis of the mathematics curricula in five high-performing jurisdictions and the mathematics National Curriculum in England. The jurisdictions are: Finland; Flemish Belgium; Massachusetts, USA; Hong Kong; and Singapore.

The purpose of comparing the curricula has been to identify whether there are any similarities and differences between the curricula which could be used to inform the development of the National Curriculum in England. The content analysis focuses on the level of expectation of the statutory curricula for mathematics in high-performing jurisdictions compared to the 1999 and 2007 National Curricula for England. As stated in Section 1.3, the analysis does not include wider non-statutory guidance and other related resources. For this reason, the National Strategies' *Frameworks for teaching* - non-statutory guidance for the teaching of literacy and mathematics, introduced by the previous Government - are not within the scope of this analysis.

The focus has been on the organisation, breadth, specificity and, where possible, the level of challenge and sequencing of content within comparable age-phases (see Appendix B for more detail). The analysis examines the aims and domains common to the mathematics curricula in the different jurisdictions.

A number of examples are provided showing key differences between the National Curriculum and the statutory curricula of high-performing jurisdictions, focusing in particular on where the content in high-performing jurisdictions appears more challenging than in England. These are intended to illustrate where the new National Curriculum for mathematics could be strengthened so that the content, standards and expectations are on a par with the highest-performing jurisdictions.

4.2 Key findings

- ***Whole number***: in comparison to England, Singapore and Hong Kong are more explicit about the need to secure conceptual understanding and the recall of multiplication facts before written methods are taught. Confidence, fluency and attainment in number are important for future performance in *algebra*.

- ***Fractions***: Singapore, Hong Kong, Massachusetts and Finland sequence more demanding content earlier in the domains of *fractions* and *decimals*, covering the majority of this sub-domain by the end of primary. Notably, Singapore and Hong Kong cover all four operations with *fractions* and *decimals* by the end of primary.

- ***Shape, space and measure***: of all the content domains the highest degree of variation in the way content is specified can be found in *shape, space and measure*. In the context of area and volume, Hong Kong, Singapore and Massachusetts appear to have higher expectations in the primary phase compared to England, Finland and Flemish Belgium.

- ***Algebra***: the majority of high-performing nations studied broadly cover the same algebraic curriculum content at the same time, with the exception of Hong Kong and Singapore. For example, Hong Kong appears the most challenging at the end of the primary stage, while Singapore is by far the most challenging in secondary by covering significantly more demanding content at an earlier stage, including introducing quadratic equations by the equivalent to Year 9 in England.

- ***Data, statistics and probability***: the majority of the high-performing systems, including Hong Kong, Singapore and Flemish Belgium, do not include *probability* until upper secondary. In contrast, England introduces *probability* significantly earlier, in upper primary and early secondary, but does not score significantly higher in related domains in TIMSS (2007).

4.3 Selecting comparator jurisdictions

The curriculum analysis first involved the selection of a small number of high-performing jurisdictions in mathematics to benchmark against England. Identifying comparator jurisdictions was in part based on a synthesis of the results from these international comparisons and also on whether an education system for the given jurisdiction is organised at a national or sub-national (state, province, region) level. The education system, including the setting of the statutory curriculum, is therefore at the level of the province. Given this, it was sometimes necessary to draw on other studies to identify regions with the highest performing pupils within a particular nation. The jurisdictions covered in each survey are set out in Table 4.1[75].

Table 4.1: Jurisdictions covered in recent waves of PISA and TIMSS

		Australia	Alberta	Flemish Belgium	Finland	Hong Kong	Massachusetts	New Zealand	Singapore
Maths	TIMSS 2007 *age 10*	☑	☑			☑	☑	☑	☑
	TIMSS 2007 *age 14*	☑				☑	☑		☑
	PISA 2009 *age 15*	☑	☑ (Can.)	☑ (Bel.)	☑	☑	☑ (US)	☑	☑

[75] PISA 2003 covered mathematics at age 15 but the OECD excluded the data for the UK from its international report because the UK fell short of the minimum school and pupil participation rates required by PISA.

The 2007 wave of TIMSS involved more than 60 participating education systems[76]. The minimum age of pupils tested at the fourth grade was 9.5, and the sample size was approximately 161,000 pupils in participating education systems, plus 22,000 pupils in benchmarking participant education systems. Hong Kong and Singapore were the highest scoring education systems for fourth grade mathematics, with average scale[77] scores of 607 and 599 respectively. The third highest performing education system was Chinese Taipei (576). England achieved an average scale score of 541, which was significantly higher than the scale average of 500.

The minimum age of pupils tested at the eighth grade was 13.5, and the sample size was approximately 222,000 pupils in participating education systems and 21,000 pupils in benchmarking participants[78]. The highest performing education system was Chinese Taipei, with an average scale score of 598. The second and third highest performing education systems for eighth grade mathematics were the Republic of Korea (597) and Singapore (593). England achieved an average score of 513, which was significantly higher than the scale average of 500[79].

The PISA 2009 tests were administered to around 470,000 15 year-old pupils from 65 participating education systems and economies. The highest scoring education systems for mathematics were Shanghai[80] (600), Singapore (562) and Hong Kong-China (555). England achieved a mean score of 493, which was not statistically significantly different from the OECD average of 496[81].

Although Finland and Flemish Belgium did not participate in the TIMSS 2007 study, they have been selected on the basis of other studies. Finland has performed consistently well in PISA mathematics tests since 2000; Finland also scored statistically significantly higher than England in the TIMSS 1999 mathematics tests, but has not participated in the more recent TIMSS studies. Flemish Belgium participated in TIMSS 2003 and scored statistically

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[76] Mullis, I.V.S. Martin, M.O. and Foy, P. (with Olson, J.F. Preuschoff, C. Erberber, E. Arora, A. and Galia, J.) (2008). *TIMSS 2007 International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*. Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.

[77] The metric for fourth and eights grade mathematics and science scores in TIMSS 2007 were set at 500 using country mean scores from TIMSS 1995. Both had a standard deviation of 100. Foy, P. Galia, J. and Li, I. (2008). *Scaling the Data from the TIMSS 2007 Mathematics and Science Assessments*. In Olson, J.F. Martin, M.O. and Mullis, I.V.S. (eds.) (2008). *TIMSS 2007 Technical Report*. Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.

[78] Joncas, M. (2008). *TIMSS 2007 Sampling Weights and Participation Weights.* In Olson, J.F. Martin, M.O. and Mullis, I.V.S. (eds.) (2008). *TIMSS 2007 Technical Report.* Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.

[79] Mullis, I.V.S. Martin, M.O. and Foy, P. (with Olson, J.F. Preuschoff, C. Erberber, E. Arora, A. and Galia, J.) (2008). *TIMSS 2007 International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*. Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.

[80] Shanghai achieved the highest score in the PISA 2009 mathematics tests, and the Shanghai curriculum is of interest to the National Curriculum review. Research into the Shanghai mathematics curriculum is ongoing, but is not sufficiently developed to include in this report.

[81] Bradshaw, J. Ager, R. Burge, B. and Wheater, R. (2010). *PISA 2009: Achievement of 15-Year-Olds in England*. Slough: NFER.

significantly higher than England in grade 4 mathematics[82].

Among all the jurisdictions taking part in the above studies, it is possible to identify five jurisdictions with the highest achieving pupils in mathematics. The selected jurisdictions are:

- Finland;
- Flemish Belgium;
- Hong Kong;
- Massachusetts, USA; and
- Singapore.

4.4 Curriculum analysis for mathematics – an overview

The purpose of the content analysis is to draw out key similarities and differences in the breadth, the level of specificity and – where possible – the level of challenge and sequencing (see Appendix B). Although not every domain or sub-domain of school mathematics is examined, the analysis is intended to give a clear indication of how the curricula vary and what can be learned from high-performing jurisdictions.

Breadth

The content analysis showed significant commonality in how jurisdictions organise their mathematics curriculum. The curricula analysed were found to be principally content-oriented by being focused on a number of traditional mathematical domains, specifically:

- *Whole number and the four operations*;
- *Fractions, decimals and the four operat*ions;
- *Shape, space and measure*;
- *Algebra*;
- *Data, statistics and probability*.

Curriculum aims and mathematical processes were also a common feature of all the curricula analysed, though the approach varied across the different jurisdictions.

Specificity

The curricula set out on a year-on-year basis generally give a clearer indication of the level of expectation and progression compared to longer age phases. Those that organise a large proportion of their curriculum by year are Hong Kong, Singapore and Massachusetts. For primary, Hong Kong organises its curriculum on both an age phase and year-on-year basis but only uses longer age phases at secondary level. The majority of the curricula

[82] Mullis, I.V.S. Martin, M.O. Gonzalez, E.J. and Chrostowski, S.J. (2004). *TIMSS 2003 International Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades.* Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Boston College.

of Singapore and Massachusetts are organised on a year-on-year basis. In contrast, curricula in England, Flemish Belgium and Finland are organised into longer age phases (see Table 1.2 for a detailed comparison of ages and phases across jurisdictions). However, it is worth noting that in the case of the National Curriculum in England, Attainment Targets with the 8 level structure sit alongside the Programmes of Study. This enables a clearer assessment of progression and challenge than curricula with similar age phase structures such as Finland and Flemish Belgium.

In general, the analysis found that England (1999), Singapore, Hong Kong and Massachusetts are the most prescriptive and detailed curricula. This finding is true in terms of their content structure (e.g. year-on-year and Attainment Targets) but also in the way in which the domains and sub-domains are broken down into further detail. For example, they specify domains into a greater number of steps and provide exemplification to support interpretation of challenge and approach. The 2007 England National Curriculum for secondary is far less specific compared to the 1999 version as the Programme of Study only contains very broad statements for domains. Therefore, the 2007 Attainment Targets provide the only clear indication of the level of challenge and progression. Similarly, Flemish Belgium and Finland lack this detail.

More specifically, the domain of *number* in primary is specified more precisely in Hong Kong and Singapore compared to England (1999). There is a greater specification of *algebra* and *geometry* in the secondary phase in Hong Kong and Singapore compared to other jurisdictions, including England (2007). The domain of *data, statistics and probability* is the least specified overall across all jurisdictions, with the exception of England (1999).

It is also notable that the Singapore curriculum is more highly specified in primary than in secondary. The primary curriculum has a strong emphasis on pupils mastering the particular content of each year. There is also an explicit emphasis of factual, procedural and conceptual knowledge throughout.

Challenge

Although there is high commonality of content across the curricula analysed, there are some differences in the sequencing of content and age-related expectations. In some cases this is difficult to determine given the differences in the age-phase structure of curricula. However, the analysis indicates that the curricula in Hong Kong, Singapore and Massachusetts generally appear to be more demanding than in other jurisdictions, particularly for *number* and *algebra*. More specifically, this is most apparent in the domains of *number (whole numbers and fractions/decimals),* in which pupils are expected to understand and use whole numbers, fractions and decimals with increasing sophistication – including operations with numbers (add, subtract, multiply and divide). In addition, in the domain of *algebra*, Hong Kong demands most in primary compared to other jurisdictions, while the Singapore curriculum is significantly more challenging in secondary, particularly apparent in the earlier introduction of *quadratic equations*.

In contrast, compared with the other jurisdictions, the National Curriculum for England appears more demanding for *data, statistics and probability*. This difference in challenge is most notable in primary. However, towards the end of secondary, the differences in challenge and breadth between England, Hong Kong and Singapore and other jurisdictions begin to level out.

4.5 Curriculum aims

Curriculum aims for mathematics were clearly specified in all the curricula analysed, although the amount of detail across jurisdictions differed. The purpose is mainly to frame the curriculum within a coherent conceptual framework for teachers, as well as to define the subject itself as a coherent and inter-connected discipline. The importance of mathematics to all aspects of life and its centrality to all major scientific technological advances is covered by all curricula, to varying degrees. In summary, curriculum content on the aims of a mathematics curriculum can be grouped into four overarching aims:

- *developing fluency in acquiring and applying mental and written procedures underpinned by mathematical concepts*

The notion of conceptual understanding and application of these mathematical concepts is articulated in most detail in Hong Kong and Singapore e.g. in relation to number, measure, algebra, appreciating and formalising structures and patterns. As part of this notion, all curricula emphasise the importance of pupils becoming fluent in recalling facts and using mental and written methods accurately.

- *solving problems in unfamiliar contexts, including real life, scientific and more formal mathematical problems*

This notion includes breaking down problems into a series of simpler problems or steps; making decisions about gathering, processing and calculating to acquire new information; and showing perseverance in finding solutions. This is most specific in Finland, Hong Kong and Singapore.

- *reasoning mathematically by following a line of enquiry to deduce and present a justification or argument using mathematical language*

This notion includes analysing information presented in different forms, recognising what additional information may be needed; identifying relationships, applying logical reasoning, making generalisations and communicating thinking with mathematical language. Among all the curricula, Singapore is most specific in the use of mathematical language to communicate ideas and arguments.

- *developing positive attitudes towards mathematics*

Whilst promoting a positive attitude towards mathematics is implicit in all curricula, Hong Kong and Singapore provide more detail on attitudes in their aims, including defining this as a separate domain about the fostering of appreciation, interest, confidence and perseverance in mathematics.

4.6 Mathematical processes

Curriculum aims for mathematics within each jurisdiction are invariably translated into a more detailed specification of particular kinds of mathematical processes. These processes are commonly specified separately to the domains of, for example, *number* and *geometry*, and are intended to work across these domains. The intention is primarily to ensure that teachers focus on all aspects of mathematics education, including the: factual (e.g. number bonds, multiplication tables); procedural (e.g. performing accurately particular written or mental calculations); and conceptual (e.g. understanding the multiplicative relationship between length, width and area of a rectangle). The development of quick recall, accuracy and fluency in parallel with the development of understanding and reasoning are all required to promote sound mathematical development.

There is a growing body of research[83] [84] that explores different aspects of mathematics teaching and learning, including the relationship between factual, procedural and conceptual knowledge. While individual studies[85] [86] [87] explore specific aspects of this knowledge, the wider debate is starting to move away from the opposition of conceptual understanding from factual and procedural knowledge. For example, the recent Ofsted survey of good practice in primary mathematics shows that many successful schools teach both fluency in mental and written methods of calculation, and understanding of the underlying mathematical concepts[88].

Indeed, there is a wider consensus amongst mathematics educators that conceptual understanding, procedural and factual fluency and the ability to apply knowledge to solve problems are all important and mutually reinforce each other. While a different emphasis on individual processes may occur during primary and secondary, a combination of all these processes is required for pupils to become adaptable mathematical problem-solvers. Within this there is also broad consensus that automatic retrieval of basic facts facilitates the solving of more complex problems[89].

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[83] Nunes,T.,Bryant,P., Barros, R. & Sylva, K.(2011). *Development of Maths Capabilities and Confidence in Primary School* DCSFF Research Report RR118.
[84] Heid, M.K. (undated) *Mathematical Knowledge for Secondary School Mathematics Teaching*. http://tsg.icme11.org/document/get/744
[85] Skwarchuk, S-L (2008). *Look who's counting! The 123s of Children's Mathematical Development During the Early School Years. http://literacyencyclopedia.ca/pdfs/Look_Who's_Counting!__The_123s_of_Children's_Mathematical_Development_During_the_Early_School_Years.pdf*
[86] Dowker, A. (2009). *What Works for Children with Mathematical Difficulties?* DfES Research Report RR554
[87] Geary, Liu, Chen, Saults & Hoard, 1999 cited in Campbell, J. (2005). *Handbook of Mathematic Cognition.* New York, NY: Psychology Press.
[88] Ofsted, (2011) Good practice in primary mathematics: evidence from 20 successful schools. http://www.ofsted.gov.uk/resources/110140
[89] Cowan, R., Donlan, C. Shepherd, D-L, Cole-Fletcher, R., Saxton, M. & Hurry, J. (2011). B*asic Calculation Proficiency and Mathematics Achievement in Elementary School Children.* Journal of Educational Psychology Vol.103 Issue 4 pp786-803

Solving problems is central to mathematical proficiency and is articulated to a varying degree across the international curricula. Singapore applies the highest degree of specificity to it, placing it at the centre of all mathematical learning. Its curriculum clearly articulates the development of all mathematical concepts, skills, attitudes and processes through a problem-solving approach, both in number and through simple and complex word problems.

4.7 Domains

In the following analysis, the focus is on a selection of domains and sub-domains for illustrative purposes, rather than a comprehensive analysis of all the content. Exemplar domain content across jurisdictions is shown below in tables against the equivalent year content covered in the 1999 National Curriculum and 2007 National Curriculum for England where relevant (see Appendix B, Tables B1-B6).

The mapping suggests that despite some variation in structure and organisation, there is a commonality of content in mathematics disciplines that can be organised into domains and sub-domains.

These are:

- *Whole number and the four operations;*
- *Fractions, decimals and the four operations;*
- *Shape, space and measure;*
- *Algebra; and*
- *Data, statistics and probability*.

Mathematical processes, referred to above, are positioned within curricula to work across each of the mathematical domains of *number*, *geometry and measure* and *data, statistics and probability*. Factual recall and procedural accuracy are particularly important for *number*, *fractions* and *algebra*. However, these are put alongside content that emphasises conceptual understanding and solving problems using these techniques.

Whole number and the four operations

In this domain, the analysis concentrated on the introduction, sequencing and development of multiplication and division using whole numbers. *Number* at primary is of particular interest. Research in mathematics education[90] indicates that a good understanding of conceptual and procedural operations in number is important for subsequent mathematical fluency and understanding. The analysis below draws out some key points of interest in the years in which particular concepts and methods are introduced and developed.

For example, in focusing on how multiplication and division are introduced

[90] Nunes,T., Bryant,P., Barros, R. & Sylva, K.(2011). *Development of Maths Capabilities and Confidence in Primary School* DCSF Research Report RR118

and developed in each of the jurisdictions, there is a common pattern in the way each curriculum focuses on: conceptual understanding underpinning multiplication and division (e.g. multiplication as repeated addition; the relationship between multiplication and division; multiplication as area); mental methods through the recall of multiplication and division facts; written methods for more complex multiplication and division; and applying this knowledge to solve problems.

Generally these dimensions are made explicit in all of the curricula examined and all appear to cover them by the end of primary[91] (see Table 4.2 for development of multiplication and division across jurisdictions). However, it is more difficult to establish progression in the Flemish Belgium and Finland curricula as they are both generally specified at a very high level. This includes content being defined over a single 6-year age phase in the Flemish Belgium curriculum. Formal education commences two years later in Finland, meaning key stages are less comparable to England. Progression is clearer in England, Hong Kong and Singapore as they show comparable content between Years 1 to 6. See Table 4.3 for comparison of content between England. Hong Kong and Singapore (See also Appendix B, Tables B1-B3).

Table 4.2: Overview of the introduction of multiplication and division written methods across jurisdictions

	England (1999)	**Singapore (2001)**	**Hong Kong (2000)**	**Flemish Belgium (2010)**	**Finland (2004)**	**Mass. (2000; 2004)**
Introduction of concept	Year 1 -2	Year 1-2	Year 3	Not explicit	Year 3-4	Year 3
Multiplication & division facts	Year 2	Year 3	Year 3	Year 2-7	Year 3-4	Year 4- 5
Written methods	Year 3-6	Year 4 (mult'n) Year 5 (division)	Year 4	Year 2-7	Year 5-6	Year 4 -5

[91] In Flemish Belgium conceptual understanding underpinning multiplication and division is not fully explicit in the document outlining their end of primary outcomes.

Table 4.3: Example of difference in demand in multiplication and division in England (1999), Hong Kong (2000) and Singapore (2001)

	England (1999)	Hong Kong (2000)	Singapore (2001)
Introduction of concept	**Year 1-2** Understand multiplication as repeated addition; understand that halving inverse of doubling.	**Year 3** Develop conceptual understanding of multiplication (repeated addition).	**Year 2** Understanding of multiplication as repeated addition; problem solving using pictorial representations Multiplication with products no greater than 40.
Multiplication and area	**Year 3-6** Find areas of *rectangles* using the formula, understanding the connection to counting squares and how it extends this approach *Attainment Targets:* Find areas by counting squares (Level 4 Attainment Target 2007) Pupils understand and use the formula for the area of a rectangle (Level 5 Attainment Target 2007)	**Year 5** Develop the concept of area. Understand and apply the formulae for calculating the area of *squares and rectangles*	**Year 4** Compare the area of shapes in non-standard units Use formula to calculate the area of a square and a rectangle
Multiplication and division facts	**Year 1-2** x2 and x10 and related division facts **Year 3-6** Recall multiplication facts to 10 x 10 and use then to derive quickly the corresponding division facts *Attainment Targets:* Mental recall of the 2, 3, 4, 5 and 10 times tables and derive the associated division facts (Level 3 Attainment Target) Mental recall of multiplication facts up to 10 x 10 and quick derivation of corresponding division factors (Level 4 Attainment Target)	**Year 3** Construct multiplication tables to 10	**Year 3** Times tables and related division facts for 2,3,4,5 and 10 **Year 4** Memorise all tables to 10 x10 and related division facts
Written methods	**Year 3-6** Use written methods for short multiplication and division by a single-digit	**Year 4** Multiplication and division of 2 or 3 digits by 1 digit	**Year 4** Multiplication and division of up to 3 digits by 1 digit

	England (1999)	Hong Kong (2000)	Singapore (2001)
	integer of two-digit then three-digit then four-digit integers Use long multiplication, at first for two-digit by two-digit integer calculations, then for three-digit by two-digit calculations Extend division to informal methods of dividing by a two-digit divisor (for example, 64 ÷ 16), use approximations and other strategies to check that their answers are reasonable *Attainment Targets:* Solve whole number problems involving multiplication and division including those that give rise to remainders (Level 3 Attainment Target) Use efficient written methods of short multiplication and division. (Level 4 Attainment Target) Understand and use an appropriate non-calculator method for solving problems that involve multiplying and dividing any three-digit number by any two-digit number (Level 5 Attainment Target) – above national expectation at end of Year 6	**Year 5** Perform 2-digit by 3-digit multiplication Perform written division with 2 digit divisor and 3 digit dividend	**Year 5** Division of numbers up to 4 digits by 1 digit whole number and by 10 Multiply numbers up to 3 digits by a 2 digit number and up to 4 digits by 1 digit **Year 6** Division of numbers up to 4 digits by a 2 digit whole number

There are various sub-domains that support conceptual understanding of multiplication and division. Content that relates to conceptual understanding (e.g. halving and doubling; multiplication as repeated addition) is clearly introduced early – around Years 1-3 across all jurisdictions – either before or around the same time as the introduction of some multiplication and division facts in England, Hong Kong and Singapore. Singapore seems to go further in articulating a conceptual foundation by focusing on ‘products no greater than 40’ and ‘solving problems using pictorial representations’.

The concept of area – particularly areas of rectangles - also supports conceptual understanding of multiplication (see Table 4.3 and Table 4.7 in *Shape, space and measure*). In England, the national expectation at the end of Year 6 is to count squares to calculate an area (Level 4) while the relationship between length, width and area is limited to the use of a formula and then is only for pupils working above national expectation (Level 5). Hong Kong and Singapore appear to have higher expectations by the end of primary, introducing calculating area of rectangles, including with a formula, in Year 5 and 4 respectively. In addition, they expect understanding of the area of other shapes (see Table 4.7).

Content that relates to multiplication and division facts differs across the curricula. England introduces simple multiplication tables earlier at Year 2, with the expectation that all the 10 x 10 facts are secure by the end of Year 6. Hong Kong and Singapore, by contrast, introduce some 10 x 10 facts from Year 3, and in Singapore it is expected that all these facts are taught by the end of Year 4.

Written methods for multiplication and division also differ. All three jurisdictions expect multiplication and division of multi-digit numbers by single-digit numbers early on: from Year 3 for England and Year 4 for Hong Kong and Singapore. This is extended to long multiplication: 3-digit by 2-digit numbers for Year 5 in Hong Kong and Singapore and up to Year 6 in England. However, a written method for division with 2-digit divisors is only expected in Hong Kong and Singapore, in Year 5 and Year 6 respectively. The expectation in England for 2-digit divisors is limited to informal methods and an efficient written method is not the national expectation at the end of Year 6. Instead, it is only specified as a desirable outcome for those pupils working above national expectation at the end of Year 6.

Although the importance of an efficient written method with 2-digit divisors – sometimes called long division – is hotly debated, the more general observation is that the curricula in Singapore and Hong Kong make more explicit the need to secure some conceptual understanding and the recall of multiplication facts before written methods are taught. This is made explicit through the year-on-year curriculum, which allows for clearer articulation of this progression. In addition, expectations around developing multiplicative concepts – through for example repeated addition and area – are also expected earlier.

Fractions

As with whole number and the operations, fractions are of particular interest given the added complexity of number and the importance of both factual and procedural fluency and conceptual understanding. Commonly expressed as a numerator and denominator, fractions (e.g. ¾) can represent many different mathematical entities such as part-whole relations, decimals, ratios and probabilities.

Moreover, proficiency of fractions is considered essential for accessing the secondary mathematics curriculum, in particular in the domains of *measure*, *algebra*[92] and *geometry* as well as *probability*. For example, proportional

[92] The US National Mathematics Advisory Panel (2008) reviewed a significant body of research and identified the 'Critical Foundations of Algebra' which emphasises proficiency with fractions (including decimals) were an important pre-cursor to later achievement in algebra and should be mastered in

reasoning and understanding intrinsic quantities such as density are part of the conceptual understanding that should underpin the use of fractions and associated mathematical terms such as ratios. However, pupils' development of both conceptual and procedural knowledge of these quantities has been identified as a key difficulty[93]. Research suggests that proficiency in relation to fractions, and mathematics more generally, is improved when there is an emphasis on quantitative relations and equivalencies[94] [95] [96] [97].

The curriculum analysis undertaken on *fractions* (see Appendix B, Table B4) is limited to the initial introduction of *fractions*, *decimals*, equivalence between fractions and decimals and calculations with the four operations. It was found that the curricula cover the same breadth of content and challenge in these dimensions. The differences between the curricula lie in the way the content is broken down, sequenced, and described. Tables 4.4 and 4.5 provide an overview of how conceptual and procedural sub-domains within *fractions* and *decimals* are introduced across jurisdictions.

All the curricula, including England, introduce the concept of *fractions* over the course of Years 3-7, including part-whole relationships, decimals, unit fractions, equivalent fractions, equivalence with decimal numbers, common factors and simplification of fractions. Where most high-performing jurisdictions bar Finland differ quite markedly from England is in the earlier introduction of equivalencies between fractions, decimals and percentages and calculations with fractions and decimals (see Table 4.5).

For example, Singapore, Flemish Belgium and Massachusetts include equivalencies with percentages around Years 6-7, while Finland and England do not set expectations until around Years 8-9. In addition, unlike England, all the other curricula include some expectation that pupils will be taught to develop addition, subtraction, multiplication and/or division of fractions in late primary. Singapore, Hong Kong, Massachusetts and Finland sequence more demanding content earlier than England, covering the majority of this sub-domain by the end of primary[98]. England and Flemish Belgium do not include calculations with fractions until Year 7 and beyond (see Table 4.5).

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elementary and middle school: addition and subtraction of fractions and decimals should be proficient by equivalent of end of Year 6; multiplication and division of decimals and fractions should be proficient by equivalent of end of Year 7.

[93] Howe, C., Nunes, T., Bryant, P., (2010). *Rational number and proportional reasoning: using intensive quantities to promote achievement in mathematics and science*. International Journal of Science and Mathematics Education Vol.9, No. 2 pp391-417

[94] Howe, C., Nunes, T., Bryant, P., D. Bell, D., Desli, D. (2010). *Intensive quantities: Towards their recognition at primary level; Understanding Number Development and Difficulties*. BJEP Monograph Series II, Number 7 Vol.28 Issue 2 pp307-329.

[95] Howe, C., Nunes, T., Bryant, P., (2010). *Intensive quantities: Why they matter to developmental research*; British Journal of Developmental Psychology, 28, 307-329.

[96] Nunes, T., Bryant, P., (2009). *Understanding rational numbers and intensive quantities; Key Understandings in mathematics learning*. London: Nuffield Foundation.

[97] Howe, C., Nunes, T., Bryant, P., (2010). *Rational number and proportional reasoning: using intensive quantities to promote achievement in mathematics and science*. International Journal of Science and Mathematics Education Vol.9, No. 2 pp391-417

[98] End of primary key stage in Finland includes equivalent to England Year 7, so these findings need to be interpreted with caution.

Table 4.4: Overview of conceptual development of fractions and decimals and key equivalencies across jurisdictions

	England (1999; 2007)	Hong Kong (1999; 2000)	Singapore (2001)	Flemish Belgium (2010)	Finland (2004)	Mass. (2000; 2004)
Introduction of fractions	Year 3-6	Year 4	Year 3	Year 2-7	Year 3-4	Year 4
Introduction of decimals	Year 3-6	Year 5	Year 5	Year 2-7	Year 3-4	Year 5
Introduction of equivalencies between fractions and decimals	Year 3-6	Year 5	Year 5	Year 2-7	Year 5-7	Year 5
Introduction of equivalencies between percentages and fractions/ decimals	Year 7-9 (Level 6 Attainment Target, 2007)	Year 7	Year 6	Year 2-7	Year 8-11	Year 6

Among the curricula analysed, Hong Kong and Singapore seem to be the most demanding in expecting all four operations to be introduced in some form by Year 6. For a detailed view of the level of challenge of calculations with fractions in primary in these jurisdictions in comparison to England, see Table 4.6. For example, in Year 6, Singapore expects pupils to be taught to multiply proper fractions with a proper or improper fraction and to divide proper fractions with whole numbers. Hong Kong is more challenging in primary in relation to division of fractions and expects pupils to be taught to divide fractions with fractions.

Table 4.5: Overview of fractions and decimals across jurisdictions

	England (1999; 2007)	**Hong Kong (1999; 2000)**	**Singapore (2001)**	**Flemish Belgium (2010)**	**Finland (2004)**	**Mass. (2000; 2004)**
Fractions: Addition and subtraction with like denominators	Year 7-9 (Level 6 Attainment Target, 2007)	Year 5	Year 3-5	Year 2-7; 8-9	Year 5-7	Year 5 & 6
Fractions: Addition and subtraction with unlike denominators	Year 7-9	Year 6	Year 5 & 6	Year 8-9	Year 5-7	Year 6
Fractions: Addition & subtraction with mixed numbers	Year 7-9	Year 6	Year 6	Year 8-9	Year 5-7	Year 6
Fractions: Multiplication by whole numbers	Year 7-9	No reference	Year 5	Year 2-7 (simple fractions only)	Year 5-7	Year 6
Fractions: Multiplication with fractions	Year 7-9	Year 6	Year 6	Year 8-9 (implicit)	8-11	Year 7
Fractions: Division by whole numbers	Year 7-9	No reference	Year 6	No reference	Year 5-7	No reference
Fractions: Division with fractions	Year 7-9	Year 6	Year 8	Year 8-9 (implicit)	Year 8-11	Year 7
Decimals: Introduction of addition and subtraction	Year 3-6	Year 6	Year 4 (in context of money)	Year 2-7 (simple decimals)	Year 5-7	Year 6 (with whole numbers)
Decimals: Addition and subtraction of numbers to 2 decimal places	Year 7-9 (Level 5 Attainment Target, 2007)	Year 6	Year 5	Year 8-9 (implicit)	Year 5-7	Year 8 (implicit)
Decimals: Multiplication & division by multiples of 10 or whole numbers	Year 3-6	Year 6 (multi'n) Year 7 (division)	Year 5 (in context of money)	Year 2-7	Year 5-7	Year 5
Decimals: Multiplication & division of numbers to 2 decimal places	Year 7-9 (Level 5 Attainment Target, 2007)	Year 6 (multi'n) Year 7 (division)	Year 8 (implicit)	Year 8-9 (implicit)	Year 8-11 (implicit)	Year 8 (implicit)

Table 4.6: Example of addition and subtraction of fractions in England (1999, 2007), Hong Kong (2000) and Singapore (2001)

	England (1999, 2007)	Hong Kong (2000)	Singapore (2001)
Addition and subtraction of fractions with like denominators	**Year 7-9** Arithmetic and fractions not included in primary National Curriculum (1999) Rules of arithmetic applied to calculations and manipulations with rational numbers (2007) *Attainment Targets:* [Pupils] add and subtract fractions by writing them with a common denominator (Level 6 Attainment Target –national expectation at end of Year 9)	**Year 5** Add and subtract fractions with the same denominators and reduce the answers to the simplest form	**Year 3-5** **Year 3 - fractions within one whole** Very basic addition and subtraction in context of interpretation of a fraction as a whole: 'addition and subtraction of like fractions within one whole Denominators of given fractions should not exceed 12 **Year 4 - Related fractions within one whole** Addition and subtraction of two related fractions within one whole - Denominators of given fractions should not exceed 12 **Year 5 - like fractions and related fractions** Addition and subtraction of like fractions and related fractions - denominators of given fractions should not exceed 12; exclude calculations involving more than 2 different denominators
Addition and subtraction of fractions using unlike denominators	**Year 7-9** See above	**Year 6** Perform addition and subtraction of simple fractions with different denominators for sums involving at most two operations; solve problems involving addition and subtraction of simple fractions. Denominators involved should not exceed 12	No reference

Shape, space and measure

As with other domains, where content is sufficiently comparable, it appears that broadly the same content is covered in all curricula. The differences again lie in the way the curriculum is broken down and sequenced. For example, it was found that in the sub-domain of *geometry* and *measure*, there is a great degree of variation in the way in which content is specified. This is particularly true when comparing the secondary curricula.

An example of this can be seen in relation to the knowledge and application of properties of shapes and Pythagoras' theorem. Some curricula simply list shapes, properties and proofs (e.g. Singapore and Finland); others provide specific detail about how knowledge and proofs should be applied (e.g. England 1999); and some present a mix of detailed and less detailed content (e.g. Hong Kong).

Another example is how transformational geometry is specified. Although transformational geometry is included in all jurisdictions to some extent, some only cover this in primary (Flemish Belgium and Finland) and others only in secondary (Hong Kong and Singapore), while there is a stronger overall emphasis in England that is not found in the other jurisdictions. This is supported by findings in Ruddock and Sainsbury, 2008[99]. Notably, the most recent revision to the Singapore curriculum in 2007 has removed references to transformational geometry in the express curriculum route (completed by the majority of pupils in Singapore). However, it is still present in the technical curriculum route.

Area

In the context of *area* further differences can be found, particularly in relation to calculating areas using an appropriate formula (see Table 4.7 below). It can be seen that Hong Kong, Singapore and Massachusetts all have higher expectations with regard to understanding the area of squares, rectangles and triangles – around Years 4-6.

Table 4.7: Sequence of area across jurisdictions

	England (1999; 2007)	**Singapore (2001)**	**Hong Kong (2000)**	**Flemish Belgium (2010)**	**Finland (2004)**	**Mass. (2000; 2004)**
Introduction of area[100]	Years 3-6	Year 4	Year 5	Year 2-7	Year 3-4	Year 2-5
Squares & rectangles - Inc. calculating with formula	Year 3-6 (Level 5 Attainment Target, 2007)	Year 4	Year 5	Year 8-9	No reference	Year 6
Triangles – Inc. calculating with formula	Year 7-9	Year 6	Year 6	Year 8-9	Year 5-7	Year 6
Other shapes – Inc. calculating with formula	Year 7-9 (parall'ms, composite shapes and circles)	Year 8 (parall'ms, trapezia, composite shapes and circles)	Year 6 (parall'ms, trapezia and other polygons) Year 8-10 (circles)	Year 8-9 (circles)	Year 5-7 (parall'ms) Year 8-11 (circles and other plane figures)	Year 7 (parall'ms and composite shapes) Year 8 (trapezia and circles)

As highlighted earlier in relation to multiplication and area, calculating

[99] Ruddock, G. and Sainsbury, M. (2008). *Comparison of the core primary curriculum in England to those of other high performing countries.* DCSF Research Report DCSF-RW048.
[100] For example, understanding of area in concrete terms; counting squares; units of area.

rectangular areas is not the national expectation at the end of Year 6 in England. Instead, it is only specified as a desirable outcome for those pupils working above the national expectation. Similarly, introducing the area of a circle is the expectation in Year 8 in Singapore and Massachusetts while the national expectation in England is at the end of Year 9. Table 4.8 provides a more detailed example of the level of expectation in this sub-domain between England and Hong Kong.

Table 4.8: Example of difference in level of demand of calculations of area with formulae in England (1999, 2007) and Hong Kong (2000)

	England (1999, 2007)	Hong Kong (2000)
Squares & rectangles	**Year 3-6** Find areas of *rectangles* using the formula, understanding the connection to counting squares and how it extends this approach *Attainment Targets:* Find areas by counting squares (Level 4 Attainment Target 2007 - national expectation at end of Year 6) Pupils understand and use the formula for the area of a rectangle' (Level 5 Attainment Target 2007 - above national expectation at end of Year 6)	**Year 5** Understand and apply the formulae for calculating the area of squares and rectangles
Triangles	**Year 7-9** Use their knowledge of rectangles, parallelograms and triangles to deduce formulae for the area of a parallelogram, and a triangle, from the formula of a rectangle Calculate perimeters and areas of shapes made from triangles and rectangles *Attainment Targets:* [Pupils] understand and use appropriate formulae for finding circumferences and areas of circles, areas of plane rectilinear figures (Level 6 Attainment Target 2007 - national expectation at end of Year 9)	**Year 6** Understand and apply the formulae for finding the area of parallelograms, triangles and trapeziums.
Other shapes	**Year 7-9** **Parallelograms, composite shapes and circles** Use their knowledge of rectangles, parallelograms and triangles to deduce formulae for the area of a parallelogram, and a triangle, from the formula of a rectangle Recall and use the formulae for the area of a parallelogram and a triangle Calculate perimeters and areas of shapes made from triangles and rectangles Find […] areas enclosed by circles, recalling relevant formulae *Attainment Targets:* [Pupils] understand and use appropriate formulae for finding circumferences and areas of circles, areas of plane rectilinear figures…(Level 6 Attainment Target 2007 - national expectation at end of Year 9)	**Year 6** **Parallelograms, trapezia and polygons** Understand and apply the formulae for finding the area of parallelograms, triangles and trapeziums Find the area of polygons **Year 8-10** **Circles** Explore the formula for the area of a circle Calculate circumferences and areas of circles

Volume

In relation to *volume*, the picture is similar. Hong Kong, Singapore and Massachusetts appear to have the highest expectations (see Table 4.9). For example, they all introduce the concept of measuring volume (e.g. counting cubes) and how to calculate volume around Year 4-7. England, and indeed Finland and Flemish Belgium, set expectations from Year 7 or 8 onwards. Table 4.10 provides a more detailed example of the level of expectation in this sub-domain between England, Hong Kong and Singapore.

Table 4.9: Sequence of volume calculations across jurisdictions

	England (1999, 2007)	**Singapore (2001)**	**Hong Kong (1999, 2000)**	**Flemish Belgium (2010)**	**Finland (2004)**	**Mass. (2000, 2004)**
Measuring volume (e.g.. counting cubes)	Year 7-9	Year 5	Year 7	No reference	No reference	Year 4-5
Volume of cubes and cuboids	Year 7-9 (Level 6 Attainment Target, 2007)	Year 5	Year 6	Year 8-9	Year 8-11	Year 6
Volume of prisms, pyramids, cylinders, cones and spheres	Year 7-9 (right prisms – (Level 7 Attainment Target, 2007) Year 10-11 (other shapes)	Year 8 (prisms & cylinders) Year 9 (other shapes)	Year 8-10	No reference	No reference	Year 8 (prisms & cylinders) Year 10-11 (cones and spheres)

Table 4.10: Example of difference in level of demand of calculations of volume with formula in England (1999, 2007), Hong Kong (1999, 2000) and Singapore (2001)

	England (1999, 2007 where stated)	Hong Kong (1999, 2000)	Singapore (2001)
Cubes/ cuboids	**Year 7-9** Find volumes of cuboids, recalling the formula and understanding the connection to counting cubes and how it extends this approach *Attainment Targets:* [Pupils] understand and use appropriate formulae for finding… volumes of cuboids when solving problems ((Level 6 Attainment Target 2007 - national expectation at end of Year 9)	**Year 6** Use formula to find volume of a cuboid Use formula to find volume of liquid in a rectangular container	**Year 5** Understand and apply the formula for finding the volume of cube and cuboids
Other solids	**Year 7-9** **Prisms:** Volumes of right prisms *Attainment Targets:* [Pupils] calculate lengths… volumes in… right prisms (Level 7 Attainment Target 2007 – above national expectation at end of Year 9) **Year 10-11** **Pyramids, cylinders, cones & spheres:** Solve problems involving surface areas and volumes of prisms, pyramids, cylinders, cones and spheres; solve problems involving more complex shapes and solids, including segments of circles and frustums of cones *Attainment Targets:* Calculate… volumes of cones and spheres' (Exceptional performance Attainment Target 2007)	**Year 8-10** **Pyramids, cones and spheres:** Understand and use the formulas for volumes of pyramids, circular cones and spheres	**Year 8** **Prisms and cylinders:** Find volume and surface area of cubes, cuboids, prisms and cylinders **Year 9** **Pyramids, cones and spheres:** Find volume and surface area of spheres, pyramids and cones

Algebra

The majority of comparator jurisdictions cover the same algebraic curriculum content at the same time. However, Hong Kong and Singapore have higher expectations in primary and secondary respectively. In addition, a study conducted by NFER[101] found that England had a particular weakness in algebra, including simple algebraic manipulation. In Table 4.11, three aspects of the *algebra* curriculum are compared across England, Hong Kong and Singapore curricula (see also Appendix B, Table B5).

Interestingly the level of expectation between Singapore and Hong Kong in algebra differs significantly across primary and secondary. For example, Hong Kong is unique in expecting pupils to be introduced to solving simple

[101] Ruddock, G. Clausen-May, T. Purple, C. and Ager, R. (2006). *Validation Study of the PISA 2000, PISA 2003 and TIMSS 2003 International Studies of Pupil Attainment.* (p123) DfES Research Report RR772.

equations in Year 6. The majority of high-performing jurisdictions introduce letters to symbolise an unknown but specific number (e.g. missing number problems). Singapore and Flemish Belgium do not introduce algebraic notation until Year 7.

While Singapore's curriculum up to Year 6 appears to be one of the least challenging in terms of algebraic content, Singapore is by far the most challenging in secondary in that it covers significantly more demanding content at an earlier stage. This key difference in expectation is apparent in the content sub-domain of quadratic equations, which is first covered substantially in Year 9 (see Table 4.11). By contrast, most of the other comparator jurisdictions do not introduce quadratic equations until Year 10-11. Massachusetts is the exception, introducing the concept from Year 8 through the use of tables and graphs. The expectation is that problems with quadratic equations are solved numerically or graphically through the use of technology. Analytic approaches to quadratic equations are introduced from Year 10.

Table 4.11: Sequence of algebra sub-domains in England (1999, 2007), Hong Kong (2000), and Singapore (2001)

	England NC (1999, 2007 where stated)	**Hong Kong (2000)**	**Singapore (2001)**
Introduction to algebra	**Year 3-6 (Key Stage 2)** Recognise, represent and interpret simple number relationships, constructing and using formulae in words then symbols [for example, c = 15 n is the cost, in pence, of n articles of 15p each] *Attainment Targets:* Begin to use simple formulae expressed in words (Level 4 Attainment Target 2007 - national expectation at end Year 6) Construct, express in symbolic form, and use simple formulae involving one or two operations (Level 5 Attainment Target 2007 – above national expectation at end Year 6)	**Year 6** Use symbols or letters to represent numbers	**Year 7** Use a letter to represent an unknown number and write a simple algebraic expression in one variable for a given situation Simplify algebraic expressions Evaluate simple algebraic expressions by substitution Solve word problems involving algebraic expressions
Introduction to linear equations	**Year 7-9** Solve linear equations, with integer coefficients, in which the unknown appears on either side or on both sides of the equation; solve linear equations that require prior simplification of brackets, including those that have negative signs occurring anywhere in the equation, and those with a negative	**Year 6** Solve simple equations involving one step in the solutions and check the answers (involving whole numbers only)	**Year 8** Solve simple linear equations - include simple cases involving fractional and decimal coefficients

	England NC (1999, 2007 where stated)	Hong Kong (2000)	Singapore (2001)
	solution (1999) Linear equations - includes setting up equations, including inequalities and simultaneous equations. Pupils should be able to recognise equations with no solutions or an infinite number of solutions (2007) *Attainment Targets:* [Pupils] formulate and solve linear equations with whole-number coefficients (Level 6 Attainment Target 2007 - national expectation at end Year 9) They use algebraic and graphical methods to solve simultaneous linear equations in two variables (Level 7 Attainment Target 2007) They manipulate algebraic formulae, equations and expressions, finding common factors and multiplying two linear expressions (Level 8 Attainment Target 2007)		

	England NC (1999, 2007 where stated)	Hong Kong (2000)	Singapore (2001)
Introduction of quadratic equations	**Year 10-11** Factorisation; completing the square; using the quadratic formula; simultaneous equations with one quadratic (1999) Linear, quadratic and other expressions and equations **–** includes relationships between solutions found using algebraic or graphical representations and trial and improvement methods. Simultaneous equations should include one linear and one quadratic equation (2007) *Attainment Targets:* [Pupils] sketch and interpret graphs of linear, quadratic, cubic and reciprocal functions, and graphs that model real situations (Level 8 Attainment Target, 2007) Solve simultaneous equations in two variables where one equation is linear and the other is quadratic (Level 8/exceptional performance)	**Year 11-12** Quadratic equations in one unknown; graphical methods	**Year 9** Solving quadratic equations in one unknown; factorisation; special products; simple quadratic algebraic fractions; addition and subtraction of algebraic fractions with quadratic denominators **Year 10-11** Solving quadratic equations in one unknown using formula; completing the square; solving fractional quadratic equations

Data, statistics and probability

Data and statistics

The introduction of *data and statistics* varies significantly across jurisdictions. Hong Kong, Singapore, Massachusetts and England introduce in early primary and gradually develop throughout the primary and secondary stages. However, at primary level, England appears to cover a broader range of sub-domains within *data handling* which would suggest that the National Curriculum in England is more demanding than Hong Kong and Singapore. See Table 4.12 for an overview of a number of key representations and concepts within *data and statistics*.

Table 4.12: Overview of sequence of sub-domains in data and statistics

	England (1999)	Singapore (2001)	Hong Kong (1999, 2000)	Flemish Belgium (2010)	Finland (2004)	Mass. (2000, 2004)
Simple data handling & interpret-ation[102]	Year 1-2 (simple lists, tables and charts) Year 3-6 (discrete & continuous data)	Year 2 (pictograms) Year 3-6 (block & line graphs)	Year 3 (pictograms) Year4-6 (block graphs, bar charts)	Year 8-9	Year 3-4 (simple tables, diagrams, bar graphs)	Year 4
Measures of central tendency	Year 3-6 (mode) Year7-9 (mean, median)	Year 9	Year 8-10 (mean, median, mode)	Year 10-11 (mode, mean)	Year 5-7	Year 6
Standard deviation – statistical measures of spread or variability	Year 7-9 (distribution) Year10-11 Higher tier (spread)	Year 10-11	Year 11-12	Post-16	Year 8-11 (Finland use the term dispersion)	Year 9
Quartiles and inter-quartile range	Year 10-11 Higher tier	Year 10-11	Year 11-12	After Year 11	After Year 11	After Year 11

From Year 1, England sets high expectations in relation to *data collection* and *data display* earlier, with a wider repertoire of methods, than other jurisdictions. This is reflected in the findings from Ruddock and Sainsbury (2008)[103]. As Table 4.12 shows, the National Curriculum covers concepts such as discrete and continuous data and mode from Year 3 and later sets expectation on measures of central tendency (averages) and measures of spread relatively early compared to the other jurisdictions. Table 4.13 illustrates the differences in levels of expectation between England, Hong Kong and Singapore in these areas.

Table 4.13: Example of difference in level of demand within data and statistics in England (1999,2007), Hong Kong (1999) and Singapore (2001)

	England (1999, 2007)	Hong Kong (1999)	Singapore (2001)
Measures of central tenancy	**Year 3-6** **Mean** Know that mode is a measure of average **Year 7-9** **Mode and median** Identify the modal class for grouped data Find the median for large data sets	**Year 8-10** Discuss the relative merits of different measures of central tendency for a given situation	**Year 9** Find mean, median and mode; distinguish between the purposes for which mean, median and mode are used

102 Includes collecting, classifying, organising data; constructing and interpreting simple tables, diagrams and graphs.
103 Ruddock, G. and Sainsbury, M. (2008). *Comparison of the core primary curriculum in England to those of other high performing countries.* DCSF Research Report DCSF-RW048.

	England (1999, 2007)	Hong Kong (1999)	Singapore (2001)
	and calculate an estimate of the mean for large data sets with grouped data *Attainment Targets* Pupils understand and use the mean of discrete data. They compare two simple distributions using the range and one of the mode, median or mean (Level 5 Attainment Target 2007 - national expectation at end Year 9) They determine the modal class and estimate the mean, median and range of sets of grouped data, selecting the statistic most appropriate to their line of enquiry (Level 7 Attainment Target 2007)		
Measures of spread	**Year 7-9** Compare distributions and make inferences, using the shapes of distributions measures of central tendency and spread (2007) **Year 10-11 - Higher tier** Compare distributions and make inferences, using shapes of distributions and measures of average and spread, including median and quartiles; understand frequency density	**Year 11-12** Recognize range, inter-quartile range and standard deviation as measures of dispersion for a set of data	No references to measures of spread

Probability

The majority of the high-performing jurisdictions including Hong Kong, Singapore and Flemish Belgium do not expect *probability* to be introduced until between Year 8 and 10. By contrast, England expects pupils to be introduced to the concept from Year 3 while in Finland the expectation is from Year 5. Table 4.14 provides an overview of four concepts that are part of probability across the comparator jurisdictions.

Table 4.14: Overview of sequence of sub-domains within probability

	England (1999, 2007)	Singapore (2001)	Hong Kong (1999)	Flemish Belgium (2010)	Finland (2004)	Mass. (2000, 2004)
Introduction (e.g. via simple experiments; related vocabulary)	Years 3-6	Years 10-11	Years 8-10	Years 10-11 (implicit)	Years 5-7	Years 3-4
Simple experimental probability	Years 7- 9	No reference	Years 8-10	Years 10-11	Years 8-11	Years 5-6
Equally likely outcomes	Years 7- 9	Years 10-11	Years 8-10	No reference	No reference	No reference
Mutually exclusive events	Years 7- 9 (Level 7 Attainment Target, 2007)	Years 10-11	Years 10-11 (extension)	No reference	No reference	No reference

The broad conclusion seems to be that the England National Curriculum sets higher expectations covering a wider range of *probability* concepts than some other jurisdictions such as Flemish Belgium, Finland and Massachusetts. Moreover, concepts such as equally likely outcomes and mutually exclusive events are expected earlier in England than in the curricula of Singapore and Hong Kong. Table 4.15 illustrates difference in level of expectation between England and Singapore in these areas.

Table 4.15: Example of probability in England (1999, 2007) and Singapore (2001)

	England (1999, 2007)	Singapore (2001)
Theoretical & experimental probability	**Year 7-9** Understand and use the probability scale; understand and use estimates or measures of probability from theoretical models, relative frequency; list all outcomes for single events, and for two successive events, in a systematic way**;** know that the sum of the probabilities of all these outcomes is 1 Experimental and theoretical probabilities, including those based on equally likely outcomes (2007) *Attainment Targets:* When solving problems, [pupils] use their knowledge that the total probability of all the mutually exclusive outcomes of an experiment is 1 (Level 6 Attainment Target 2007) They understand relative frequency as an estimate of probability and use this to compare outcomes of experiments (Level 7 Attainment Target 2007)	**Year 10-11** Calculate the probability of a single event as either a fraction or a decimal (not a ratio); calculate the probability of simple combined events, using possibility diagrams and tree diagrams where appropriate (in possibility diagrams outcomes will be represented by points on a grid and in tree diagrams outcomes will be written at the end of branches and probabilities by the side of the branches) No reference to experimental probability

Section 5 – Curriculum comparisons for science

5.1 Introduction

This section first sets out the selection of five comparator jurisdictions based on the findings of the international comparison studies, followed by the initial findings from the content analysis of the science curricula in five high-performing jurisdictions and the science National Curriculum for England. The jurisdictions are: Alberta, Canada; Hong Kong; Massachusetts, USA; Singapore; and Victoria, Australia[104].

As with English and mathematics, the purpose of comparing the curricula has been to identify whether there are any similarities and differences between the curricula which could be used to inform the development of the National Curriculum in England. The content analysis focuses on the level of the statutory curricula for science in high-performing jurisdictions compared to the 1999 and 2007[105] National Curricula for England. As stated in Section 1.3, the analysis does not include wider non-statutory guidance and other related resources. For this reason, the secondary Science Framework and related resources introduced as part of the National Strategies are not within the scope of this analysis.

The focus has been on the organisation, breadth, specificity and, where possible, the level of challenge and sequencing of content within comparable age-phases (see Appendix C for more detail). The analysis examines the aims and domains common to the science curricula in the different jurisdictions.

A number of examples are provided showing key differences between the National Curriculum and the statutory curricula of high-performing jurisdictions, focusing in particular on where the content in high-performing jurisdictions appears to be more challenging than in England. These are intended to illustrate where the new National Curriculum for science could be strengthened so that the content, standards and expectations are on a par with the highest-performing jurisdictions.

5.2 Key findings

- Despite variation in terms of structure and approach, curricula reviewed largely cover the same ground in terms of the key domains of *biology*, *chemistry* and *physics*. Whilst they are not usually presented as separate science disciplines, the content is identifiable under these headings.

- *Earth and space science* is also covered across all the curricula analysed, but is only presented as a separate discipline in Alberta and

[104] The Victoria science curriculum 2008 was only analysed in relation to scientific processes and enquiry.
[105] For brevity, reference is made to the 2007 National Curriculum for secondary science even though Key Stage 4 was first published in 2005 and Key Stage 3 was subsequently published in 2007.

- Massachusetts. The curricula reviewed also cover the same ground in terms of the key concepts and knowledge within the domains of *biology*, *chemistry* and *physics*. None of the curricula reviewed sacrifices breadth for depth in terms of coverage.

- All curricula reviewed emphasise the importance of *scientific processes* and *scientific enquiry* at both primary and secondary and the coverage is broadly similar across the jurisdictions analysed.

- The curricula reviewed differ in the level of specificity of the statements: England (2007) has the highest level of generic statements; England (1999), Hong Kong and Massachusetts have medium level specificity; and Singapore and Alberta have statements at the highest level of specificity.

- The level of challenge in England seems to be broadly similar to the high-performing jurisdictions analysed, in terms of when content is introduced and when key knowledge and concepts are covered. Singapore and Alberta seem more challenging in places, but this could be a reflection of their high level of specificity.

5.3 Selecting comparator jurisdictions

The curriculum analysis first involved the selection of a small number of high-performing jurisdictions in science to benchmark against England. Identifying comparator jurisdictions was in part based on a synthesis of the results from these international comparisons and also on whether an education system for the given jurisdiction is organised at a national or sub-national (state, province, region) level. Given this, it was sometimes necessary to draw on other studies to identify regions with the highest performing pupils within a particular nation. The jurisdictions covered in each survey are set out in Table 5.1.

Table 5.1: Jurisdictions covered in recent waves of PISA and TIMSS

		Australia	Alberta	Flemish Belgium	Finland	Hong Kong	Massachusetts	New Zealand	Singapore
Science	TIMSS 2007 *age 10*	☑	☑			☑	☑	☑	☑
	TIMSS 2007 *age 14*	☑				☑	☑		☑
	PISA 2006 *age 15*	☑	☑ (Can.)	☑ (Belg.)	☑	☑	☑ (USA)	☑	

In the fourth grade TIMSS 2007 science tests, when pupils were at least 9.5 years old, Singapore was the highest-scoring education system, with an average score of 587. The second and third highest-performing education systems were Massachusetts (571) and Chinese Taipei (557). England achieved an average score of 542, which was significantly higher than the scale average of 500.

For eighth grade science, when pupils were at least 13.5 years old, the highest-performing education system was Singapore with an average scale score of 567. The second and third highest scores were recorded by Chinese Taipei (561) and Massachusetts (556). England achieved an average score of 542 (coincidentally the same score as the age 10 tests), which was significantly higher than the TIMSS scale average of 500[106].

The highest-scoring jurisdictions in the 2009 PISA age 15 science tests were Shanghai (575), followed by Finland (554) and Hong Kong (549) [107]. Australia (527) and England (515) both scored higher than the OECD average (501) at a statistically significant level.

Alberta is included as results from the PISA 2000 study showed that Alberta was the highest-performing Canadian province in science, while Canada as a whole out-performed England in the PISA 2009 study in science. Victoria is included as national tests of 12 year olds in 2009 showed Victoria was the second highest-performing Australian state in scientific literacy[108], while Australia as a whole out-performed England in the PISA 2009 study in science[109].
Among all the jurisdictions taking part in the above studies, it is possible to identify five jurisdictions with the highest achieving pupils in science. The selected jurisdictions are:

- Alberta, Canada;
- Hong Kong;
- Massachusetts, USA;
- Singapore; and
- Victoria, Australia.

5.4 Curriculum analysis for science – an overview

The purpose of the content analysis is to draw out key similarities and differences in the breadth, the level of specificity and – where possible – the level of challenge and sequencing. Although not every domain or sub-domain of science is examined, the analysis is intended to give a clear indication of how the curricula vary and what can be learned from high-performing

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[106] Martin, M.O. Mullis, I.V.S. and Foy, P. (with Olson, J.F. Erberber, E. Preuschoff, C. and Galia, J.) (2008). *TIMSS 2007 International Science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*. Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.
[107] OECD (2010a). *PISA 2009 Results: What Students Know and Can Do – Student Performance in Reading, Mathematics and Science (Volume I)*. Paris, OECD Publishing.
[108] The Australian Capital Territory (ACT) was the highest performing but was excluded due to the unique and very small nature of this jurisdiction. The survey results are published in by the Australian Curriculum, Assessment and Reporting Authority (2010) *National Assessment Program – Science Literacy Year 6 Report 2009*, ACARA: Australia.
http://www.nap.edu.au/_Documents/MCEECDYA/2009%20NAP%20SL%20Public%20report.pdf
[109] Bradshaw, J. Ager, R. Burge, B. and Wheater, R. (2010). *PISA 2009: Achievement of 15-Year-Olds in England.* Slough: NFER.

jurisdictions.

Breadth

Despite variation in how the curricula are organised and presented, the analysis has shown that there is a commonality in terms of the coverage of the domains of science. The analysis also demonstrates that all the curricula reviewed largely cover the same content within the domains of science – in other words the key concepts, knowledge and processes are broadly similar across all the curricula analysed. Therefore none of those reviewed sacrifices breadth for depth.

All the jurisdictions analysed organise their curriculum around the key domains of *biology, chemistry and physics,* although they are not usually presented under these headings. At primary, most jurisdictions, including England, offer general science, with the exception of Hong Kong where science is taught as a unit within General Studies; and Massachusetts, where science is broken down into *earth and space science, life sciences, physical sciences*; and *technology and engineering*.

At secondary, most of the jurisdictions analysed do not separate the sciences, but it is possible to distinguish the content as *biology*, *chemistry* and *physics*. Massachusetts organises its content into separate disciplines across secondary, although *physical science* is not separated out into *chemistry* and *physics* until upper secondary.

- ***England:*** General science from primary to the end of secondary; although pupils can study separate sciences (*biology*, *chemistry* and *physics*) to GCSE level in Years 10 and 11. Both the1999 and 2007 National Curricula are set out in domains that are related to the disciplines of *biology*, *chemistry* and *physics*. Design and technology is specified as a stand-alone subject, separate from science.

- ***Alberta:*** General science from primary to the equivalent of Year 11, although the content is set out in domains that are largely related to the disciplines of *biology*, *chemistry* and *physics*.

- ***Massachusetts:*** *Earth and space science, life sciences, physical sciences*; and *technology and engineering* from primary to end of junior secondary; and *physical sciences* are then separated into *chemistry* and *physics* in senior secondary.

- ***Hong Kong:*** Primary science is a unit within general studies; and at secondary it is titled General Science. The content is set out in domains that are related to the disciplines of *biology*, *chemistry* and *physics*.

- ***Singapore:*** General science in both primary and secondary, although in secondary separate qualifications (O-levels) are available in *biology*, *chemistry* and *physics*. Again, the content is set out in domains that are related to the disciplines of *biology*, *chemistry* and *physics*.

- ***Victoria*[110]*:*** General science covering *biology*, *chemistry*, *earth science*, *environmental science*, *health sciences*, *neuroscience*, *physics* and *space sciences* and emerging sciences such as *biotechnology*. A strong theme on *scientific enquiry* is embedded within the programme content and also expressed as a separate set of learning standards under the heading *science at work*.

The analysis also suggests that there is a commonality of core content within the science domains of *biology*, *chemistry* and *physics*. Across the curricula analysed, coverage of the key concepts and knowledge seems broadly comparable:

- ***Biology:*** All cover *plants and animals*, including *humans*; *structure and function*; *interactions and interdependencies; energy*; and *evolution*;

- ***Chemistry:*** All cover the *nature of matter and energy*; *physical change*; *chemical change*; and *properties of materials*; and

- ***Physics:*** All cover *forces and motion*, *light, sound and waves*, *electricity and magnetism*, *energy and matter*, and *the earth and universe*.

All the curricula analysed also include *scientific processes and enquiry* at both primary and lower secondary level which commonly include:

- ***At primary:*** Designing, carrying out and interpreting the findings of scientific investigations;

- ***At lower secondary:*** Reflecting critically on the nature of scientific explanation, theory, models and their relationship to scientific evidence; framing hypotheses and research questions; designing and carrying out investigations and experiments; using established scientific equipment and techniques; recording, presenting and interpreting scientific data; interpreting data and findings with reference to hypotheses and conclusions; using scientific language and terminology; and suggesting improvements to methods.

Specificity

The analysis of comparator jurisdictions showed significant variation across the documents reviewed in terms of the level of detail provided. The analysis also showed significant variation in terms of how the science curricula are expressed, with most focus on learning outcomes.

[110] The main interest in Victoria (2008) relates to the highly specified treatment of scientific enquiry while the content specification was much more general. The analysis therefore only focused on scientific enquiry.

- ***England:*** Content is expressed in terms of what pupils should be taught, with Attainment Targets defining the standard expected. The 2007 National Curriculum for secondary retains the Attainment Targets but sets out the content as key target concepts that pupils should be able to understand;

- ***Hong Kong:*** The science curriculum is expressed in term both of what pupils should learn and of what they should be able to do;

- ***Singapore:*** The science curriculum sets out very detailed learning outcomes;

- ***Alberta:*** A general overview of the content is provided, with the detail of the subject content expressed as learning outcomes; and

- ***Massachusetts:*** The content is set out as learning standards alongside some explanatory notes for developing the content.

The National Curriculum for England (1999) has broad statements about what should be taught and summarises the standard that is expected in terms of level descriptors. England (2007) sets out very high level generic statements about what students should be taught. For both, the content is set out in age bands of two to four year age-phases.

The Hong Kong primary framework for general studies, which includes science, sets out the core elements of the subject and learning objectives in broad statements. At lower secondary the curriculum has much more detailed statements setting out what pupils should learn and what they should be able to do. Content is set out over three-year age phases. The Massachusetts framework sets out broad concept statements but includes more detail alongside this by way of explanatory notes and is set out in three-year blocks. Both of these curricula are comparable to England 1999 in terms of specificity.

The curriculum in Singapore is very detailed in comparison with others. Domains and sub-domains are broken-down and coverage explained to a high level of specification. Content is set out on a year-on-year basis for lower secondary. Alberta is comparable here, with domains and sub-domains set out at various levels of specificity. For example, an overview of the domain is provided, then some focusing questions, then the key concepts covered in the domain and then the outcomes expected in detail. Content is also expressed on a year-on-year basis. Both these curricula are more detailed than England 1999 or 2007.

Challenge

Level of challenge has been analysed in terms of when content is introduced and when key concepts are covered. Despite limitations noted elsewhere in relation to mapping age-phases (see Section 1.3), our analysis seems broadly in line with that carried out by Ruddock and Sainsbury (2008) in their report of the primary curriculum[111]. Their analysis suggests that overall the primary science curriculum for Hong Kong is both narrower and less demanding than the curriculum for England (1999). The content of the Singapore primary curriculum on the other hand is broadly similar to the curriculum for England (1999), but slightly more demanding in some respects e.g. *life sciences* and *physics*. These findings are consistent with our analyses.

At secondary, Table C7 (Appendix C) sets out arrangements at Years 10-11 and demonstrates that these are not directly comparable across the jurisdictions. Whilst science is largely compulsory at Years 7-9 or equivalent[112], upper secondary science tends to be elective (or have elective units) and is a foundation for the A level equivalent. Therefore at secondary level, it is only at Years 7-9 where fair comparisons can be drawn. However, given that the international tests PISA and TIMSS are conducted at age 15 and 14 years respectively, the Year 7-9 curriculum has high relevance to pupil achievement in these studies.

For Hong Kong, the content at Years 7-9 was broadly in line with the previous 1999 National Curriculum for England, although there are examples where it is more challenging than England (e.g. in *chemistry*) and examples where it seems less challenging (e.g. in *biology*). This is interesting given that the Hong Kong curriculum is mapped against England in terms of slightly different key stages, so pupils in Hong Kong will be on average eight months older than English pupils in the comparable age-phases (see Section 1.3 for further explanation of the mapping used). For Singapore, the content at Years 7-9 seems broadly similar to the 1999 National Curriculum but slightly more demanding in some areas. However, the current 2007 England National Curriculum for secondary is not sufficiently specific to assess comparable levels of challenge.

The content in the Massachusetts and Alberta curricula seems broadly consistent with the 1999 England National Curriculum in terms of coverage of topics and concepts and when they are introduced, including *scientific enquiry*, at both primary (Years 2-6) and lower secondary (Years 7-9). The Alberta curriculum is specified in much more detail so can appear more challenging. However it is difficult to assess whether this is actually more demanding in practice. Again, the current 2007 England National Curriculum for secondary is not sufficiently specific to assess comparable levels of challenge.

Analysis of *scientific enquiry* for primary and secondary suggests that the 1999 England National Curriculum seems to require more sophistication – in that there is a focus on pupils thinking critically and thinking for themselves (e.g. reflecting critically on experimental procedures and deciding for themselves what data to collect) than in Hong Kong and Singapore. However, for primary this conclusion is not supported by Ruddock and Sainsbury

[111] Ruddock, G. and Sainsbury, M. (2008). *Comparison of the core primary curriculum in England to those of other high performing countries.* DCSF Research Report DCSF-RW048.
[112] In Singapore, around 85% of students follow the 'normal academic' route while around 15% follow the 'normal technical' route.

(2008), who suggest that *scientific enquiry* is broader in England than in Hong Kong and Singapore but is similar in terms of level of difficulty.

5.5 Curriculum aims

All curricula analysed have a clear set of curriculum aims for science (see Appendix C, Table C1). All emphasise the importance of encouraging pupils' curiosity about the world around them at primary. They all also take a broadly constructivist approach to science at primary as building on their existing knowledge and understanding. Some curricula have overarching aims for primary and secondary science, whilst others have separate but related aims for primary and secondary.

All jurisdictions emphasise the importance in the science curriculum of developing knowledge in the fundamental concepts and knowledge of science. They all also stress the central importance of the processes needed in science – observation, investigation, experimentation, measurement, theory-building and problem solving. For example, the Singapore curriculum suggests that it is not possible to know and understand all scientific knowledge in a rapidly changing technological world; therefore it is important to develop scientific literacy and give pupils the skills and attitudes for scientific enquiry.

Taken together, these can be grouped into three overarching aims:

- increasing scientific knowledge through the inter-related disciplines of *biology*, *chemistry* and *physics* – including concepts and principles;

- applying the processes and methods of science through practical activity – such as observation and measurement;

- developing an understanding of *scientific enquiry* – the relationship between empirical evidence, scientific theory and explanation.

In terms of the overall purpose of science, most though not all refer to preparation for further study and ensuring that pupils become scientifically informed and responsible adults.

5.6 Scientific processes and enquiry

Science education in England and elsewhere has always required that pupils should learn about the processes through which scientific theory and knowledge advance, as well as being taught the concepts and theories that make up the substantive content of science. Science is a practical subject, in which pupils carry out investigations, analyse the data they collect, draw conclusions from it and relate their empirical evidence to theories and hypotheses. Traditional science education integrated these elements into their syllabi through a 'piecemeal process of accretion'[113]. Research has shown

[113] Osborne J., Collins, S., Ratcliffe, M., Millar, R., and Duschl, R. (2003). *What "Ideas-about-Science" should be taught in school science? A Delphi study of the expert community.* Journal of Research in Science Teaching Vol. 40 No. 7 pp692-720

that there is a consensus among scientists and educators about the core processes that make up all forms of scientific enquiry[114] [115] [116] [117]. This consensus is reflected in the curriculum documents of other high-performing jurisdictions, as well as in the England National Curriculum. Curriculum aims for science within each jurisdiction are translated into more detailed specifications of particular kinds of scientific processes. These processes are commonly specified separately from the domains of *biology*, *chemistry* and *physics*.

Scientific literacy

More recently, the England National Curriculum for science was revised so that *scientific enquiry* at Key Stage 4 was embedded under the umbrella of a broader conceptual framework called 'How Science Works'. This development reflected an international shift in emphasis in science education, which had formerly been conceived of as providing foundational study for those who were to become the next generation of scientists. More recently, science courses have been focused in addition on providing a foundation in 'scientific literacy' for the general citizen[118]. The curricula of Singapore, Massachusetts and Alberta also refer explicitly to the importance of developing scientific literacy within science education. However, the England 2007 Programme of Study has been criticised for over-emphasising the social, cultural and philosophical aspects of science at the cost of failing to deliver secure coverage of the substantive content of science[119]. Most jurisdictions do nevertheless specify that science should be taught in the context of history of science and contemporary societal issues[120].

How scientific enquiry is reflected in curricula

The tables at Appendix C (Tables C5-C6[121]) provide an overview of the content for England and the five comparator jurisdictions in relation to scientific enquiry. At primary and lower secondary[122], overarching principles of

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[114] McComas, W.F. and Olson, J.K (1998). *The nature of science in international science education standards documents* in W.F. McComas (Ed) *The nature of science in science education: rationales and strategies* Dordrecht: Kluwer.
[115] Osborne J., Collins, S., Ratcliffe, M., Millar, R., and Duschl, R. (2003). *What "Ideas-about-Science" should be taught in school science? A Delphi study of the expert community.* Journal of Research in Science Teaching, Vol. 40 No. 7 pp692-720
[116] Schwartz, R. and Lederman N. (2008). *What scientists say: scientists' views of nature of science and relation to science context* International Journal of Science Education Vol. 30 No. 6 pp727-771.
[117] Eurydice (2006). *Science teaching in schools in Europe: policies and research.* last retrieved 16th December 2011 from http://www.mp.gov.rs/resursi/dokumenti/dok13-eng-Science_teaching.pdf
[118] Millar, R. (2006). *Twenty First Century Science: insights from the design and implementation of a scientific literacy approach in school science.* International Journal of Science Education Vol. 28 No. 13 pp1499-1521
[119] For example, see Shaha, A. (2009). *How science works isn't working in British schools*. New Scientist web article: http://www.newscientist.com/blogs/thesword/2009/12/how-science-works-isnt-working.html
[120] For example, see Eurydice (2006). *Science teaching in schools in Europe: policies and research.* last retrieved 16th December 2011 from http://www.mp.gov.rs/resursi/dokumenti/dok13-eng-Science_teaching.pdf
[121] Note that Singapore appears separately below the table as the way in which scientific enquiry was expressed in the Singapore curriculum could not be analysed this way.
[122] Lower secondary is largely Key Stage 3 equivalent but in some jurisdictions it cuts into the first part of KS4. Upper secondary is largely A level equivalent and late KS4.

scientific enquiry tend to be specified as separate statements within a broad general science curriculum. However, by upper secondary, all comparator curricula offer pupils an aptitude and preference-based choice of study of integrated/combined science or separate scientific disciplines. The content of *scientific enquiry* is then tailored to the specific route chosen.

All comparator curricula include aspects of *scientific enquiry* at both primary and lower secondary level (here equated to England's Years 7-9). This corresponds with the primary level findings of Sainsbury and Ruddock (2008) that compared the curricula of five countries (Singapore, Chinese Taipei, Hong Kong, Latvia and Ontario) with England. They concluded that the emphasis on *scientific enquiry* was shared by all other curricula, although not all include it as a separate element. With respect to *scientific enquiry*, they judged that the curricula of both Hong Kong and Singapore were similar in difficulty to that of England, but narrower in scope[123]. For the analysis in this report, the focus is on the core concepts of *scientific enquiry*. Therefore the scale of the difference noted by Ruddock and Sainsbury in the breadth of the primary *scientific enquiry* content will be less apparent.

Practical science

The TIMSS 2007 study found that *practical science* was a particular strength of England's science education[124]. Pupils in England had high levels of experience of practical work compared with pupils in other jurisdictions. The effect was particularly marked at age 10 but still apparent at age 14, by which stage most jurisdictions included a significant volume of practical work.

All the curricula analysed specify that, at primary, pupils should be participating in designing, carrying out and interpreting the findings of scientific investigations. Most require younger primary school pupils to begin to explore the world through basic data, and all require older primary school children to begin to reflect on and use scientific explanation and relate it to empirical evidence. Most require even the youngest primary school children to begin to make predictions that they can test.

There are some examples where the curricula of high-performing jurisdictions seem more challenging than England at primary. For example, England, Massachusetts and Victoria all require primary school pupils to begin from the earliest age to ask questions about the world, and by around Year 3-6 to be able to suggest ways in which they might answer their questions by collecting evidence. In England, the expectation is couched in everyday language (ask questions; decide how to find answers; think about what might happen; try things out.) At this stage, Massachusetts is already introducing a more precise and rigorous description of scientific process (ask questions about objects, organisms and events; make predictions based on observed patterns;

[123] Ruddock, G. and Sainsbury, M. (2008). *Comparison of the core primary curriculum in England to those of other high performing countries.* DCSF Research Report DCSF-RW048.
[124] Martin, M.O., Mullis, I.V.S., and Foy, P. (with Olson, J.F., Erberber, E., Preuschoff, C., & Galia, J((2008). *TIMSS 2007 International Science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades.* Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College

make predictions that can be tested). Victoria requires pupils from Year 2-3 to use repeated observations to make predictions, and by Year 4-5 to see how the design of an experiment is directly related to the question asked. Therefore, Massachusetts and Victoria are introducing pupils to the idea that asking a scientific question is different from asking a day-to-day question – one that is based on previous observation of patterns and the formulation of specific predictions that can be tested (see Table 5.2).

Table 5.2: Example of scientific enquiry in lower primary: England (1999), Massachusetts (2001) and Victoria (2008)

England 1999 – Years 1-2	**Massachusetts 2001 – Reception to Year 3**	**Victoria 2008 Year 2-3**
Pupils should be taught: • To ask questions and decide how they might find answers to them. • To think about what might happen before deciding what to do.	• Ask questions about objects, organisms, and events in the environment. • Tell about why and what would happen if? • Make predictions based on observed patterns.	• Students begin to generate questions about situations and phenomena • They repeat observations over time to make predictions.*)*
England 1999 – Years 3-6	**Massachusetts 2001 – Years 4-6**	**Victoria 2008 Year 4-5**
Pupils should be taught: • To ask questions that can be investigated scientifically and decide how to find answers. • To think about what might happen or try things out when deciding what to do, what kind of evidence to collect, and what equipment and materials to use.	• Ask questions and make predictions that can be tested.	• They begin to understand that the design of experiments is directly related to their questions about things and events.

This also echoes a finding from Ruddock and Sainsbury (2008)[125] who judged that the Singapore curriculum element 'construct a hypothesis' did not have a direct correspondence in the England curriculum. The closest match - 'ask questions that can be investigated scientifically and decide how to find answers' – does not require application of scientific knowledge and understanding to develop a theoretical construct or question which may subsequently be tested through scientific enquiry.

Scientific theory and language

At lower secondary level, virtually all the curricula analysed – including England - require pupils to reflect critically on the nature of scientific explanation, theory, models and their relationship to scientific evidence. All require that pupils should participate actively in: framing hypotheses and research questions; designing and carrying out investigations and

[125] Ruddock, G. and Sainsbury, M. (2008). *Comparison of the core primary curriculum in England to those of other high performing countries.* DCSF Research Report DCSF-RW048.

experiments; using established scientific equipment and techniques correctly, accurately, and with due regard to health and safety; recording, presenting and interpreting scientific data; and interpreting data and findings with reference to hypotheses and conclusions.

In addition, most jurisdictions specify that pupils should be using scientific language and terminology correctly, and be able to consider their investigation critically and to suggest improvements to methods or propose a further investigative stage.

Mathematics for science

Pupils need to have developed an appropriate level of mathematics to learn about and engage in particular science practice or theories. Analysis of how this is reflected in high-performing jurisdictions is still ongoing so is not reported here. However, an illustration of how this is achieved in the 1999 England National Curriculum is shown in Table 5.3. Inter-related content is identified but there is no explanation of how the two subjects link. It is also clear that the content and language could be aligned far more, in relation to understanding and using quantities (including standard units), representing data, data analysis techniques and using and understanding equations.

The analysis demonstrates that there is room for much greater alignment. Alignment is even less clear in the 2007 National Curricula for secondary. Table 5.4 shows that links have been made between the two subjects; for example: models are frequently expressed in the language of mathematics. However, there is no content beyond these high-level statements so it is difficult to establish the mathematical requirements for science.

Table 5.3: Programmes of Study for mathematics and science in the England 1999 National Curriculum

	Science National Curriculum (1999)	Mathematics National Curriculum (1999)
Years 1-2	**Present and communicate evidence** • communicate what happened in a variety of ways, including using ICT (e.g. in speech and writing, drawings, tables, block graphs and pictograms)	**Presentation of data using multiple/appropriate methods** • solve a relevant problem by using simple lists, tables and charts to sort, classify and organise information • discuss what they have done and explain their results
Years 3-6	**Using scientific judgement to design investigation** • make systematic observations and measurements, including the use of ICT for data logging	**Units of measure and conversion** • recognise the need for standard units of length, mass and capacity, choose which ones are suitable for a task, and use them to make sensible estimates in everyday situations; convert one metric unit to another (e.g. 3.17kg to 3170g); know the rough metric equivalents of imperial units still in daily use
Years 7-9	**Use diagrams to find, describe and explain relationships in data, draw conclusions from data and subsequently evaluate predictions** • use diagrams, tables, charts and graphs, including lines of best fit, to identify and describe patterns or relationships in data • use observations, measurements and other data to draw conclusions	**Interpret and discuss results. Interpret graphs, find patterns and anomalies, compare distributions using average and range, evaluate results, use correlation and lines of best fit** • relate summarised data to the initial questions • interpret a wide range of graphs and diagrams and draw conclusions • look at data to find patterns and exceptions • compare distributions and make inferences, using the shapes of distributions and measures of average and range • evaluate and check results, answer questions, and modify their approach if necessary • have a basic understanding of correlation • use lines of best fit
Years 10-11	**Understand the quantitative relationship between resistance, voltage and current**	**Use formulae in word and symbol form, substitute, derive and change subject** **(foundation)** • use formulae from mathematics and other subjects expressed initially in words and then using letters and symbols; substitute numbers into a

	Science National Curriculum (1999)	Mathematics National Curriculum (1999)
		formula; derive a formula and change its subject. **(higher)** • use formulae from mathematics and other subjects; substitute numbers into a formula; change the subject of a formula, including cases where the subject occurs twice, or where a power of the subject appears; generate a formula.

Table 5.4: Programmes of Study for mathematics and science in the 2007 National Curricula

	Science National Curriculum (2005, 2007)	Mathematics National Curriculum (2007)
Years 7-9	**Key Concepts** **Scientific thinking** • using scientific ideas and models to explain phenomena and developing them creatively to generate and test theories **Key Processes** **Critical understanding of evidence** Pupils should be able to: • obtain, record and analyse data from a wide range of primary and secondary sources, including ICT sources, and use their findings to provide evidence for scientific explanations • evaluate scientific evidence and working methods	**Key Concepts** **Critical understanding of evidence** • knowing that mathematics is essentially abstract and can be used to model, interpret or represent situations • recognising the limitations and scope of a model or representation. **Key Processes:** **2.3 Interpreting and evaluating** Pupils should be able to: • form convincing arguments based on findings and make general statements • consider the assumptions made and the appropriateness and accuracy of results and conclusions • be aware of the strength of empirical evidence and appreciate the difference between evidence and proof • look at data to find patterns and exceptions • relate findings to the original context, identifying whether they support or refute conjecture • engage with someone else's mathematical reasoning in the context of a problem or particular situation • consider the effectiveness of alternative strategies.

	Science National Curriculum (2005, 2007)	Mathematics National Curriculum (2007)
Years 10-11	**How science works: Communication skills** Students should be able to recall, analyse, interpret, apply and question scientific information or ideas.	**Key processes: Interpreting and evaluating** Students should be able to: • form convincing arguments to justify findings and general statements • consider the assumptions made and the appropriateness and accuracy of results and conclusions • appreciate the strength of empirical evidence and distinguish between evidence and proof • look at data to find patterns and exceptions • relate their findings to the original question or conjecture, and indicate reliability • make sense of someone else's findings and judge their value in the light of the evidence they present • critically examine strategies adopted.

Technology and application

There are some differences across the curricula analysed, in terms of the relationship of key scientific concepts to application and technology. Some curricula place great emphasis on technology. For example: its importance is emphasised as part of the curriculum background information; there may be explicit references to application within subject domains; or its content may be presented as a separate domain. For example: Alberta identifies technology and society as one of the foundations of its science programme, alongside knowledge in key domains, skills and attitudes; Massachusetts has a specific domain on *engineering and technology*; Hong Kong has elements in General Studies relating to technology and application; and Singapore emphasises the importance of application in the technological world within its aims and vision. This relationship is not particularly emphasised in England (1999 and 2007), although there are some elements within the sub-domains and introductory text. However, it should be noted that the analysis did not cover the subject of Design and Technology (or equivalent) across the jurisdictions analysed.

5.7 Domains

As set out in Section 5.4, the main domains for science are *biology*, *chemistry* and *physics*. The tables at Appendix C (Tables C2-C4) provide an overview of the content for England and the five comparator jurisdictions analysed in relation to *biology, chemistry, physics and Earth science*. It should be noted that the content is not intended to be a fully comprehensive analysis of all science content but it does cover the majority of content.

The mapping suggests that despite some variation in structure and organisation, the analysis has shown a commonality of content in the science disciplines that can be organised into domains and sub-domains.

In the following analysis, the focus is on a selection of domains and sub-domains rather than a comprehensive analysis of all the content, together with a number of examples to illustrate key differences between the England National Curriculum and the statutory curricula of high-performing jurisdictions, focusing in particular on where the content of high-performing jurisdictions appears more challenging than in England.

These examples are intended to illustrate where the new National Curriculum for science can be strengthened so that the content, standards and expectations are on a par with highest-performing jurisdictions. The analysis includes:

- *Biology;*
- *Chemistry;*
- *Physics; and*
- *Earth science*.

The tables at Appendix C provide a summary of the curriculum content analysed, rather than present the content verbatim, in order to facilitate direct comparisons and for the sake of accessibility and brevity.

Biology

Across the curricula analysed, coverage of the key sub-domains and concepts for *biology* seems comparable. All cover *structure and function*; *interactions and interdependency*; *energy*; and *evolution*. All include *animals*, including *humans*, and *plants*. Set out below is a summary of the content across the key sub-domains as set out in Appendix C (Table C2).

- ***Classification:*** This is covered across all curricula and phases, starting from simple classification based on observable features in Years 1 and 2 in England, Alberta and Massachusetts but Years 4-6 in Hong Kong and Singapore. Classification is also covered in secondary across all the jurisdictions using, for example, Five Kingdom classification. This is usually introduced during Years 7-9.

- ***Structure and function:*** This is the most extensive sub-domain in *biology*. Therefore, to assist the analysis, it has been broken down in Table C2 into *animals* including *humans*, *plants* and *cells*. This sub-domain starts with simple external body parts or parts of plants in early primary. *Internal organs* and *systems* are introduced in late primary in England and Singapore; but elsewhere in secondary. *Cells* are usually introduced in early secondary, with the exception of Singapore where they are introduced in late primary.

- ***Interactions and interdependencies:*** This is largely covered across all curricula although there are some differences in terms of the amount of content, i.e. there seems to be more content in Alberta where there are sub-domains covering different types of ecosystems e.g. fresh and salt water, forests etc.

- ***Energy:*** This is covered across all curricula reviewed for both plants and animals, including *humans*. The key common elements are *photosynthesis, digestion* and *food chains*. There seems to be less coverage of *plants* in the Hong Kong curriculum.

- ***Evolution:*** This is covered across all curricula and includes key concepts such as *variation* and *inheritance*. Coverage is very detailed in Alberta and Massachusetts, for example, where the latter includes the work of Mendel and Darwin.

One example where curricula in high-performing jurisdictions seem to be more challenging than in England is in relation to *cells*. *Cells* are introduced in upper primary in Singapore (equivalent to Year 6); whereas they are introduced in lower secondary (Years 7-9) in England. Their content is broadly similar in that they both specify cell structure and function. However, the Singapore curriculum is more challenging in three ways: by learning the different parts and their functions in both plant and animal cells at primary; by explicitly setting out the need to examine the different parts of the cell at lower secondary; and by being more explicit about the life processes to be studied at the cellular level in both upper primary and lower secondary (See Table 5.5).

Table 5.5: Example of coverage of cells in primary: England (1999) and Singapore (2001)

England 1999	Singapore 2001
Years 1-6 Cells not specified in Years 1-6.	**Year 6** Show an understanding that a cell is a basic unit of life. Identify the typical parts of a plant cell and relate the parts to the functions: • cell wall • cell membrane • cytoplasm • nucleus • chloroplasts Identify the different parts of a typical animal cell and relate the parts to the functions: • cell membrane • cytoplasm • nucleus Show an understanding that a cell divides to produce new cells and that this division is necessary for an organism to grow
Years 7-9 (1999) Pupils should be taught: • that animal and plant cells can form tissues, and tissues can form organs • the functions of chloroplasts and cell	**Year 8 (2001)** Examine plant cells under microscope and identify the different parts of a cell: • cell wall • cell membrane

England 1999	Singapore 2001
walls in plant cells and the functions of the cell membrane, cytoplasm and nucleus in both plant and animal cells • to relate cells and cell functions to life processes in a variety of organisms. **Years 10-11 (2007)** The ways in which organisms function are related to the genes in their cells.	• cytoplasm • nucleus • vacuole • chloroplast Examine animal cell under microscope and identify the different parts of the animal cell: • cell membrane • cytoplasm • nucleus Compare a typical plant cell and typical animal cell. Show an understanding of the functions of the different parts of a cell, including the nucleus which contains genetic material that determines heredity. Recognise that multi-cellular organisms (both plants and animals), cells of similar structures are organised into tissues; several tissues may make up an organ; organs are organised into systems Explain the significance of the division of labour, even at the cellular level

Chemistry

All jurisdictions cover the sub-domains of *nature of matter and energy*; *physical change*; *chemical change*; and *properties of materials*.

- ***Physical change:*** The different *states of matter* are commonly introduced at primary level. They are explained in terms of *particles* and *energy transfer* at lower secondary level. *Mixtures* are generally introduced at lower secondary level, and techniques for separating out mixtures appear mostly at lower secondary level.

- ***Chemical change:*** Only England introduces a *distinction between physical and chemical change* at primary level. The domain is mainly introduced at lower secondary level. Understanding *patterns of chemical change* in terms of the model of the atom, chemical bonding and the patterns of the Periodic Table appears at upper secondary. Curricula commonly specify that reactions should include combustion, thermal decomposition, oxidisation and neutralisation.

- **Properties of materials:** All jurisdictions introduce the relationship between properties of materials and their uses at early primary. At lower secondary, pupils are introduced to the properties of particular elements and groups of elements, and the production of useful new substances by chemical reaction. At upper secondary, curricula mostly demand deeper and more quantitative understanding of the various types of reaction (for example, control of rate of reaction by use of catalysts, and calculations of chemical yield). Only England, Singapore and Hong Kong include detailed coverage of products of crude oil.

One example where the curriculum of high-performing jurisdictions seems more challenging than in England is in relation to *industrial processes*.

England and Hong Kong both introduce key chemistry concepts in lower secondary, namely: *atoms and elements*: *compounds as consisting of atoms/elements chemically combined in specific proportions*; *mixtures as consisting of substances that are not chemically combined*; and *separation of mixtures by fractional distillation*.

Table 5.6: Example of crude oil and plastics: England (1999, 2007) and Hong Kong (1998)

England (1999, 2007)	Hong Kong 1998
Year 7-9 (1999) Pupils should be taught: • How materials can be characterised by melting point, boiling point and density. • How elements combine through chemical reactions to form compounds with a definite composition. • That mixtures are composed of constituents that are not combined. • How to separate mixtures into their constituents using distillation, chromatography and other appropriate methods. • That virtually all materials, including those in living systems, are made through chemical reactions, and to recognise the importance of chemical change in everyday situations. **Year 10-11 (2007)** • elements consist of atoms that combine together in chemical reactions to form compounds	**Year 7-9** • Crude oil is a mixture of hydrocarbons. • Hydrocarbons are compounds of hydrogen and carbon. • Different hydrocarbon molecules are of different size; they consist of different number of carbon and hydrogen atoms. • Molecule as group of atoms that forms the smallest stable unit of some elements or compounds. • Separation of crude oil into different fractions by fractional distillation. • Different fractions consist of hydro-carbons of different boiling points. • Making plastics: small hydrocarbon molecules can be joined together to produce macro-molecules e.g. ethane (obtained by the breaking down of naphtha) to polythene.
Year 10-11 (1999) Pupils should be taught: • That new substances are formed when atoms combine • How the mixture of substances in crude oil, most of which are hydrocarbons, can be separated by fractional distillation • How addition polymers can be formed from the products of crude oil by cracking and polymerisation **Year 10-11 (2007)** • new materials are made from natural resources by chemical reactions	**Year 10-11** • Petroleum as a mixture of hydrocarbons and its separation into useful fractions by fractional distillation. • Relation of the gradation in properties (e.g. colour, viscosity, volatility and burning characteristics) with the number of carbon atoms in the molecules of the various fractions. • Monomers, polymers and repeating units. • Addition polymerisation

However, in Hong Kong pupils are also required to be taught about the *manufacture of plastics* (see Table 5.6). Thus, crude oil is identified as a mixture of hydrocarbons, and the separation of crude oil into its fractions is followed by coverage of the manufacture of plastics by joining small hydrocarbons to form macro-molecules. Non-statutory guidance is also provided on practical experiments involving distilling a small amount of crude oil and investigating the properties of its products and making epoxy resin. In England, the manufacture of plastic from crude oil is not covered until upper secondary (at upper secondary level, both England and Hong Kong cover manufacture of plastic from crude oil at similar depth, introducing the chemical concept of polymerisation).

Physics

Across the curricula reviewed, there were a number of different sub-domains which covered *forces and motion*, *light, sound and waves*, *electricity and magnetism*, *energy and matter*, and *the earth and universe*:

- ***Matter and energy (also part of chemistry):*** Covered in all curricula with typical sub-domains of *types of energy, conservation of energy* and *properties of matter*. A basic understanding of the *conservation of matter* is introduced at primary in Singapore; however, this domain is mainly introduced in all jurisdictions at lower secondary as *particulate nature of matter* (atoms, molecules, elements and compounds). Demonstration of *conservation of matter* through quantitative interpretation of equations is introduced at upper secondary, as is the concept of *conservation of energy*.

- ***Forces and motion:*** This is covered in all the curricula analysed and includes sub-domains such as *concepts of forces, laws of motion, position* and *movement*;

- ***Light, sound and waves:*** Covered in all curricula although in less detail in England 2007. Other curricula include *reflection and refraction, spectrum, vibration, pitch and loudness, properties and characteristics of waves, waves in relation to light and sound and the electromagnetic spectrum*;

- ***Electricity and magnetism:*** Covered in most curricula, progressing from simple circuits through to sub-domains such as *current, resistance, voltage, magnets, conductors and insulation* and *electromagnetism*;

- ***The earth and universe:*** Covered in all curricula with typical sub-domains of: *the sun, earth and moon relationships, the solar system and origins of the universe*.

One example of where the curricula of high-performing jurisdictions seem more challenging is in relation to forces and machines. Table 5.7 shows the different expectations to the introduction of *forces and motion* in England and Singapore. In England, the types of forces covered within *forces and motion* at primary level only include simple linear *forces and motion*. Those involving motion around a pivot are not introduced until lower secondary school (Year 7-9). In Singapore, primary pupils in Year 6 equivalent are required to apply their understanding of forces by manipulating simple machines, including ones that involve rotation around a pivot (wheel and axle, gears). This difference in level of challenge between England and Singapore was also noted by Ruddock and Sainsbury (2008)[126], who concluded that physical sciences in

[126] Ruddock, G. and Sainsbury, M. (2008). *Comparison of the core primary curriculum in England to*

the Singapore primary curriculum are broader and slightly harder than in England.

Table 5.7: Example of forces and machines: England (1999) and Singapore (2001)

England	Singapore
Years 3-6 (1999) Pupils should be taught: *Types of force* • that when objects (for example, a spring, a table) are pushed or pulled, an opposing pull or push can be felt • how to measure forces and identify the direction in which they act. **Years 7-9 (1999)** Pupils should be taught: *Forces and rotation* • that forces can cause objects to turn about a pivot • the principle of moments and its application to situations involving one pivot	**Year 6 (2001)** • identify a force as a push or a pull. • list some simple machines. [Curriculum remarks: The simple machines are lever, pulley, wheel and axle, inclined plane, gears.] • manipulate these simple machines to determine their characteristics and uses.

Earth science

As set out in Section 2.6, *earth and space* was identified among other domains as an particular area for improvement in the analysis of PISA results for England. Table C8 (Appendix C) provides a map of the content of the curricula reviewed in terms of coverage of material on earth science[127].

Some curricula cover this in more detail than others. For example, in Massachusetts and Alberta e*arth and space science* is a separate discipline at both primary and secondary; and is therefore covered in detail. However, there seems to be less coverage in other curricula, such as Singapore and Hong Kong.

For England (1999), *earth science* material is covered across the three science disciplines and is therefore not presented as a single discipline. However, in England (2007), *earth and space* content is set out separately from the content of *biology*, *chemistry* and *physics* as *the environment, Earth and the universe* (although there are, of course, overlaps with the other disciplines).

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those of other high performing countries. DCSF Research Report DCSF-RW048.

[127] 'Earth science' includes content related to the lithosphere, atmosphere, hydrosphere, biosphere, oceans, the physical aspects of the earth and the relationship of earth in the universe.

Appendix 1: Background on PISA, PIRLS and TIMSS studies

This appendix provides background information on PISA, PIRLS and TIMSS, together with a more detailed breakdown of the different domains of reading, mathematics and science that were assessed in the most recent waves, namely PISA 2009, PIRLS 2006 and TIMSS 2007.

PISA

PISA is a series of surveys and tests that are administered by the Organisation for Economic Co-operation and Development (OECD) triennially to 15-year-old pupils in OECD member countries and also partner countries and economies. The most recent round of PISA was conducted in 2009, with earlier rounds occurring in 2000, 2003 and 2006. The PISA tests focus on reading, mathematics and science, and aim to assess the extent to which pupils nearing the end of compulsory education have acquired the knowledge and skills that have been selected by PISA as important for full participation in society[128]. Each assessment wave of PISA focuses on a different subject selected from literacy, mathematics and science. Two-thirds of testing time is devoted to the focus subject in each wave, to provide a detailed measurement of performance against several sub-areas within that subject. The assessment of the remaining subjects (mathematics and science in PISA 2009) provides a less detailed summary of performance.

For the 2009 wave, the tests took the format of paper-and-pencil tests lasting two hours for each pupil, with an additional elective test in which 40 minutes were allocated for the assessment of the reading and understanding of electronic texts, taken in some education systems but not others. Test items consisted of a mixture of multiple choice items and questions that required pupils to formulate their own responses (constructed response items). Test items were organised in groups based on a passage which describes a real-life situation. In total, 390 minutes of test-items were covered by PISA in 2009, with different groups of pupils attempting different combinations of items. PISA 2009 also included a 30 minute pupil questionnaire which asked participants about their background, their learning habits, attitudes to reading, along with their involvement and motivation. There was also a questionnaire administered to school principals to gather demographic information about their school, in addition to an assessment of the learning quality of the school[129].

PIRLS

PIRLS is a system of regular assessment of pupils’ reading literacy in their fourth year of formal schooling (approximately aged 10) that is undertaken in multiple jurisdictions and is administered by the International Association for the Evaluation of Educational Achievement (IEA). The PIRLS programme was established in 2001 and is conducted every five years, with the second wave undertaken in 2006. Its principal aim is to measure the progress made by education systems in pupils’ reading ability,

[128] OECD (2010c). *PISA 2009 Results: What Makes a School Successful? – Resources, Policies and Practices (Volume IV)*. Paris: OECD Publishing

[129] OECD (2009). *PISA 2009 Assessment Framework: Key competencies in reading, mathematics and science.* Paris: OECD Publishing

along with trends in any associated home and school contexts that might affect children's progress in learning to read[130].

PIRLS 2006 focused on assessing a range of reading comprehension processes under two major reading purposes, namely *literary* and *informational*. PIRLS 2006 used a series of booklets as a means of assessing reading literacy, with booklets containing five literary passages and five informational passages. Each passage was accompanied by 12 questions, about half of which were multiple choice, with the other half consisting of constructed-response format questions. Altogether the assessment consisted of 126 test items. The PIRLS 2006 assessment also included questionnaires administered to pupils, teachers and school principals in order to collect information on classrooms and schools, along with questionnaires to parents and caregivers to collect information on the home and school environments for learning to read[131].

TIMSS

TIMSS is undertaken every four years and assesses achievements in mathematics and science for pupils at the end of four years of formal schooling (aged approximately 10) and at the end of eight years of formal schooling (aged approximately 14). TIMSS is administered by the International Association for the Evaluation of Educational Achievement (IEA), and was first undertaken in 1995[132], with following waves occurring in 1999, 2003 and 2007. The 2007 wave of TIMSS included questionnaires completed by participating jurisdictions on their education system, and teachers were asked to complete questionnaires identifying which TIMSS topics were taught to pupils as part of the curriculum. Pupils completed questionnaires on their home and classroom experiences, and school principals and teachers provided information on school resources, the learning climate and instructional practices[133].

All tests within TIMSS 2007 (both mathematics and science, at age 10 and 14) were organized around two dimensions. These were a content dimension, which specified the subject domains to be assessed, and a cognitive dimension which specified the thinking processes to be assessed. The mathematics assessment for pupils aged 10 included 179 test items; the age 14 assessment had 215. The science assessment for pupils aged 10 included 174 test items; the age 14 assessment had 214. For both the science and mathematics assessments at both ages, around half the items were

[130] Mullis, I.V.S. Martin, M.O. Kennedy, A.M. Trong, K.L. and Sainsbury, M. (2009). *PIRLS 2011 Assessment Framework*. Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.

[131] Mullis, I.V.S. Martin, M.O. Kennedy, A.M. and Foy, P. (2007). *PIRLS 2006 International Report: IEA's Progress in International Reading Literacy Study in Primary Schools in 40 Countries*. Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.

[132] Although TIMSS was first administered in 1995, it built on the earlier First International Mathematics Study (FIMS) and Second International Mathematics Study (SIMS) assessments. FIMS was undertaken between 1961 and 1965, and SIMS between 1980 and 1982. These earlier assessments only focused on maths, and did not include science. Mullis, I.V.S. and Martin, M.O. (2006). *TIMSS in Perspective: Lessons Learned from IEA's Four Decades of International Mathematics Assessments.* Last retrieved 15th November 2011 from http://www.brookings.edu/gs/brown/irc2006conference/MullisMartin_paper.pdf

[133] Mullis, I.V.S. Martin, M.O. and Foy, P. (with Olson, J.F. Preuschoff, C. Erberber, E. Arora, A. and Galia, J.) (2008). *TIMSS 2007 International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades.* Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.

multiple-choice responses, the other half were constructed responses[134][135].

Domains measured in PISA, PIRLS and TIMSS

Outlined below are details of the reading, mathematics and science sub-domains assessed in PISA 2009, PIRLS 2006 and TIMSS 2007.

Reading processes in PIRLS 2006

[Source: PIRLS 2006 Assessment Framework[136]]

Interpreting ideas and information typically involves:

- discerning the overall message or theme of a text;
- considering an alternative to actions of characters;
- evaluating the likelihood that the events described could actually happen; and
- describing how the author devised a surprise ending.

Making straightforward inferences typically involves:

- looking for specific ideas;
- searching for definitions of words or phrases;
- concluding what the main point is of a series of arguments; and
- determining the referent of a pronoun.

Reading processes in PISA 2009

[Source: PISA 2009 Assessment Framework[137]]

Accessing and retrieving information typically involves:

- locating the details required by an employer from a job advertisement;
- finding a telephone number with several prefix codes; and
- finding a particular fact to support or disprove a claim someone has made.

Integrating and interpreting typically involves:

- recognising a relationship that is not explicit;
- inferring (from evidence and reasoning) the connotation of a phrase or a sentence;
- processing the text to form a summary of the main ideas; and
- connecting various pieces of information to make meaning.

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[134] Mullis, I.V.S. Martin, M.O. and Foy, P. (with Olson, J.F. Preuschoff, C. Erberber, E. Arora, A. and Galia, J.) (2008). *TIMSS 2007 International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades.* Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.
[135] Martin, M.O. Mullis, I.V.S. and Foy, P. (with Olson, J.F. Erberber, E. Preuschoff, C. and Galia, C.) (2008). *TIMSS 2007 International Science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades.* Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.
[136] Mullis, I. Kennedy, A. Martin, M. and Sainsbury, M. (2006). *PIRLS 2006 Assessment Framework and Specifications*, *2nd Edition*. Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Boston College.
[137] OECD (2009). *PISA 2009 Assessment Framework – Key competencies in reading, mathematics and science.* Paris: OECD Publishing.

Reflecting and evaluating typically involves:

- connecting information in a text to knowledge from outside sources; and
- assessing the claims made in the text against their own knowledge of the world and articulating and defending a point of view.

Mathematics domains at age 10 in TIMSS 2007

[Source: TIMSS 2007 Assessment Framework[138]]

Number typically involves such tasks as:

- recognising multiples and factors of numbers;
- adding and subtracting fractions and decimals;
- Finding the missing number in a number sentence, *e.g.* 13 + ? = 21; and
- describing relationships between adjacent numbers in a sequence.

Geometric shapes and measures typically involve such tasks as:

- comparing angles by size and drawing angles;
- calculating areas and perimeters of squares and rectangles; and
- drawing reflections and rotations of figures.

Data display typically involves such tasks as:

- comparing information from different data sets; and
- displaying data in bar charts and pictographs.

Knowing typically involves:

- recalling definitions and properties;
- recognising mathematical objects;
- computational procedures;
- retrieving information;
- measuring; and
- classifying objects according to common properties.

Applying typically involves:

- selecting the right procedure to solve a problem;
- displaying mathematical information;
- generating a model (*e.g.* an equation) for solving a routine problem;
- following mathematical instructions; and
- solving routine problems (of a type that will be familiar).

Reasoning typically involves:

- making valid inferences from given information;
- restating results in a more widely applicable form;
- making linkages between different mathematical ideas;
- justifying a statement using mathematical reasoning; and
- solving non-routine problems.

[138] Mullis, I. Martin, M. Ruddock, G. O'Sullivan, C. Arora, A. and Erberber, E. (2007). *TIMSS 2007 Assessment Frameworks.* Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.

Mathematics domains at age 14 in TIMSS 2007

[Source: TIMSS 2007 Assessment Framework[139]]

Number typically involves such tasks as:

- evaluating powers of numbers and square roots of perfect squares to 144;
- converting between fractions and decimals; and
- dividing a quantity in a given ratio.

Algebra typically involves such tasks as:

- showing pattern relationships in a sequence using algebraic expressions;
- comparing algebraic expressions to show equivalence; and
- solving simple linear and two-variable equations.

Geometry typically involves such tasks as:

- using Pythagoras's Theorem to solve problems;
- finding a way to measure irregular or compound areas; and
- demonstrating translation, reflection and rotation.

Data and chance typically involves such tasks as:

- matching different representations of the same data;
- recognising approaches to displaying data that could lead to confusion; and
- determining the chances of possible outcomes.

Knowing typically involves:

- recalling definitions and properties;
- recognising mathematical objects;
- computational procedures;
- retrieving information;
- measuring; and
- classifying objects according to common properties.

Applying typically involves:

- selecting the right procedure to solve a problem;
- displaying mathematical information;
- generating a model (*e.g.* an equation) for solving a routine problem;
- following mathematical instructions; and
- solving routine problems (of a type that will be familiar).

Reasoning typically involves:

- making valid inferences from given information;
- restating results in a more widely applicable form;
- making linkages between different mathematical ideas;
- justifying a statement using mathematical reasoning; and

[139] Mullis, I. Martin, M. Ruddock, G. O'Sullivan, C. Arora, A. and Erberber, E. (2007). *TIMSS 2007 Assessment Frameworks.* Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.

- solving non-routine problems.

Science domains at age 10 in TIMSS 2007

[Source: TIMSS 2007 Assessment Framework[140]]

Life science typically involves such tasks as:
- relating body structures to their function;
- comparing the life cycles of familiar organisms;
- associating physical features of organisms with their environment;
- explaining relationships in a community based on food chains; and
- describing ways of maintaining good human health.

Physical science typically involves such tasks as:
- describing mixtures on the basis of physical appearance;
- describing difference between liquids, solids and gases;
- identifying common materials that conduct heat;
- recognising that sound is produced by vibrations;
- identifying a complete electrical circuit; and
- identifying familiar forces that cause objects to move.

Earth science typically involves such tasks as:
- identifying examples of the uses of air;
- relating the formations of clouds to change of state of water; and
- relating daily patterns observed on Earth to its rotation.

Knowing typically involves:
- recalling scientific facts and concepts;
- defining scientific terms;
- describing organisms, materials or science processes;
- supporting statements of fact with examples; and
- knowing how to use scientific tools and procedures.

Applying typically involves:
- comparing and contrasting organisms, materials or processes;
- using a diagram or model to demonstrate understanding;
- relating knowledge of a concept or property to observed behaviour;
- interpreting information in the light of a scientific concept;
- using a relationship, equation or formula to find a solution; and
- explaining an observation or phenomenon using scientific knowledge.

Reasoning typically involves:
- analysing a problem to determine the right steps to solve it;
- synthesising a number of different concepts;
- forming hypotheses to explain observations;

[140] Mullis, I. Martin, M. Ruddock, G. O'Sullivan, C. Arora, A. and Erberber, E. (2007). *TIMSS 2007 Assessment Frameworks.* Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.

- designing an investigation to answer a question;
- drawing conclusions from patterns in data;
- drawing conclusions that go beyond observed conditions; and
- evaluating the results of investigations.

Science domains at age 14 in TIMSS 2007 Science

[Source: TIMSS 2007 Assessment Framework[141]]

Biology typically involves such tasks as:
- locating the major organs of the human body;
- identifying cell structures and the functions of some organs;
- relating the inheritance of traits to the passing on of genetic material;
- relating the survival of species to reproductive success;
- describing the role of organisms in cycling materials; and
- describing causes of common infectious diseases.

Chemistry typically involves such tasks as:
- differentiating between pure substances and mixtures;
- relating the behaviour of water to its physical properties; and
- recognising that mass is conserved during chemical change.

Physics typically involves such tasks as:
- recognising that mass is conserved during physical changes;
- identifying different forms of energy;
- interpreting ray diagrams to identify the path of light;
- describing some basic properties of sound;
- identifying practical uses of electromagnets; and
- predicting changes of motion of an object due to forces acting on it.

Earth science typically involves such tasks as:
- interpreting topographical maps;
- describing the steps of the Earth's water cycle;
- providing examples of renewable and non-renewable resources; and
- contrasting the physical features of Earth with other planets.

Knowing typically involves:
- recalling scientific facts and concepts;
- defining scientific terms;
- describing organisms, materials or science processes;
- supporting statements of fact with examples; and
- knowing how to use scientific tools and procedures.

Applying typically involves:
- comparing and contrasting organisms, materials or processes;

[141] Mullis, I. Martin, M. Ruddock, G. O'Sullivan, C. Arora, A. and Erberber, E. (2007). *TIMSS 2007 Assessment Frameworks.* Chestnut Hill, MA: TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College.

- using a diagram or model to demonstrate understanding;
- relating knowledge of a concept or property to observed behaviour;
- interpreting information in the light of a scientific concept;
- using a relationship, equation or formula to find a solution; and
- explaining an observation or phenomenon using scientific knowledge.

Reasoning typically involves:
- analysing a problem to determine the right steps to solve it;
- synthesising a number of different concepts;
- forming hypotheses to explain observations;
- designing an investigation to answer a question;
- drawing conclusions from patterns in data;
- drawing conclusions that go beyond observed conditions; and
- evaluating the results of investigations.

Science at age 15 in PISA 2006

[Source: PISA 2006 Assessment Framework[142]]

Identifying scientific issues typically involves:
- recognising issues that it is possible to investigate scientifically;
- identifying keywords to search for scientific information; and
- recognising the key features of a scientific investigation.

Explaining phenomena scientifically typically involves:
- applying knowledge of science in a given situation;
- describing or interpreting phenomena scientifically and predicting changes; and
- identifying appropriate descriptions, explanations, and predictions.

Using scientific evidence typically involves:
- interpreting scientific evidence; making and communicating conclusions;
- identifying the assumptions, evidence and reasoning behind conclusions; and
- reflecting on the implications of scientific or technological developments.

Knowledge about science typically involves such tasks as:
- identifying fruitful questions for scientific enquiry;
- identifying the assumptions made by a given scientific study; and
- identifying possible weaknesses in an experimental method.

Earth and space systems typically involves:
- structures of the Earth systems (*e.g.* lithosphere, atmosphere);
- energy in the Earth systems (*e.g.* sources, global climate);
- change in Earth systems (*e.g.* plate tectonics, geochemical cycles);
- Earth's history (*e.g.* fossils, origin and evolution); and
- Earth in space (*e.g.* gravity, solar systems).

[142] OECD (2009). *PISA 2009 Assessment Framework – Key competencies in reading, mathematics and science.* Paris: OECD Publishing.

Living systems typically involves:

- cells (*e.g.* structures and function, DNA, plant and animal);
- humans (*e.g.* health, nutrition, disease, reproduction);
- populations (*e.g.* species, evolution, biodiversity, genetic variation);
- ecosystems (*e.g.* food chains, matter and energy flow); and
- biosphere (*e.g.* ecosystem services, sustainability.

Physical systems typically involves:

- structure of matter (*e.g.* particle model, bonds);
- properties of matter (*e.g.* changes of state, thermal conductivity);
- chemical changes of matter (*e.g.* reactions, energy transfer, acids/bases);
- motions and forces (*e.g.* velocity, friction);
- energy and its transformation (*e.g.* conservation, chemical reactions); and
- interactions of energy and matter (*e.g.* light and radio waves).

Appendix 2: Curriculum document references

English

England 1999 English Key Stages 1 to 4
http://webarchive.nationalarchives.gov.uk/20101221004558/http://curriculum.qcda.gov.uk/uploads/English%201999%20programme%20of%20study_tcm8-12054.pdf

England 2007 English Key Stage 3
http://webarchive.nationalarchives.gov.uk/20101221004558/http://curriculum.qcda.gov.uk/uploads/QCA-07-3332-pEnglish3_tcm8-399.pdf

England 2007 English Key Stage 4
http://webarchive.nationalarchives.gov.uk/20101221004558/http://curriculum.qcda.gov.uk/uploads/QCA-07-3333-pEnglish4_tcm8-415.pdf

Alberta 2000 English Language Arts: Grades K-9
http://education.alberta.ca/media/450519/elak-9.pdf

Alberta 2003 English Language Arts: Grades 10-12
http://education.alberta.ca/media/645805/srhelapofs.pdf

Massachusetts 2001 'English Language Arts': Grades Pre-K to 12
http://www.doe.mass.edu/frameworks/ela/0601.doc

New Zealand 1994 'English' Levels 1 to 8
http://www.minedu.govt.nz/~/media/MinEdu/Files/EducationSectors/Schools/EnglishInTheNewZealandCurriculum.pdf

New South Wales 2007 (first published 1998) 'English' K to 6
http://k6.boardofstudies.nsw.edu.au/files/english/k6_english_syl.pdf

New South Wales 2003 'English' Years 7 to 10
http://www.boardofstudies.nsw.edu.au/syllabus_sc/pdf_doc/english_710_syllabus.pdf

Singapore 2001 'English Language for Primary and Secondary Schools
http://www.moe.gov.sg/education/syllabuses/languages-and-literature/files/english-primary-secondary.pdf

Mathematics

England 1999
http://webarchive.nationalarchives.gov.uk/20101221004558/http://curriculum.qcda.gov.uk/uploads/Mathematics%201999%20programme%20of%20study_tcm8-12059.pdf

England 2007 KS3
http://webarchive.nationalarchives.gov.uk/20101221004558/http://curriculum.qcda.gov.uk/uploads/QCA-07-3338-p_Maths_3_tcm8-403.pdf

England 2007 KS4
http://webarchive.nationalarchives.gov.uk/20101221004558/http://curriculum.qcda.gov.uk/uploads/QCA-07-3339-p_Maths_4_tcm8-404.pdf

Finland (Mathematics – Chapter 7.6)
http://www.oph.fi/download/47672_core_curricula_basic_education_3.pdf

Flemish Belgium (2010)
Mainstream primary education
http://www.ond.vlaanderen.be/dvo/english/corecurriculum/primary/indexprimary.htm
First stage of mainstream secondary education A-stream
http://www.ond.vlaanderen.be/dvo/english/corecurriculum/secondary/1grade/astream/indexstreama.htm
Second stage of mainstream secondary education
http://www.ond.vlaanderen.be/dvo/english/corecurriculum/secondary/2grade/index.htm
Third stage of mainstream secondary education
http://www.ond.vlaanderen.be/dvo/english/corecurriculum/secondary/3grade/index.htm

Hong Kong Primary 2000
http://www.edb.gov.hk/index.aspx?nodeID=4907&langno=1

Hong Kong Secondary 1999
http://www.edb.gov.hk/index.aspx?nodeID=4905&langno=1

Massachusetts 2000
http://www.doe.mass.edu/frameworks/math/2000/final.pdf

Massachusetts Addendum 2004
http://www.doe.mass.edu/frameworks/math/052504_sup.pdf

Singapore curriculum Primary 2001
http://www3.moe.edu.sg/cpdd/doc/Maths_Pri.pdf

Singapore Primary 2007
http://www.moe.gov.sg/education/syllabuses/sciences/files/maths-primary-2007.pdf

Singapore Secondary 2007
http://www.moe.gov.sg/education/syllabuses/sciences/files/maths-secondary.pdf

Science

England 1999
http://webarchive.nationalarchives.gov.uk/20101221004558/http://curriculum.qcda.gov.uk/uploads/Science%201999%20programme%20of%20study_tcm8-12062.pdf

England 2007 Key Stage 3
http://webarchive.nationalarchives.gov.uk/20101221004558/http://curriculum.qcda.gov.uk/uploads/QCA-07-3344-p_Science_KS3_tcm8-413.pdf

England 2007 Key Stage 4
http://webarchive.nationalarchives.gov.uk/20101221004558/http://curriculum.qcda.gov.uk/uploads/QCA-07-3345-p_Science_KS4_tcm8-1799.pdf

Alberta 1996 (G1-G6)
http://education.alberta.ca/media/654825/elemsci.pdf

Alberta 2003 (G7-G9)
http://education.alberta.ca/media/654829/sci7to9.pdf

Alberta 2007 (G10-12 Science)
http://education.alberta.ca/media/654837/sci2030_07.pdf

Alberta 2007 (G10-12 biology)
http://education.alberta.ca/media/654841/bio203007.pdf

Alberta 2007 (G10-12 chemistry)
http://education.alberta.ca/media/654849/chem2030_07.pdf

Alberta 2007 (G10-12 physics)
http://education.alberta.ca/media/654853/phy2030_07.pdf

Hong Kong 2002 (KS1 & KS2)
https://cd.edb.gov.hk/kla_guide/GS_HTML/english/frame.html
[Note Science is taught as part of general studies in primary]

Hong Kong 1998 (Sec1-3)
http://cd1.edb.hkedcity.net/cd/science/is/sci_syllabus_S1to3_e.pdf

Hong Kong 2007 (KS4 Combined Science)
http://www.edb.gov.hk/FileManager/EN/Content_2855/com_sci_final_e_20091005.pdf

Hong Kong 2007 (KS4 Biology)
http://www.edb.gov.hk/FileManager/EN/Content_2855/bio_final_e_20091005.pdf

Hong Kong 2007 (KS4 Chemistry)
http://www.edb.gov.hk/FileManager/EN/Content_2855/chem_final_e_20091005.pdf

Hong Kong 2007 (KS4 Physics)
http://www.edb.gov.hk/FileManager/EN/Content_2855/phy_final_e_20091005.pdf

Massachusetts 2006 (K-G9)
http://www.doe.mass.edu/frameworks/scitech/1006.pdf

Singapore 2001 (P1-P6)
http://www3.moe.edu.sg/cpdd/doc/Science_Pri.pdf

Singapore 2001 (Lower Secondary 1&2)
http://www3.moe.edu.sg/cpdd/doc/Science_LowSec_All.pdf

Victoria – 2008- Scientific enquiry (Level 1-Level 6)
http://vels.vcaa.vic.edu.au/downloads/vels_standards/velsrevisedscience.pdf

Appendix A: English curriculum comparison tables

Table A1: High-level organisation

	England (1999)	England (2007)	[i]Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	[ii]New South Wales (2001 and 2003)	Singapore (2001)
High level organisation of curriculum document **Definition of curriculum statements**	**'English'** <u>Statement type and Year groupings:</u> Defines the curriculum by *learning outcomes* for each Key Stage : KS1 (Y[iii] 1-2) KS2 (Y 3-6) KS3 (Y 7-9) KS4 (Y 10-11) <u>Typical statement stem:</u> *'Pupils should be taught to…'* <u>Attainment:</u> Expected levels of attainment are set out in a separate section 'Attainment Target Level Descriptors'. <u>Organisation of content:</u> Programme of study for English is arranged into 3 key domains: -*Speaking & listening*; -*Reading*; and -*Writing*. Each domain is	**'English'** <u>Statement type and Year groupings:</u> Defines the curriculum by *learning outcomes* for each : KS1 (Y 1-2) KS2 (Y 3-6) KS3 (Y 7-9) KS4 (Y 10-11) <u>Typical statement stem:</u> *'Pupils should be able to…'* <u>Attainment:</u> Expected levels of attainment are set out in a separate section 'Attainment Target Level Descriptors'. <u>Organisation of content:</u> Programme of study for English is arranged into 3 key domains: -*Speaking &*	**'English Language Arts'** <u>Statement type and Year groupings:</u> Defines the curriculum by *learning outcomes* on a Year by Year basis. <u>Typical statement stem:</u> *'Pupils will…'* <u>Attainment:</u> The curriculum statements serve as expected levels of attainment for each Year. <u>Organisation of content:</u> 5 general outcomes: Students will listen, speak, read, write, view and represent to: - *explore thoughts, ideas, feelings and experiences;* - *comprehend and respond critically to oral, print and other media texts;* - *manage ideas and information;* - *enhance the clarity and artistry of communication; and* - *respect, support and collaborate with others.*	**'English Language Arts'** <u>Statement type and Year groupings:</u> Defines the curriculum by *learning outcomes* generally arranged in two-Year groupings: PreK-2 (Eng[iv]. YR[v]-3) 3-4 (Eng. Y 4-5) 5-6 (Eng. Y 6-7) 7-8 (Eng. Y 8-9) 9-10 (Eng. Y 10-11) Learning outcomes for vocabulary, reading and for composition are further divided into PreK-K and two Year blocks. <u>Typical statement stem:</u> '*Students will…'* <u>Attainment:</u> The curriculum statements serve as expected levels of attainment for each Year. <u>Organisation of content:</u> Curriculum has 4 domains: - language; - reading and literature; - composition; and - media. These are supported by 27 general standards,	**'English'** <u>Statement type and Year groupings:</u> Defines the curriculum by *learning outcomes* using a grade level system (levels 1 to 8). These levels of learning outcomes are not age specific, but the following rough equivalences can be used: Level 1 (Eng. Y 1-2) Level 2 (Eng. Y 3-4) Level 3 (Eng. Y 5-6) Level 4 (Eng. Y 7-8) Level 5 (Eng. Y 9-10) Level 6 (Eng. Y 11+) Levels 7 and 8 apply to the Years beyond compulsory schooling in England. <u>Typical statement stem:</u> '*Students should be able to…'* <u>Attainment:</u> The expected levels of attainment ("Achievement Objectives") form the organisational basis of the curriculum	**'English'** <u>Statement type and Year groupings:</u> Defines the curriculum by *learning outcomes* which are defined by stages set out in two-Year blocks: Early Stage 1 (Eng. Y1) Stage 1 (Eng. Y 2-3) Stage 2 (Eng. Y 4-5) Stage 3 (Eng. Y 6-7) Stage 4 (Eng. Y 8-9) Stage 5 (Eng. Y 10-11) <u>Typical statement stem:</u> *'A student…'* (e.g. '…*enjoys creating a range of spoken and written texts*', '…*responds to and composes texts for* …') <u>Attainment:</u> Learning outcomes are accompanied by a set of "indicators" demonstrating the behaviour students might display once outcome statements have been mastered. <u>Organisation of content:</u>	**'English Language'** <u>Statement type and Year groupings:</u> Defines the curriculum by *learning outcomes* for the end of: primary 2 (Eng. Y3), primary 6 (Eng. Y7), secondary 2 (Eng. Y9), secondary 4 (Eng. Y11) <u>Typical statement stem:</u> *'Students will…'* <u>Attainment:</u> The Learning Outcome curriculum statements are the expected attainment targets for pupils at the end of each two-Year period. <u>Organisation of Content:</u> Content is divided into: - Language for information; - Language for literary response and expression; and - Language for social

	England (1999)	England (2007)	[i] Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	[ii] New South Wales (2001 and 2003)	Singapore (2001)
	further divided into *Knowledge, skills and understanding,* and *Breadth of study.* The breadth of study specifies the increasing range of activities, contexts and purposes through which pupils should be taught knowledge, skills and understanding.	*Listening*; -*Reading*; and -*Writing*. Each domain is divided into *Key processes, Range and content* and *Curriculum opportunities*. There are detailed guidance notes alongside the programme of study statements in the curriculum document.	These are interrelated and interdependent; achieved through a variety of listening, speaking, reading, writing, viewing and representing. Each general learning outcome includes specific outcomes that pupils are to achieve by the end of each Year grade.	which are subsequently separated into Learning Standards for each of the age phases.	framework (hence the curriculum set out by attainment levels, rather than by ages/ Years). <u>Organisation of content:</u> The learning outcomes are organised into 3 domains: -Oral language (listening and speaking); -Written language (reading and writing); and -Visual language: (viewing and presenting). These are further split into *functions* and *processes.*	Y1–8 curriculum is organised under 3 strands: - talking and listening; - reading; and - writing. Y9–11 curriculum is organised under 5 objectives: - speaking, listening, reading, writing, viewing and representing; - using language and communicating appropriately and effectively; - thinking in ways that are imaginative, interpretive and critical; - expressing oneself and relationships with others and the world; and - learning and reflecting on learning through study of English. The curriculum splits outcome statements into *learning to* and *learning about.*	interaction. Separates the documents into 3 main areas: skills; strategies and attitudes; and text types. The curriculum is streamed at Y7 and Secondary. Outlined below are those analysed in this report: - Primary Two - Primary Four - Primary Six (EM1 and EM2) - Primary Six (EM3)*[vi] - Secondary Two (Special / Express / Normal Academic) - Secondary Two (Normal Technical)* - Secondary Four / Five (Special / Express / Normal Academic)* - Secondary Four / Five (Normal Technical)
Curriculum aims and principles	Statement about the 'Importance of English: *"English is a vital way of communicating in school, in public life and internationally. Literature in English is rich and*	Learning and undertaking activities in English contribute to achievement of the curriculum aims for all young people to become:	The aim of English Language Arts is: "*To enable each student to understand and appreciate language, and to use it confidently and competently in a variety of situations for communication, personal*	10 Guiding Principles which articulate a set of beliefs about the teaching, learning, and assessing of speaking, viewing, listening, reading, and writing. The principles are philosophical statements that underlie every	English in the New Zealand curriculum aims to enable students to: *- engage with and enjoy language in all its varieties; and* *- understand, respond to, and use oral, written, and*	Each curricula sets out broad aims for the teaching of English during that phase. The aim of the English K–6 curriculum is: "*to encourage positive*	Describes a *"philosophy of language underlying the syllabus"* and six principles that are said to be "*embodied*" in the curriculum and underpin all content and its

	England (1999)	England (2007)	[i] Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	[ii] New South Wales (2001 and 2003)	Singapore (2001)
	influential, reflecting the experience of people from many countries and times." *"In studying English pupils develop skills in speaking, listening, reading and writing. It enables them to express themselves creatively and imaginatively and to communicate with others effectively."* *"Pupils learn to become enthusiastic and critical readers of stories, poetry and drama as well as non-fiction and media texts. The study of English helps pupils understand how language works by looking at its patterns, structures and origins. Using this knowledge pupils can choose and adapt what they say and write in different situations."*	"• *successful learners who enjoy learning, make progress and achieve;* • *confident individuals who are able to live safe, healthy and fulfilling lives; and* • *responsible citizens who make a positive contribution to society."* Statement on the importance of English, which is largely the same as the statement in the 1999 document.	*satisfaction and learning. Students become confident and competent users of all 6 language arts through many opportunities to listen and speak, read and write, and view and represent in a variety of combinations and relevant contexts. All the language arts are interrelated and interdependent; facility in one strengthens and supports the others*."	domain and standard of the curriculum framework and they should guide the construction and evaluation of English Language Arts curricula. [The full curricula are too detailed to reproduce as part of this table].	*visual language effectively in a range of contexts.* These aims are reflected in and achieved through each of the 3 domains of the English curriculum: -oral language; -written language; and - visual language. The essential skills developed through the English curriculum are: *communication; information; social and co-operative; self management; and working and study.*	*attitudes towards learning English, to develop students' ability in using language effectively and to enable critical reflection on how language works."* The aim of English, in the NSW curriculum during Y7-10 is to "*enable students to use, understand, appreciate, reflect on and enjoy the English language in a variety of texts and to shape meaning in ways that are imaginative, interpretive, critical and powerful."*	implementation: Pupils will be able to: *"-listen to, read and view with understanding, accuracy and critical appreciation; -speak, write and make presentations; -think through, interpret and evaluate fiction and non-fiction texts; and -Interact effectively with people from their own or different cultures."* There are 6 '"*principles of language learning and teaching*": *contextualisation; learner-centeredness; interaction; integration; process-orientation*; and *spiral progression*.

Table A2: Reading and Literature

Domain	England (1999)	England (2007)	Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	New South Wales (2001 and 2003)	Singapore (2001)
Reading strategies Covers: • word reading • reading processes • phonics (alphabetic knowledge, blending sounds etc.)	**Introduced in Y1** **Medium specificity** The focus for reading in Y1-2 is on securing strategies for word reading, with the expectation that through teaching, pupils will be able to read fluently and accurately, and to *"make sense of what they read"*. The programme of study sets out reading strategies under the following headers: *phonemic awareness and phonic knowledge; word recognition and graphic knowledge; and grammatical awareness and contextual understanding.* In Y3 onwards, the focus moves onto text comprehension; although reading strategies should still be taught as specified in the earlier Years.	**[Secondary curriculum only]** **Low specificity** There is no content connected to word-level reading skills in the secondary-level curriculum. The focus is on how meaning is constructed at the sentence, paragraph and text level. Most of the detail provided on this is in the non-statutory explanatory notes.	**Introduced in Y1 (to Y3)** **Medium specificity** Reading strategies is within General Outcome 2.1 "*Use strategies and cues*" and later (Y3) in "*Enhance and improve".* The curriculum mainly uses phonic strategies for learning to read, but also includes: using cues, prediction and reading-on. Statements are fairly sparse at Y1-2, but increase in Y3-4. By Y6 pupils are expected to use sight vocabulary, phonics and knowledge of text structure to read words in context. The *Phonic and Structural Analysis* sub-domain continues until Y10, with students expected to apply earlier reading strategies, rather than new or more complex phonic instruction.	**Introduced in Y1** **High specificity** Requirements for reading set out in the *reading and literature* domain. Word reading is set out in a *beginning to read* domain. Expectations are expressed in two-Year blocks for Y1-5. At Y5 it is expected that the majority of pupils will have met the required standards, with the focus then moving on to understanding texts, making connections, developing knowledge about genre and theme. In achieving the required level in *beginning reading* a pupil is expected to *"understand the nature of written English and the relationship between letters and spelling patterns to the sound of speech".*	**Introduced in Y1** **Low specificity** Expectations are set out in the *personal reading* section. The '*personal reading'* levels set out expectations for selecting own texts and sets broad progression goals for word reading, without specifying particular reading strategies. There is basic coverage of the technicalities of word reading in the *reading functions* section at levels 1 and 2 (approximately Y1–4). In the early Years (levels 1 and 2, approximately Y1–4) the focus of word reading is on the use of semantic, syntactic, visual, and grapho-phonic cues. In attaining level 3 (approximately Y5–6) pupils are expected to integrate reading processes with ease, and then move on to use a variety of reading	**Introduced in Y1** **Medium specificity** Requirements are set as a sub-domain of the Reading section. Reading skills and strategies at primary level are set out at a high level: pupils should *"use phonological and graphological cues to decode written texts*"; however there is no further specification of exactly what these should be. Expected outcomes, on the other hand, are quite detailed, and give a very full picture of what a pupil who reaches the expected standard will be able to do, for example, "*hears a sequence of sounds and blends single sounds in vowel–consonant (vc), consonant–vowel (cv) and*	**Introduced in Y1** **Medium specificity** In Y1 the expectation is that pupils will use phonological awareness strategies to begin to word read alongside meaning-based strategies such as using contextual cues. It is expected that pupils have secure phonological awareness strategies by the end of Y5. The focus is then on developing wider reading strategies to develop meaning and reading for varying purposes, for example, skimming for gist. Pupils to be able to read common irregular words such as "the", "have" and "said" by Y5, which is later than in other curricula.

Domain	England (1999)	England (2007)	Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	New South Wales (2001 and 2003)	Singapore (2001)
					strategies.	*consonant–vowel–consonant (cvc) words"*. This level of detail in expected outcomes creates implied teaching requirements.	
Comprehension Covers: • wide reading • understanding literary devices • setting and characterisation • literal and inferential understanding • personal opinion • summarising and synthesising **Forms & genres** • fiction/narrative • non-fiction/non narrative • poetry • plays	**Introduced in Y3** **Medium specificity** In Y1-2 the focus is on reading strategies to secure word reading, with pupils developing understanding of different forms of literature. In Y3 -6 the focus moves onto comprehension, with a sub-domain detailing expectations for *understanding texts*. Pupils are required to develop a more sophisticated understanding of texts, using inference and deduction, looking for meaning beyond the literal, and making connections between different parts of the text	**[Secondary curriculum only]** **Low specificity** The *Reading* domain of the curriculum covers both extraction of meaning and appreciation of the craft of writing. The content statements are written at a high level of generality, so that there are about 20 statements for reading at each Key Stage. For example, pupils should be able to "*infer and deduce meanings, recognising the writers' intentions*", and "*recognise and discuss different interpretations of texts, justifying their own views*". Linked to these content statements are attainment targets at 6 levels (from 4 to	**Introduced in Y1** **High specificity** Reading comprehension is a feature of all 5 General Outcomes at the highest level. *("Pupils will listen, speak, <u>read,</u> write, view and represent to…")* General Outcome 2 focuses on comprehension of all types of text (as opposed to just books) *("… comprehend and respond personally and critically to oral, print and other media texts.")* Main areas where comprehension is concentrated include: *"1.1 Discover and explore;* *1.2 Clarify and extend;* *2.1 Use strategies and cues;* *2.2 Respond to texts;* *2.3 Understand forms,*	**Introduced in Y1** **High specificity** Requirements for reading are set out in the *Reading and literature* domain. Reading comprehension is detailed in the *understanding a text* sub-domain, which is built upon in further domains, which set out requirements for pupils to make connections to context and background, and explore and analyse a range of genres, themes. Level of demand is high at Key Stage 1 equivalent; for example pupils are expected to *"identify different interpretations of plot setting and character in the same work by different authors'*	**Introduced in Y1** **Low specificity** Requirements for reading are set out in the *Written Language* section. The programme of study splits reading functions into *Personal reading* and *Close reading*. Reading and writing are grouped together as parts of written English. The processes associated with the ability to understand and use written language are: - exploring language; - thinking critically; and -processing information. *Personal reading* specifies the expectations for pupils to read widely and details the breadth of reading for both enjoyment	**Introduced in Y1** **Medium specificity** Requirements are set out within the domain of *Reading*. Until the end of Y7 very detailed indicators of attainment are set out for 4 sub-domains in each stage: -talking and listening; -skills and strategies; -context and text; and -language structure. Years up to Y7 are covered in the same curriculum document. However, Y8 -11 have a separate document with quite a different style; there is far less specific	**Introduced in Y1** **Low specificity** Reading comprehension is specified as part of general comprehension from Y1 with a requirement for pupils to respond to a variety of texts, written and oral, formulating questions to clarify meaning. By the end of Y7 there is a requirement for pupils to use reading strategies to monitor and confirm understanding of texts, developing comprehension skills. By the end of Y11, pupils are expected to infer and draw conclusions "*about characters, their actions and motives, events, setting, atmosphere*

Domain	England (1999)	England (2007)	Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	New South Wales (2001 and 2003)	Singapore (2001)
	and other texts. In the secondary phase reading is focused on comprehension, with expectations based on reading for meaning and understanding the author's craft. During the secondary phase, significant emphasis is placed on reading a wide range of texts. The programme of study details the types of texts that pupils are to be exposed to.	Exceptional Performance) which describe, in general terms, the performance required to reach each level.	*elements and Techniques;* *4.1 Enhance and improve; and* *4.2 Attend to conventions."* In early grades comprehension skills are developed through texts both read and heard read aloud. Very quickly pupils are expected to consider character, textual organisation, and personal preferences. Inference and prediction are introduced at Y3. By the end of Y6, a relatively sophisticated grasp of text features is expected. Secondary phase content explores a greater variety of texts in more depth, with Y10-11 focusing on analysis and interpretation of all text types. The range of texts to be covered is not specified, other than the expectation that texts must be from a range of cultures and reflect personal experiences.	*and 'identify differences among common forms of literature*." Literary texts: during the secondary phase the emphasis is placed on indentifying and analysing sensory detail, figurative language, imagery and symbolism, and exploring genre characteristics and themes. Informational texts: during the secondary phase pupils are required to analyse the logic and use of evidence in an author's argument.	and information. The level of sophistication increases, with pupils required to select their own texts and read fluently using a range of reading processes and strategies. *Close reading* specifies the skills and knowledge for reading comprehension; detailing the progression expected for the way pupils respond to language, meaning and texts, and the skills for analysing language, meaning, ideas and literary qualities. Because progression is set out in terms of outcomes rather than ages, there is no clear break in expectation between primary and secondary phases.	emphasis on speaking and listening – the outcomes are set out in terms of general language ability.	*and writer's purpose."*

Research (finding and using information) Covers: • formatting research questions • finding information • using information • evaluating sources • organising and presenting tables	**Introduced in Y1** **Low specificity** Reading for information is developed throughout the curriculum from Y1. During Y1-2 pupils are taught to use key features to navigate various informational texts sources. In Y3-6 pupils are taught to obtain specific information from reading, distinguishing between fact and opinions and critically analysing information. In secondary requirements for *research* reading focus on the use of ICT-based resources and media texts, rather than on the strategies and processes for extracting and using information. It is expected that students will compare and synthesise information from these sources and evaluate how the information is presented.	**[Secondary curriculum only]** **Low specificity** There is no detail provided on specific research techniques that should be used. Some reference is made to evaluating information, but no detail is given.	**Introduced in Y1** **High specificity** Requirements are set out in General Outcome 3, "…*manage ideas and Information."* Initially (Y1-2) pupils are taught to understand and use information texts and to categorise and gather information. By Y6 pupils are expected to use a range of strategies to access information and can examine, summarise and evaluate information found. Through secondary, pupils plan their research methods, obtain information from a variety of sources, use skills such as skimming and scanning and evaluate the success of their research techniques.	**Introduced in Y1** **High specificity** Requirements are set out in a *research* sub-domain, which forms part of the *Composition* domain. Early requirements (Y1-3) are for pupils to generate questions and collect information using a variety of sources. In later Years, pupils are expected to know how to identify and apply steps for collecting information, organise ideas for emphasis, use the information and evaluate sources.	**Introduced in Y1** **Medium specificity** *Research* is covered in reading and writing processes, with a specific domain focused on processing information. At levels 1 and 2 (approximately Y1–4) the expectation is focused on identifying, retrieving and presenting coherent information from more than one source. The requirement becomes more sophisticated by level 5 and 6 (approximately Y9–11 and beyond), with the need to use appropriate technologies, present information accurately and analyse the process used.	**Introduced in Y2** **Low specificity** There is very little specification on this topic. Pupils are expected to be able to extract information from texts and discuss the techniques that can be used to present information, but there is no specific guidance on techniques for reading for information. Focuses on the use of technology, both for written and visual language texts.	**Introduced in Y1** **High specificity** Expectation for pupils to gather and use information from Y1, using various cues as signposts. The requirements by the end of Y7 are that the information is organised and summarised effectively, with reasons to support and evaluative comments. By the end of secondary pupils should also be evaluating sources of information, establishing their own criteria and further exploring factors relating to a topic.

Table A3: Writing

Domain	England (1999)	England (2007)	Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	New South Wales (2001 and 2003)	Singapore (2001)
Planning writing Covers: • organising ideas • planning writing • audience and purpose	**Introduced in Y1** **Medium specificity** *Planning and drafting* is a sub-domain of *writing* in Y1-2. Expectation is focused on assembling and developing ideas, planning and reviewing their writing, with support, and discussing its quality. In Y3-6, the planning and drafting sub-theme is split into *plan, draft, revise, proof reading, present, and discuss and evaluate.* These themes continue through to secondary, with the additional requirement to analyse critically their own and other's writing.	**[Secondary curriculum only]** **Low specificity** There is no specification of organisational or planning techniques – the only specification is that pupils should be able to organise, plan and proof read their work.	**Introduced in Y3** **Low content level but high specificity** Planning for writing appears across the General Outcomes, commencing with *recording and experimenting with ideas*, which progresses to *organising ideas and information* in Y5-6. Secondary requires pupils to select the right strategies, plan to write for particular audiences and organising ideas and appropriate text structures. Expectations also cover the planning of spoken texts.	**Introduced in Y6** (limited planning required from Y1) **Medium specificity** *Organising ideas* is a sub-domain that requires pupils to organise their writing in a way that makes sense for its purpose. During the primary phase pupils are required to organise ideas in a way that makes sense, through sequencing events in their own writing. The secondary curriculum is less prescriptive, simply saying that pupils should *"Organize ideas for a critical essay about literature or a research report with an original thesis statement in the introduction, well constructed paragraphs that build an effective argument, transition sentences to link paragraphs into a coherent whole, and a conclusion"*.	**Not specified** Planning a written text is not explicitly covered.	**Introduced in Y3** **Medium specificity** Requirements are set out as a sub-domain of the *Writing* section. For the primary Years, some guidance is given as to the skills and strategies that should be used in planning writing (*e.g. "uses a flowchart"*, *"uses a … matrix, flowchart, semantic map"*.) This guidance becomes much more general for Y8 onwards (*e.g. "use and adapt the processes of planning, drafting, rehearsing, responding to feedback, editing, and publishing to compose texts over time*".)	**Introduced in Y5** **Low specificity** Expectation for pupils to plan a presentation is introduced in Y5. By the end of Y7 pupils are required to plan and organise, considering purpose and audience.

Domain	England (1999)	England (2007)	Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	New South Wales (2001 and 2003)	Singapore (2001)
Composition Covers: • composition • audience and purpose • structure of writing (sentence and text) • use of language (styles and conventions) • meta-language Genres: • literary • non-literary • poetry • play-scripts	**Introduced in Y1** **Medium specificity** In Y1-2 the expectation is that pupils will organise their ideas into sentences, with varied vocabulary and writing to suit the purpose and reader, using the texts they read as models for their own writing. In Y3 -6 pupils are expected to choose form and content to suit a particular purpose for writing, with broadening vocabulary, flexing the form of writing and using additional features. In the secondary phase, writing for different purposes becomes the focus; with composition split out into: *writing to imagine, explore, entertain, writing to inform, explain, describe, writing to persuade, argue, advise, and writing to analyse, review and comment.*	**[Secondary curriculum only]** **Medium specificity** There is a section dedicated to writing. Pupils are expected to be able to use a range of structures and devices to write for a range of purposes and audiences. By the end of Y11, pupils are expected to "*write imaginatively, creatively and thoughtfully, producing texts that interest, engage and challenge the reader*."	**Introduced in Y1** **High specificity** Writing is particularly covered in General Outcome 4: *"…enhance the clarity and artistry of communication"* and is also addressed across the other General Outcomes. Most statements include expectations that communication learning will include written, oral and other media texts. Early writing consists of beginning to write punctuated sentences, and experimenting with letters and words. By the end of Y6 the focus moves to experimenting with language, sentence and text structures to create different effects. Y7-9 focuses on using and experimenting with specific writing techniques to engage the reader, including identifying	**Introduced in Y1** **Medium specificity** Composition is set out as a process. Each stage of the writing process is covered and split into: *-writing;* *- consideration of audience and purpose;* *- revising;* *-standard English conventions;* *-organising ideas in writing;* *-research;* *-evaluating writing; and* *-presentations.* The writing standards set out separate requirements for imaginative/literary writing and informational/expository writing from Year 1. Imaginative/ literary texts: during the primary stage, pupils are expected to write stories that have a beginning, middle and end, and short poems that have a sense	**Introduced in Y1** **Medium specificity** Writing composition split by expressive, poetic and transactional writing. Each of the level statements aim to detail the expectations for each type of composition. Expressive writing: by the end of Year 11, pupils are expected to "*write regularly, confidently, and fluently to reflect on a range of experiences, ideas, feelings, and texts, developing a personal voice."* Poetic writing: by the end of Year 11, pupils are expected to *"write on a variety of topics, shaping, editing, and reworking texts to express experiences and ideas imaginatively in an extended range of genres."* Transactional writing: by the end of Year 11 pupils	**Introduced in Y2** **High specificity** Requirements are set out as a sub-domain of the *Writing* section. For the primary Years, some guidance is given as to the skills and techniques that should be used in text composition (*e.g.,* "*uses a checklist", "writes paragraphs that contain a main idea and elaboration of the main idea*".) This guidance becomes much more general for Year 8 onwards (e.g. "*Students learn about considerations in drafting and editing such as content, vocabulary, accuracy, cohesion, linguistic and visual forms, textual structures, tone and style."*	**Introduced in Y1** **Medium specificity** The types of texts pupils are to compose are specified Year-on-Year, for example, the types of information texts being produced by the end of Year 3 should be: *-simple fiction texts;* *- lists; and* *-scrapbooks.* However, there is relatively little on specific compositional techniques. The range of texts types for composition widens throughout each Year. The composition process is expected to include *draft, edit and revise* with or without input from peers or teachers as necessary. By the end of Year 3 the expectation is that pupils should be able to write coherently and cohesively, to suit audience and

Domain	England (1999)	England (2007)	Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	New South Wales (2001 and 2003)	Singapore (2001)
			how others use structures and devices for effect. In Y10 -11, writing has a specific focus on pupils being clear about the purpose of their writing and making the correct choices of writing form and style. There is high demand in the use of named devices and techniques to be employed in writing (e.g. parallel structure, repetition, subordination and apposition). A number of statements include using other modes to support writing, including camera, voice, and visuals.	of detail. In the secondary phase, the level of demand increases with pupils expected to write increasingly well-developed stories which include basic elements of fiction. Informational/ expository: in the earlier years pupils are expected to produce brief summaries, interpretations and explanations; by the end of the secondary phase the expectation is that pupils are able to write well organised essays, which have a clear focus and logical development.	are expected to *"write clear, coherent instructions, explanations, and factual reports and express and justify a point of view persuasively, structuring material confidently."* Because progression is set out in terms of outcomes rather than ages, there is no clear break in expectations between primary and secondary.		purpose. By the end of Y11, pupils are expected to be able to pick text type to suit the purpose and audience; and use appropriate organisation structures, style, register and tone.
Evaluate, edit and proof covers: • own writing • others' writing (peers)	**Introduced in Y3** **Low specificity** As part of the planning and drafting process from Y3, pupils are expected to proof and revise their drafts, and discuss and evaluate their own and others' writing. This continues in	**[Secondary curriculum only]** **Low specificity** This is covered in the *writing* section of the curriculum – there are no specific techniques suggested, but pupils are expected to be able to proof-read and evaluate their work.	**Introduced in Y3** **Medium specificity** covered in General Outcome 4: "*…enhance the clarity and artistry of communication"* Reflecting on own writing commences in Y3, with focus on proof reading for errors and some	**Introduced in Y1** **High specificity** During primary, pupils are expected to use knowledge of correct mechanics (end marks, commas for series, capitalization), usage (subject and verb agreement in a simple sentence), and sentence structure	**Introduced in Y9** **Low specificity** At levels 5–6 (approximately Y9–11 and beyond) the expectation is that pupils will interpret, analyse, and produce written texts, identifying and discussing their literary qualities. There are no further	**Introduced in Y2** **Medium specificity** Requirements are set as a sub-domain of the *Writing* section. For the primary Years, some guidance is given as to the skills and strategies that should be used in	**Introduced in Y1** **Low specificity** By the end of Y3 the requirement is for pupils to be able to draft, revise and edit a text with their teacher. By the end of Y11, pupils should be confident in undertaking this process independently or

Domain	England (1999)	England (2007)	Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	New South Wales (2001 and 2003)	Singapore (2001)
	secondary with further emphasis on the critical analysis of pupils' own and others' writing.		improvement to text. In Y5-6 statements cover setting criteria for evaluation and using this to check own and others' work. Some technical review is required. Y5 pupils are expected to "*identify and reduce fragments and run-on sentences*" and "*edit for subject-verb agreement*". At secondary, the focus is on reflecting on the success of producing whole texts, including consistency, effectiveness, use of devices and meeting intended purpose.	(elimination of fragments) when writing and editing. During secondary, pupils should revise writing to improve level of detail and precision of language, combine and vary sentences, rearrange text and improve word choice by using dictionaries or thesauruses. Pupils are expected to evaluate their own work, which in secondary involves developing and applying criteria for different forms of writing.	expectations setting out how pupils should evaluate their own work, or the work of others. No explicit mention of proof reading or editing.	evaluating and editing ("*uses a checklist"* and *"redrafts the same text for different audience*"). This guidance becomes much more general for Y8 onwards (*e.g.* "*different ways of using feedback to improve their texts*").	with peers.
Grammar Covers: • knowledge of the conventions of the written and spoken language • ability to analyse sentences and utterances grammatically • ability to distinguish	**Introduced in Y1** **Medium specificity** From Y1 pupils are expected to show basic grammatical awareness when reading texts. From Y3, expectations are set out in the *language structure*	**[Secondary curriculum only]** **Low specificity** The *Key Concepts* sets out the importance of "*demonstrating a secure understanding of the conventions of written language, including spelling,*	**Introduced in Y1** **Medium specificity** Requirements are set out Year-on-Year in General Outcome 4.2 *Attend to Conventions* that covers spelling, grammar and punctuation. There is little integration of	**Introduced in Y1** **High specificity** Requirements set out in two-Year blocks, in 3 separate sections of the curriculum that cover vocabulary, grammar, and spelling/ punctuation. There	**Introduced in Y1** **No specificity** This curriculum contains no specific requirements for grammatical knowledge. There are references to knowledge of the "*conventions and structures*" of language, but these	**Introduced in Y1** **Medium specificity** Requirements are integrated into the three main domains of the curriculum: *talking and listening*, *reading, and writing*. Each domain refers to grammatical	**Introduced in Y1** **High specificity** Requirements are set out in a separate grammar section of the curriculum. The grammatical content is not integrated into other parts of the curriculum,

Domain	England (1999)	England (2007)	Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	New South Wales (2001 and 2003)	Singapore (2001)
standard from non-standard English	section of the *writing* domain. By the end of primary school, pupils are expected to know: "*word classes and … grammatical functions…; the features of different types of sentence…; the grammar of complex sentences…; the purposes and organisational features of paragraphs.*" By the end of Y11, pupils are expected to know: "*word classes … and their grammatical functions; the structure of phrases and clauses…; paragraph structure and how to form different types of paragraph; the structure of whole texts, including cohesion…; the use of appropriate grammatical terminology…*"	*grammar and punctuation*" and there is then very little detail about grammar functions in the *Key Processes* section. The explanatory notes provide some additional guidance, about verb agreement, formation of past tense and demonstrative pronouns in relation to standard English (*Speaking and Listening*). The 'Writing' guidance notes give supplementary information about grammar devices when varying sentence structure (Y7-9) and demarcating paragraphs (Y7-11).	the grammatical content into other parts of the curriculum. The curriculum is minimal in its listing of specific grammar functions for pupils to learn and use; most statements are broader and address the overall use of correct grammar, for example *"use a variety of strategies to make effective transitions between sentences and paragraphs in own writing"* (Y6), or *"edit for subject-verb agreement"* (Y5). By the end of Y6 pupils are expected to be able to write a simple and compound sentences in clearly constructed paragraphs, using verbs and verb tenses correctly. Secondary phase focuses on use of more complex sentences, and correct construction of sentences to achieve clear	is little integration of the grammatical content into other parts of the curriculum. Pupils are required to learn simple transformational linguistic analysis, and examples of word borrowing, in addition to practical grammar for the pupils' own use.	are not specified.	knowledge. By the end of Y3, pupils are taught to identify some word types, use conjunctions, and use noun/pronoun agreement. By the end of Y7, pupils have covered, for example: distinguishing between colloquial and formal language; adverbial phrases and adjectival phrases; word chains, synonyms, antonyms; and relative pronouns. Beyond Y7, the curriculum documents are much less specific; they talk in terms of 'appropriate' language rather than specifying knowledge or particular grammatical features.	although there is guidance on how to use texts to teach grammatical features. The content is specified in great detail. Progression is fast and demanding up to Y7. After that, the focus is on consolidation of concepts that have already been introduced. There is little or no new grammar in the curriculum after Y7.

Domain	England (1999)	England (2007)	Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	New South Wales (2001 and 2003)	Singapore (2001)
			communication.				
Spelling Covers: • spelling strategies • encoding • spelling rules • sight vocabulary • affixes • extending spelling repertoire	**Introduced in Y1** **Medium specificity** Requirements in both the reading and writing domain from Y1. Spelling strategies set out for learning basic spelling, along with strategies for checking spelling. From Y3 it is expected that pupils understand and apply morphology in spelling. From Y7 onwards pupils are expected to increase existing knowledge, spell more complex words, and use a range of resources in checking spelling.	**[Secondary curriculum only]** **Low specificity** There is very little specification of spelling at secondary. For Y7-9, pupils are expected to apply knowledge of spelling strategies, for regular and irregular words and increase their knowledge of root words, their derivations and affixes.	**Introduced in Y1** **High specificity** General Outcome 4.2 *attend to spelling* is a discrete domain within General Outcome 4 *"…enhance the clarity and artistry of communication* ". Spelling also addressed in General Outcome 2.1 *"Use strategies and cues".* There is a fairly broad approach to spelling, with statements such as *"connect letters with sounds in words* (Y1)" and "*use phonic knowledge and skills and visual memory to attempt to spell words*". Complexity of demand increases each Year; increasing the number of syllables in words expected to be spelt correctly and with attention moving to application of spelling	**Introduced in Y2** **Medium specificity** Requirements for spelling are covered in the *Standard English Conventions'* sub-domain. Expectations for spelling are introduced in Y2, with pupils required to use correct spelling of sight and/ or spelling words. From Y4 pupils are expected to be able to spell commonly used homophones, and apply letter sound, word parts, word segmentation, and syllabication to monitor and correct spelling. From Y6, pupils are expected to continue to use standard English spelling when writing and editing. The strategies are a mixture of phonics (mainly) and knowledge of	**Not specified** Spelling is briefly mentioned in the achievement objectives, first appearing at level 3 (approximately Y5–6) with a requirement to use correct conventions in writing. There are no specified spelling strategies contained in the curriculum document.	**Introduced in Y1** **Medium specificity** Requirements are set out as a sub-domain of the *Writing* section. For the early primary Years, there is some specification of grapheme types (*"writes letters for double vowels"*), but this is not comprehensive. In later Years, the focus is on the skills and strategies used for good spelling, for example, using knowledge of familiar prefixes and suffixes to spell unfamiliar words. Expected outcomes are fairly broad and give a general overview of what a pupil who reaches the expected standard will be able to do.	**Introduced in Y1** **Low specificity** There is a short *'starter list'* of just over 300 words that pupils are expected to be able to use, spell and understand by the end of Y5, with the expectation that pupils apply knowledge of spelling conventions and strategies in their own writing. No further expectations for spelling are set out beyond the end of Y5.

Domain	England (1999)	England (2007)	Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	New South Wales (2001 and 2003)	Singapore (2001)
			conventions and meaning and function of words. There is greater attention to spelling strategies at secondary than other curricula analysed. Y10 ends with focus on proof-reading using spelling variants for effect and careful attention to spelling in writing.	syllable boundaries. Overall, the Massachusetts curriculum contains very little detail of spelling.			
Handwriting Covers: • writing numbers and letters • use of technology	**Introduced in Y1** **Low specificity** In Y1-2 the expectation is for pupils to develop a legible style, in both handwriting and presentation. In Y3-6 pupils are expected to write legibly in both joined and printed styles, using different forms of handwriting for different purposes. In secondary pupils are expected to write with fluency and speed, presenting final, polished work.	**[Secondary curriculum only]** **Low specificity** As might be expected at this age level, there is very little detail. Pupils are expected to be able to write legibly and at speed.	**Introduced in Y1 (to Y6)** **Low specificity** (but greater than other curricula analysed). Consistent with England 1999 in correct formation of letters, and correct spacing. Joined writing is introduced in Y4.	**Introduced in Y2** **Low specificity** Requirements for handwriting set out in the *standard English conventions* sub-domain, which expects pupils to learn the patience and discipline required to polish their final work. In Y1 pupils are required to print upper- and lower-case letters. In Y2 the expectation is that they will start to print legibly, using correct spacing. By the end of Y5 the expectation is that the majority of	**Introduced in Y1** **Low specificity** Handwriting is included in the achievement objectives for visual language, as part of processing information. Handwriting objectives cover levels 1 to 4 (approximately Y1–8). At levels 1–2 (approximately Y1–4) the expectation is that pupils should write letter and number forms legibly. At level 3–4 (approximately Y5–8) pupils are expected to	**Introduced in Y1** **Medium specificity** Requirements are set out as a sub-domain of the *Writing* section. There is much more detail provided for expected outcomes than for content. For example, for Y3, the content section says that pupils should "*develop handwriting of consistent size and spacing"*, while the outcomes section specifies: *"starts at the top of every upper-case letter, lower-case letter*	**Introduced in Y1** **Low specificity** Pupils are expected to use print script, spacing letters, words and sentences appropriately by the end of Y3. Progression is specified with pupils expected to be writing in a joined script by the end of Y5. No further handwriting requirements beyond Y5.

Domain	England (1999)	England (2007)	Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	New South Wales (2001 and 2003)	Singapore (2001)
				pupils will write legibly in joined style, leaving space between letters in a word and between words in a sentence. From Y6 onwards, pupils are expected to continue to address these issues, and apply the standard English conventions of handwriting.	handwrite fluently.	*and number, except 'd' and 'e' (which start in the middle) and knows that no letter starts from the bottom*." By the end of Y7, pupils should "*experiment with personal handwriting style to enhance fluency, speed, legibility and appeal*".	

Table A4: English language variation

Domain	England (1999)	England (2007)	Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	New South Wales (2001 and 2003)	Singapore (2001)
Standard & Non standard English and language variation Covers: • formal and informal language • cultural and regional differences in language use	**Introduced in Y1** **Medium specificity** In Y1-2 pupils are expected to be introduced to some of the main features of standard English in speaking and listening, and writing. Through Y3-6 it is expected that pupils should be exposed to the varying degrees of formality of standard English, and some of the difference between standard and non-standard English usage. During secondary, pupils should be using spoken standard English fluently and accurately in formal and informal situations. In writing it is expected that pupils will be able to apply variations in written standard	**[Secondary curriculum only]** **Low specificity** Exposure to the varieties of English is specified as part of the *content* section of the curriculum. Pupils should be exposed to content that includes *"variations in written standard English and how it differs from standard and non-standard spoken language."*	**Introduced in Y8 (to 10)** **Low specificity** Appears in General Outcome 4.1 *Enhance and Improve*. Pupils are required to identify differences in formal and informal language, effects of technology and popular culture on language use and derivation and use of words.	**Introduced in Y1** **Medium specificity** Covered in the *Language* domain, in the *structure and origins of modern English and Formal and Informal English* standards. Pupils are required to study changes to the English language through time, in relation to contact with other languages. By the end of Y11 pupils are expected to be able to identify, describe and apply a range of standard English conventions, and analyse how the language has changed over time.	**Introduced in Y1** **Medium specificity** Covered in the processes for speaking and written texts. Pupils are required to explore oral and written languages; becoming familiar with common conventions and develop the ability to discuss how language features are adapted to suit topic, audience and purpose.	**Introduced in Y1** **Low specificity** The concept of language variation is introduced in Y1, and reinforced in later Years. Pupils are expected to distinguish between different varieties of English and to discuss those varieties. Teachers also have to take into account the fact that, for native speakers of Aboriginal English, Australian Standard English will be unfamiliar. However, the curriculum does not give any detail on what might be meant by 'variation'.	**Introduced in Y1** **Medium specificity** Pupils are required to be able to communicate fluently, appropriately and effectively in internationally acceptable English, with knowledge of how the language system works and how language conventions can vary according to purpose, audience, context and culture. This is expected to be applied in speech and writing in both formal and informal situations. By the end of Y11 the expectation is that they will write in internationally acceptable English that is grammatically correct, fluent and appropriate for purpose, audience, context and culture.

Domain	England (1999)	England (2007)	Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	New South Wales (2001 and 2003)	Singapore (2001)
	English, recognising the differences from spoken language.						

Table A5: Speaking and Listening

Domain	England (1999)	England (2007)	Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	New South Wales (2001 and 2003)	Singapore (2001)
Speaking Covers: • oracy • language development and vocabulary	**Introduced in Y1** **Medium specificity** Speaking is combined with listening and is a separate domain in the programme of study for English. Expectations are defined for *individual speaking skills*, with further expectations defined for *group discussions and interaction* and *drama*. In Y1-2 pupils learn to speak clearly, choosing words with precision, organising their ideas and focusing in the main point. In Y3-6 pupils are taught to speak confidently in a range of contexts, with consideration for audience and purpose. By the end of Y11, pupils are expected to *"speak fluently and appropriately in different contexts,*	**[Secondary curriculum only]** **Low specificity** There is a section dedicated to speaking and listening. Statements on speaking and listening are interwoven within the outcome statements. By the end of Y11, pupils are expected to be able to "*speak fluently, adapting talk to a wide range of familiar and unfamiliar contexts and purposes*", as well as presenting confidently and effectively. The types of speaking activity that pupils are expected to undertake are: *formal presentations and debates; informal discussions; improvisation and performance; and devising, scripting and performing plays.* This curriculum	**Introduced in Y1** **High specificity** Speaking is a feature of all 5 General Outcomes at the highest level. *("All pupils will listen, speak, read, write, view and represent to…")*. Speaking is explicitly covered in: *1.1 discover and explore;* *3.1 plan and focus;* *3.4 share and review;* *4.3 present and share;* *4.1.4 develop and present; and* *5.1 respect others and strengthen community.* There is a strong correlation between speaking and writing, as well as speaking and listening, particularly from Y7 onwards. Unique focus on the role of oral development in developing respect and community. No drama aspect to speaking in the Alberta curriculum.	**Introduced in Y1** **Medium specificity** Requirements for speaking are covered in the language domain. This domain is comprised of four sub-domains: *discussion; questioning, listening and contributing; oral presentation; and vocabulary* and *concept development.* Speaking requirements are embedded within all areas. Expectations are combined for Y1-3 and then in 2 Year blocks. The sub-domain of *Vocabulary and Concept Development* has standards set out for the end of Y1, in addition to the end of Y3 (whereas other sub-domains set combined standards for Y1 – 3). Indicating the level of	**Introduced in Y1** **Low specificity** Requirements for speaking are covered in the oral language domain, which is split into speaking and listening. The speaking domain is split into 2 functions: interpersonal speaking and using texts. At *Interpersonal speaking* level 1 (approximately Y1–2) pupils are expected to converse, and talk about personal experiences. At level 6 (approximately Y11 and beyond) pupils are expected to speak independently, confidently and effectively to suit the audience and purpose. At *Using Texts At* level 1 (approximately Y1–2), pupils are expected to tell a story, recite, or	**Introduced in Y1** **High specificity** Speaking is set out within *Talking and listening*. Until the end of Y7, very detailed indicators of attainment are set out for four sub-domains in each stage: *talking and listening; skills and strategies; context and text;* and *language structure.* For example, by the end of Y7, pupils should "*recognise the main organisational structures of spoken text types studied, e.g. exposition, explanation",* and *"rehearse and modify a talk before presenting it to peers or the class, e.g. reorder ideas."* Beyond Y7, there is less specific emphasis on speaking as the outcomes are set out in terms of general language	**Introduced in Y1** **Low specificity** The curriculum document has a separate and dominant *Language for Social Interaction*, which focuses on speaking (and listening). This domain runs parallel to the non-literary and literary domains. Expectation by the end of Y3 is that pupils speak fluently and expressively on a range of topics, using clear pronunciation and speech to convey meaning. By the end of Y11 pupils are required to be able to present and develop ideas effectively in speech for a variety of different purposes and audiences; monitoring and adjusting presentation to sustain audience interest and responding to

Domain	England (1999)	England (2007)	Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	New South Wales (2001 and 2003)	Singapore (2001)
	adapting their talk for a range of purposes and audiences." Drama is specified as a part of speaking.	has some mention of drama; setting out dramatic approaches, techniques, factors contributing to dramatic moments and evaluating own dramatic performances.		progression expected in this sub-domain between Y1-3. By Y11 pupils are expected to be proficient in speaking for a range of purposes and audiences, have the ability to evaluate and analyse their own and others' speech. Drama is limited to responding to dramatic literature in the *Reading* domain. There is no focus on dramatic performance.	read aloud. At level 6 (approximately Y11 and beyond) a pupil should be able to use different techniques of speech and delivery on a wide range of texts in an organised and effective manner, drawing on different techniques. The programme of study sets out the processes for understanding and using oral language: *exploring language, thinking critically and processing information.* The processes cover 2 levels, which roughly equates to 4 teaching Years. There is no specific mention of drama or dramatic techniques.	ability. By Y11, pupils should be able to compose *"increasingly sophisticated and sustained texts for understanding, interpretation, critical analysis and pleasure."*	questions.

Domain	England (1999)	England (2007)	Alberta (2000 and 2003)	Massachusetts (2001)	New Zealand (1994)	New South Wales (2001 and 2003)	Singapore (2001)
Listening Covers: • listening • processing information • understanding others and asking questions • responding to stories and information read aloud	**Introduced in Y1** **Medium specificity** *Listening* is combined with *Speaking* and is a separate domain in the programme of study for English. Listening skills are defined separately, with the expectation that pupils listen, understand and respond to others. Listening is also defined as an integral part of *group discussion* and *interaction, and drama*. Through primary, pupils should be exposed to an increasing range of opportunities to listen. By the end of Y11, pupils are expected to *"listen, understand and respond critically to others"*, and participate in group discussions.	**[Secondary curriculum only]** **Low specificity** There is a section dedicated to speaking and listening. As with speaking, the types of listening activity that pupils are expected to undertake are: *formal presentations and debates; informal discussions; improvisation and performance; and devising, scripting and performing plays.* By the end of Y11, pupils are expected to be able to listen to "*complex information*", as well as "*judge the intentions and standpoint of a speaker.*"	**Introduced in Y1** **High specificity** Listening is a feature of all 5 General Outcomes at the highest level. *("All pupils will <u>listen</u>, speak, read, write, view and represent to…")*. *Listening* is closely paired with *speaking* in all Years and there is significantly less content than that for *speaking*. Earlier Years focus on becoming a good listener in a range of situations. In later Years this includes asking focused questions to improve and show understanding. At Y10 Alberta expects pupils to be able to detect subtle nuances when listening, for example *"differentiate between audience response to the content of a presentation and audience response to the presenter."*	**Introduced in Y1** **Medium specificity** Requirements for listening are covered in the *language* domain, specifically in the *questioning, listening and contributing* sub-domain. Expectations are set for Y1-3 and then in 2 Year blocks. The initial expectation is for pupils to contribute to class discussions, working towards generating questions to develop knowledge. From Y6 upwards the use of listening skills are more focused, with pupils expected to interview and contribute to focused discussions in order to acquire new knowledge.	**Introduced in Y1** **Low specificity** Requirements for speaking are covered in the *oral language* domain, which is split into *speaking* and *listening*. The listening domain is split into 2 functions: *interpersonal listening and listening to texts.* At *Interpersonal Listening* at level 1 (approx. Y1–2), pupils are expected to listen and respond to others, or texts (relating texts to personal experience). At level 6 (approx. Y11 and beyond) pupils are expected to interact and respond, to deepen their understanding in both communication and of texts. The programme of study sets out the processes for understanding and	**Introduced in Y1** **High specificity** Listening is set out within "*Talking and listening*". Until the end of Year 7, very detailed indicators of attainment are set out for 4 sub-domains in each stage: talking and listening; skills and strategies; context and text; and language structure. For example, by the end of Y7, pupils should *"recognise when an opinion is being offered as opposed to fact "*, and *"take notes from a range of spoken texts, e.g. guest speaker, television program, video".* Beyond Y7, there is less specific emphasis on speaking and listening – the outcomes are set out in terms of general language ability.	**Introduced in Y1** **Medium specificity** The curriculum document has a separate and dominant *Language for Social Interaction* domain, which focuses on listening (and speaking). Pupils are required to listen for information from a variety of sources, both literary and informational from Y1. Expectations are also set out for social interaction. However, specific listening techniques or skills are not covered. In Y1 the focus of listening skills is on sustaining concentration, specifically when a teacher is reading aloud and also demonstrating understanding. Expectations by Y11 are that pupils can participate fully and productively in group discussions and debates, with knowledge of discourse markers, verbal cues and the use of formal and

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					using oral language: *exploring language; thinking critically; and processing information.* The processes cover 2 levels, which roughly equates to 4 teaching Years.		informal English. Pupils should also be able to process information to take notes on main ideas and details.

Appendix B: Mathematics curriculum comparison tables

Table B1: High-level organisation

	England (1999)	England (2007)	Flemish Belgium (2010)	Finland (2004)	Hong Kong (1999 and 2000)	Massachusetts (2000 and 2004 addendum)	Singapore (2001)
High level organisation of curriculum document **Definition of curriculum statements**	<u>Statement type and Year groupings:</u> Defines the curriculum by learning outcomes for each Key Stage: KS[vii]1 (Y[viii]1-2) KS2 (Y3-6) KS3 (Y7-9) KS4 (Y10-11) <u>Typical statement stem:</u> *"Pupils should be taught to…"* <u>Attainment:</u> Expected levels of attainment are set out in a separate section 'Attainment Target Level Descriptors'. <u>Organisation of content:</u> Programme of study for mathematics (Knowledge, skills	<u>Statement type and Year groupings:</u> Defines the curriculum by learning outcomes for each Key Stage: KS3 (Y7-9) KS4 (Y10-11) <u>Typical statement stem:</u> *"The study of mathematics should include …"* <u>Attainment:</u> Expected levels of attainment are set out in a separate section 'Attainment Target Level Descriptors'. <u>Organisation of content:</u> Programme of study for mathematics is arranged into 3 key domains (Range	<u>Statement type and Year groupings:</u> Defines the curriculum by final objectives by Key Stages: End of primary (Eng. Y 7) Secondary: Stage 1 - (Eng. 8 - 9) Stage 2 - (Eng. Y 10-11) <u>Typical statement stem:</u> *"The pupils…"* <u>Attainment:</u> The curriculum final objectives serve as expected levels of attainment for each Year. Minimum objectives are what the educational authorities consider necessary and feasible for a	<u>Statement type and Year groupings:</u> Defines the curriculum by core content. Preschool (Eng. EYFS[ix] – Y 2) Grades 1-2 (Eng.Y 3-4) Grades 3-5 (Eng. Y 5-7) Grades 6-9 (Eng. Y 8-11) <u>Typical statement stem:</u> *"The pupils will…"* <u>Attainment:</u> Expected levels of attainment are set out as Description of good performance at the end of each stage. A set of performance indicators at the end of each stage. Except at end of Y11, attainment is	<u>Statement type and Year groupings:</u> Defines the curriculum by Key Stages: KS1 P1-P3 (Eng. Y2-4) KS2 P4- P6 (Eng. Y5-7) Secondary S1-S4 (Eng. Y8-11) <u>Typical statement stem:</u> Primary each domain begins with: *"Learners…"* *Secondary each domain begins: "To develop students an ever-improving capability to …"* Primary/Secondary statements are then followed by a range of opening curriculum statements: *"Develop an understanding.";*	<u>Statement type and Year groupings:</u> Defines the curriculum by two-Year spans. PreK–K (Eng. EYFS-Y 1). Grades 1-2 (Eng. Y 2-3) Grades 3-4 (Eng. Y 4-5) Grades 5-6 (Eng. Y 6-7) Grades 7-8 (Eng. Y 8-9) Grades 9-0 (Eng. Y 10-11) <u>Typical statement stem:</u> At each Year each domain begins with *"Students engage in…"* followed by the domain heading. Curriculum statements then vary including: *'understand, use, estimate, demonstrate,*	<u>Statement type and Year groupings:</u> Defines the curriculum by learning outcomes specified Year by Year: P1-P6 – (Eng. Y 2-7) S1-S4 – (Eng. Y 8 - 11) <u>Typical statement stem:</u> *"Pupils should be able to…"* <u>Attainment:</u> The curriculum statements serve as expected levels of attainment for each Year. <u>Organisation of content:</u> - *Whole numbers*; - *Money, Measures and Mensuration*;

	England (1999)	England (2007)	Flemish Belgium (2010)	Finland (2004)	Hong Kong (1999 and 2000)	Massachusetts (2000 and 2004 addendum)	Singapore (2001)
	and understanding is arranged into 3 key domains: - *Number and Algebra* (Algebra introduced at Y 7-9); - *Shape, Space and Measures*; and - *Handling Data* (domain introduced Y3-6). The breadth of study specifies the increasing range of activities, contexts and purposes through which pupils should be taught knowledge, skills and understanding.	and Content): - *Number and Algebra*; - *Geometry and Measures*; and - *Statistics*. Cross cutting processes are included in the following additional domains: - *Key Concepts*; - *Key Processes*; and - *Curriculum Opportunities*. There are detailed guidance notes alongside the Programme of Study statements in the curriculum document.	particular part of the pupil population. Final objectives apply to a minimum set of knowledge, skills and attitudes for this part of the pupil population. <u>Organisation of content:</u> Programme of study for mathematics is arranged into the following domains: - *Number Theory*; - *Algebra*; - *Measurement*; - *Geometry*; - *Statistics* (and problem solving skills – primary); and - *Real Functions*. Cross-cutting processes are included within: - *Procedures*; - *Skills*; and - *Attitudes*.	defined as Final assessment criteria for Y9. <u>Organisation of content:</u> Programme of study for mathematics is arranged into the following domains: - *Numbers and Calculations*; - *Algebra*; - *Geometry;* - *Measurement;* - *Data Processing and Statistics* (including probability at Y 5-7); and - *Functions* (Y 8-11). Cross-cutting processes are included within: *Thinking and working skills and objectives*.	*"Recognise…"; "Describe…Explore… Perform" and "Formulate…judge… enquire…manipulate".* <u>Attainment:</u> The curriculum statements serve as expected levels of attainment for each Key Stage. Presentation varies by Key Stage. <u>Organisation of content:</u> Programme of study for mathematics is arranged into 5 key areas that are first introduced at various Key Stages. These are: - *Number*; - *Shape and space*; - *Measures*; - *Data handling*; and - *Algebra*.	*identify, find, compare, sort and classify…"* <u>Attainment:</u> The learning standards (curriculum statements) specify what students should know and be able to do at the end of each Year. <u>Organisation of content:</u> - *Number Sense and Operations*; - *Patterns, Relations, and Algebra*; - *Geometry*; - *Measurement*; and - *Data Analysis, Statistics, and Probability*.	- *Statistics*; - *Geometry*; - *Fractions*; - *Decimals*; and - *Algebra*.

	England (1999)	England (2007)	Flemish Belgium (2010)	Finland (2004)	Hong Kong (1999 and 2000)	Massachusetts (2000 and 2004 addendum)	Singapore (2001)
Curriculum aims and principles Note: Many statements have been paraphrased for the purpose of this document. It is necessary to view the curriculum documents to see the aims in full.	Statement about *"the importance of mathematics…"* *"Mathematics equips pupils with a uniquely powerful set of tools to understand and change the world. These tools include logical reasoning, problem-solving skills, and the ability to think in abstract ways."* *"Mathematics is important in everyday life, many forms of employment, science and technology, medicine, the economy, the environment and development, and in public decision making. Different cultures have contributed to the development and application of mathematics."* *"Today, the subject transcends cultural*	*"Learning and undertaking activities in mathematics contribute to achievement of the curriculum aims for all young people to become:* *• successful learners who enjoy learning, make progress and achieve;* *• confident individuals who are able to live safe, healthy and fulfilling lives; and* *• responsible citizens who make a positive contribution to society."* Statement on the importance of mathematics, which is largely the same as the statement in the 1999 document.	No reference to curriculum aims and principles within English translation of Flemish Belgium curriculum.	*"The task of instruction in mathematics is to offer opportunities for the development of mathematical thinking, and for the learning of mathematical concepts and the most widely used problem-solving methods. The instruction is to develop the pupil's creative and precise thinking, and guide the pupil in finding and formulating problems, and in seeking solutions to them. The importance of mathematics has to be perceived broadly; it influences the pupil's intellectual growth and advances purposeful activity and social interaction on his or her part."* *"Mathematics instruction must progress systematically and*	*"Mathematics pervades all aspects of life, whether at home, in civic life or in the workplace. It has been central to nearly all major scientific and technological advances. Also, many of the developments and decisions made in industry and commerce, the provision of social and community services as well as government policy and planning, rely to an extent on the use of mathematics. It is important for our students to gain experience and build up the foundation skills and knowledge in mathematics that can facilitate their future development in various aspects. It is also important that our students are able to value mathematics and appreciate the beauty of mathematics after mathematics*	The curriculum document outlines a set of beliefs/philosophical statements that are called "*Guiding Philosophy (problem solving, communicating, reasoning and proof, making connections and representations) and Guiding Principles"* set around the mathematical processes and the "*teaching, learning, technology, equity and assessment of mathematics."* Information in the curriculum document is very detailed - the extract above is an illustrative example only.	*"This curriculum framework envisions all students in the Commonwealth achieving mathematical competence through a strong mathematics program that emphasizes problem solving, communicating, reasoning and proof, making connections, and using representations. Acquiring such competence depends in large part on a clear, comprehensive, coherent, and developmentally appropriate set of standards to guide curriculum expectations."*

	England (1999)	England (2007)	Flemish Belgium (2010)	Finland (2004)	Hong Kong (1999 and 2000)	Massachusetts (2000 and 2004 addendum)	Singapore (2001)
	boundaries and its importance is universally recognised." *"Mathematics is a creative discipline. It can stimulate moments of pleasure and wonder when a pupil solves a problem for the first time, discovers a more elegant solution to that problem, or suddenly sees hidden connections."*			*create a lasting foundation for the assimilation of mathematical concepts and structures. The discipline's concrete nature serves as an important aid in bringing together the pupil's experiences and systems of thought with the abstract system of mathematics. Problems that come up in day-to-day situations, and that can be resolved with the aid of mathematical thinking or operations, are to be utilized effectively. Information and communication technology are to be used to support the pupil's learning progress."*	*education in school. In the information explosion era, there are drastic changes both in our society and in the background of our students. It is vital that the curriculum should undergo continuous review and renewal in order to meet the needs of our students and the community."*		

Table B2: Sub-Domain: Mathematical processes

Sub-domain definition	England (1999)	England (2007)	Hong Kong (1999 and 2000)	Singapore (2001)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
Solving problems	**Medium specificity** Each Key Stage specifies an increasing level of mathematical process under the following three headings: *Problem solving*; *Communicating*; and *Reasoning*. Problem solving is also defined as one of a number of over-arching key skills: selecting and using methods and techniques; developing strategic thinking; and reflecting on whether the approach taken to a problem was appropriate.	**High specificity** Each Key Stage specifies an increasing level of mathematical process under the following headings: *Representing*; *Analysing*; *Use appropriate mathematical procedures*; *Interpreting and evaluating*; and *Communicating and reflecting*.	**Medium to High specificity** In the curriculum, fundamental and intertwining ways of learning and using knowledge such as inquiring, communicating, reasoning, conceptualizing, and problem-solving are considered Important. Mathematical processes are to be used to formulate and solve problems in daily life as well as in mathematical contexts.	**High specificity** The Framework of the Mathematics Curriculum for both primary and secondary, places mathematical problem-solving at the centre of the mathematics curriculum involving five separate domains: *Concepts*; *Skills*; *Attitudes*; *Processes*; and *Metacognition*. *Concepts* covers: Numerical; Algebraic; Geometrical; Statistical; Probabilistic; and Analytical. *Skills* covers: Numerical; calculation; Algebraic Manipulation; Spatial visualisation; Data Analysis; Measurement; Use of Mathematical Tools; and Estimation.	**Medium specificity** The specific final objectives for mathematics relate to *knowledge*, *insights*, *skills* and *attitudes* which pupils use to: -link mathematics and practical applications from everyday life and in doing so relate problems from society, science and technology; -link items within mathematics and in doing so structure their mathematical frame of reference more systematically; -develop a mathematical way of thinking and reasoning, closed and open problems mathematically, analyse them, and argue and discuss solutions; and -communicate about	**Medium to High specificity** The instruction is to develop the pupil's creative and precise thinking, and guide the pupil in finding and formulating problems, and in seeking solutions to them. Problems that come up in day-to-day situations, and that can be resolved with the aid of mathematical thinking or operations, are to be utilized effectively.	**Medium to High specificity** This curriculum framework envisions all students in the Commonwealth achieving mathematical competence through a strong mathematics program that emphasizes problem solving, communicating, reasoning and proof-making connections, and using representations. To become good problem solvers, students need many opportunities to formulate questions, model problem situations in a variety of ways, generalize mathematical relationships, and solve problems in both mathematical and everyday contexts.

Sub-domain definition	England (1999)	England (2007)	Hong Kong (1999 and 2000)	Singapore (2001)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
				Attitudes covers: Beliefs; Interests; Appreciation; Confidence; and Perseverance. *Mathematical processes* covers: Reasoning; Communication and Connections; Thinking Skills and Heuristics; and Application and Modelling. *Metacognition* covers: Monitoring of one's own Thinking; and Self-Regulation of Learning.	mathematically described situations, including the fluent use of a more specific mathematical language.		

Table B3: Sub-Domain: Whole numbers and four operations

Sub-domain definition	England (1999)	Hong Kong (2000)	Singapore (2001)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
Addition and subtraction Introduction: concept with simple calculations	**Covered in Y1-2** **High specificity** The topic is broken down significantly with detailed specification and exemplification, which clearly articulates the level of challenge as follows: • conceptual development (e.g. the relationship between both operations); • mental recall (addition and subtraction facts to 10 and use of knowledge to derive facts with totals to 20); • mental methods to derive unknown facts from known facts (addition of 10 to any single-digit number; then addition and subtraction of a multiple of 10 to or from a two-digit number); • use of signs (for recording number sentences accurately); and • solving problems	**Covered in Y2** **Medium- high specificity** Specifies requirements for the Year which clearly defines progression, and breaks down key elements to define challenge. The following are covered: • Conceptual development; • Mental arithmetic (addition and subtraction within 18); • Written methods (horizontal method with 2 digits); and • Problem-solving.	**Covered in Y2** **Medium - high specificity** Specifies requirements for a Year which clearly defines progression. Challenge is also clearly defined by specifying addition and subtraction of numbers to 100 and by noting the inclusion of signs, but exclusion of the formal algorithm. Topic is further broken down to specify its key elements which further articulates challenge, including: • conceptual: the relationship between the two operations; • mental recall: number facts - 9+9 number bonds; • mental methods: with 1s and 10s; • written methods: with 1s, 10s and 2-digit by 2-digits; and	**Standard expected by end of Y7** **Low-medium specificity** Primary is one Key Stage with content defined as end of primary outcomes. Early conceptual development is not specified. This topic area is broken down to some extent to define breadth and challenge. Mental recall and arithmetic is distinguished as follows: • recall of addition/ subtractions up to 10; • mental arithmetic of addition/ subtraction up to 100 and other large numbers ending in zero; and • Written methods: addition with a maximum of 5 figures: the sum < 10,000,000; subtracted number <10,000,000 and a maximum of 8 figures.	**Covered in Y3-4** **Low specificity** Introduction to mathematical concepts and basic calculations related to: • Addition and subtraction and connections (natural numbers); and • Algorithms and mental calculations. But these are not specified explicitly. Rather they are implicit in high level statements at this stage.	**Covered in Y2-3** **Medium specificity** Specifies requirements for a two Year Key Stage. Topic is broken down and exemplified to articulate key elements that define level of challenge. The sequence of statements implies a progression as follows: • conceptual development (various meanings of addition/ subtraction – e.g. repeated addition; subtraction as separation; inverse relationship); • mental recall: addition and related subtraction facts (addends to ten) facts; and • problem-solving.

Sub-domain definition	England (1999)	Hong Kong (2000)	Singapore (2001)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
	Progression is less clearly defined in programme of study for early primary as the content is set out as a Key Stage. Attainment target level descriptors (ATs) provide an indication of expected progression.		• problem-solving. Some exemplification is also provided, but is limited. Statements are more precise, fewer in number and less descriptive than the England 1999 Programme of Study.			
Addition and subtraction Further development – conceptual understanding, recall of facts, written and mental methods.	**Y3-6**	**Y3-4**	**Y3**	**Standard expected by end of Y7**	**Y3-4 and Y8-11**	**Y2-3 and Y4**
	Medium-high specificity The programme of study clearly defines the level of challenge of key elements to be covered by the end of primary Y6. These are: • mental recall (addition and subtraction facts for each number to 20; addition and subtraction of positive integers less than 1000, then up to 10,000); • mental methods to derive unknown facts (addition of two-digit numbers to make 100, then addition or	**Medium - high specificity** Clearly articulates challenge by specifying on a Year basis and describing elements/ steps to be covered. • Y3 - within 3 digits • Y4 - within 4 places	**Medium - high specificity** Clearly articulates challenge by specifying on a Year basis and describing elements/ steps to be covered. For Y3, limits of challenge are defined as addition and subtraction of numbers up to 3 digits with formal algorithm. Further detail is included to distinguish mental arithmetic requirements of 3 digits by 1s, 10s and 100s. For Y 4, limits of	**As above**	**Low specificity** See above for Y3-4 Y8-11 indicates a strengthening of calculation skills but no further specification.	**Medium specificity** Clearly articulates expectations by generally specifying on a Year basis and breaking down requirements. Specification of mental recall addition and subtraction is limited : • Y2-3: Addition and subtract up to four-digit numbers – conventional algorithm not required; and • Y4: addition of two 3-digit numbers and three 2-digit numbers; subtraction of two 3-digit numbers – ability

Sub-domain definition	England (1999)	Hong Kong (2000)	Singapore (2001)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
	subtraction of any pair of two-digit whole numbers; handle particular cases of three-digit and four-digit additions and subtractions by using compensation or other methods); and • written methods (addition and subtraction of positive integers less than 1000, then up to 10000. Y3-6 is a large Key Stage (Therefore, for middle to upper secondary, progression is less clear in the programme of study. However, Attainment Targets (ATs) indicate a clearer progression as follows: Level 3 AT: *“add and subtract numbers with two digits mentally and numbers with three digits using written methods”;* and Level 4 AT: *“use efficient written methods of addition and subtraction”* (number of digits to include in calculations not specified).		challenge are defined as addition and subtraction of numbers up to 4 digits with formal algorithm. Further detail included to distinguish mental arithmetic requirements of calculations with 2 digits.			to use algorithm.

Sub-domain definition	England (1999)	Hong Kong (2000)	Singapore (2001)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
Multiplication and division Introduction: concept and simple calculations.	**Covered in Y1-2; and Y3-6** **High specificity** Requirements to develop conceptual understanding and basic methods of division and multiplication are very descriptive. For Y1-2: • Conceptual development (e.g. specifies the relationship between halving and doubling; multiplication as repeated addition; division as grouping/ repeated subtraction); • mental recall (recall of multiplication facts for the x2 and x10… and 'corresponding division facts'); • use of signs (for recording number sentences accurately) but no written methods included at this level in programme of study; and • solving problems.	**Covered in Y 3** **Medium specificity** Articulates challenge by specifying content on Year basis and stating concept of multiplication and division. Content statements are very concise with no exemplification. Statements cover the following: • develop conceptual understanding (specifies sharing and grouping for division; commutative property of multiplication; relationship between two operations); and • Perform basic calculations (specifies with remainders for division).	**Covered in Y 2** **Medium - high specificity** Articulates challenge by specifying content on Year basis and describing elements/ steps to be covered. For multiplication, level of challenge defined as products no greater than 40. Breaks down topic in more detail, to highlight other essential elements, including meaning of multiplication as repeated addition, simple calculations, and solving problems involving pictorial representations. For division, level of challenge defined as division of numbers not greater than 20 (excluding division sign). Delivery of topic is indicated by specifying division in context of quantities/ objects only.	**Not specified** Introduction of concept and basic calculations not specified explicitly, but they are implicit in specification described in rows below.	**Covered in Y 3-4** **Low specificity** Introduction to concept and basic calculations not specified explicitly, but implicit in high level statements related to multiplication and division so introduction implicit at this stage.	**Covered in Y 3** **Medium specificity** Specifies requirements for a two Year block. But topic is broken down and exemplification included to articulate key elements, which clearly define level of challenge. Also, sequence of statements implies a progression: • Meaning of operations; and • Basic calculations.

Sub-domain definition	England (1999)	Hong Kong (2000)	Singapore (2001)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
	Early primary (Y 1-2) is defined as a Key Stage. Therefore, progression is less clear. However, attainment targets provide greater indication of the progression.					

Table B4: Sub-Domain: Whole number - multiplication and division

Sub-domain definition	England (1999[x])	Hong Kong (2000)	Singapore (2001)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
Multiplication and division of whole number Times tables and related division facts.	**Y 3-6**	**Y 3**	**Y 3- 4**	**Y 7**	**Y 5-7**	**Y 4- 5**
	Medium specificity The programme of study clearly defines the level of challenge to be taught in: • Early primary: x2 and x10 times tables and related division facts; and • By end of primary: recall of 10 x 10 times tables and related division facts. The programme of study indicates some progression by phasing the challenge over two Key Stages. However, the progression is more clearly described in the ATs as the challenge is broken down further into more stages (eg. L3 ATs: *"mental recall of the 2, 3, 4, 5 and 10 multiplication tables and derive the associated division facts"*).	**Medium** Defined for a Year. Challenge clearly defined (*"Construct multiplication tables to 10"*), but sub-domain not broken down further as done in other jurisdictions' curriculum.	**Medium - high specificity** Defined for a Year and breaks down topic area into two levels of challenge over two Years so clearly articulates progression. • Y3 includes times tables and related division facts for 2,3, 4, 5 and 10 (introduces division sign but excludes division with remainders) • Y4 specifies requirement to memorise all tables to 10 x 10 and related division facts.	**Medium specificity** Challenge at the end of primary is clear (up to 10 x 10) but progression within the stage is not specified.	**Low - Medium specificity** Defined for a three Year block. *"Multiplication times tables"* explicitly specified, but not explicit to number of times tables (i.e. whether 10 x 10 or 12 x 12).	**Medium specificity** Defined explicitly for a Year. Challenge of sub-domain divided over two Years: • Y4: 10 x 10 • Y5: 12 x 12 Sub-domain not broken down further in earlier Years as in England and Singapore.

Sub-domain definition	England (1999)	Hong Kong (2000)	Singapore (2001)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
Multiplication and division (by one-digit multiplier or divisor)	**Y 3-6**	**Y 4**	**Y 4 and Y 5**	**By Y 7**	**Y 3-4 and/or 5-7**	**Y 4-5**
	Medium specificity Defined for Key Stage only, but further information in ATs. Challenge and progression are clear, if in places implicit. For example: • Y3-6: *"use written methods for short multiplication and division by a single-digit integer of two-digit then three-digit then four-digit integers".*	**Medium - High specificity** Defined for a Year. Challenge and progression are clearly defined, in particular by breaking down sub-domain (see previous and next row) and defining on a Year basis: • Division and multiplication of 2 or 3 digits by 1.	**Medium - High specificity** Defined for a Year. Challenge and progression are clearly defined, in particular by defining on a Year basis. For example: • Y4: Multiplication and division up to 3 by 1; and • Y5: Division of numbers up to 4 digits by a 1 digit whole number and by 10.	**Low specificity** Not explicit, but implicit in statement for end of primary expectations: • *"multiplier consists of a maximum of three figures"*; and *"division: the divider consists of a maximum of 3 figures"*.	**Low specificity** Not specified explicitly. Implicit in high level statement encompassing multiplication in general ('multiplication' and 'Algorithms and mental calculations') in Y3-4 and Y 5-7. Therefore, it is assumed this is covered in mid-late primary.	**High-Medium specificity** Defined for a Year and challenge explicitly defined by stating: • Y4: Up to 2 digit by 1 digit numbers • Y5: Up to 3 by 1 (with or without remainders). Progression clear by requirements stated in following Year (see row below).
Long multiplication (up to 3 digits by a 2 digit number)	**Y 2-6**	**Y 5**	**Y 5**	**Y 7**	**Y 5-7**	**Y 5**
	Medium specificity Defined for Key Stage only, but further information in ATs. Challenge and progression are clear, if in places implicit: • *"use long multiplication, at first for two-digit by two-digit integer calculations, then for three-digit by two-digit calculations".*	**Medium-high specificity** Defined on a Year basis. Challenge and progression is clearly presented (see previous row): • *"perform multiplication with multiplied 2 digits and multiples of 3".* To note, no explicit mention of use of formal algorithm.	**Medium-high specificity** Defined on a Year basis. Challenge and progression is clearly presented (see previous row): • *"multiply numbers up 'to 3 digits by a 2 digit number' and '4 by 1."* To note, no explicit mention of use of formal algorithm.	**Low-medium specificity** Defined for end of primary only. Challenge is clear but progression is not explicit: • *"multiplier consists of a maximum of three figures".*	**Low specificity** Not specified explicitly. Implicit in high level statement encompassing multiplication in general ('multiplication'). Therefore, challenge is not clear (multiplier not defined). Algorithms and mental calculations are also stated to cover generally across operations.	**Medium-high specificity** Defined for a Year. Challenge and progression is clearly presented (see previous row): • Up to 3 digits by 2 digits (conventional algorithms also included for multiplication at this grade).

	To note, no explicit mention of use of formal algorithm but instead states ‘an efficient written method’.				Assumed it is covered at this stage of education as Y3-4 introduces multiplication and includes times tables and this is generally the next sub-domain progression. Also, Y 8-11 suggests basic multiplication methods have been taught and secondary is used to consolidate and strengthen multiplication skills (Y8-11: *“strengthen calculation skills”*).	
Long division (Dividends up to three digits and divisors up to two digits)	**Y 3-6**	**Y 5**	**Y 6**	**Y 7**	**Y 5-7**	**Not specified**
	Medium specificity *“Extend division to informal methods of dividing by a two-digit divisor”.* No explicit mention of algorithm.	**Medium –high specificity** Defined on a Year basis. Challenge and progression is clearly presented: • *“perform division with divisor 2 digits and dividend 3 digits”.* No explicit mention of use of formal algorithm.	**Medium - high specificity** Defined on a Year basis. Challenge and progression is clearly presented: • *“Division of numbers up to 4 digits by a 2 digit whole number.”* No explicit mention of use of formal algorithm.	**Low-medium specificity** Defined for end of primary only. Challenge is clear, but progression is not explicit: • *“division: the divider consists of a maximum of 3 figures.”* No explicit mention of algorithm.	**Low specificity** Same as above – this is not specified explicitly. Therefore, level of challenge is not clear. ‘Divisibility’ and ‘algorithms and mental calculations are stated and so it is assumed this sub-domain is implicit within these statements.	**N/A** There is no explicit requirement for division greater than 3 digits by 1 (with or without remainders not included). To note, in Y5-6 division required for fractions and decimals. Use of conventional algorithm only stated in relation to addition, subtraction and multiplication.

Table B5: Sub-Domain: Fractions

Sub-domain definition	England (1999)	England (2007)	Hong Kong (1999 and 2000)	Singapore (2001 and 2007 where stated)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
Fractions: Addition & subtraction - like denominators	**Y 7-9**	**Y 7-9**	**Y 5**	**Y 3, 4 & 5**	**Y 7, 8-9**	**Y 5-7**	**Y 5 & 6**
	Medium specificity Challenge defined by stating *like denominators*, but topic not broken down further or defined on Year basis.	**Medium specificity** Challenge defined by stating of *'like denominators'*, but topic not broken down further or defined on Year basis.	**Medium specificity** Defined for a Year, which suggests associated level. Challenge of fractions defined by stating *like denominators*, but topic not broken down further. Also specifies requirement to simplify fractions.	**High specificity** Defined for a Year rather than Key Stage which suggests associated level. Topic broken down to define 3 levels of challenge at different Years. Covered in Y3 at a very basic level (fractions within one whole); greater challenge in Y4 (related fractions within one whole); and further in Y5 (like fractions and related fractions).	**Low specificity** Expectation in primary is defined in terms of *add and subtract simple fractions*. Expected outcome is for end of primary rather than at a Year or smaller Key Stage basis so associated level is less prescriptive. Also, types of fractions (e.g. *'like denominators'*) or exemplification are not included so 'simple fractions' is not quantified. By Y 9– high-level statement covers all calculations with all four operations with *rational numbers*.	**Low specificity** No distinction made between types of fractions i.e. *fractions with like denominators* not specified. Instead statement encompasses all fractions and is defined for a Key Stage and not a Year level.	**High specificity** Defined for a Year rather than Key Stage, which suggests associated level. Topic broken down to define 2 levels of challenge at different Years. Simplification of answer also specified within limits. Y5 introduces at basic level (using *'common fractions'* in practical context with concrete objects); Year 6 is more challenging and goes beyond fractions with like denominators (all positive fractions, including mixed numbers and simplification of answer).
Fractions: Addition and	**Y 7-9**	**Y 7-9**	**Y 6**	**Y 5 & 6**	**Y 8-9**	**Y 5-7**	**Y 6**

Sub-domain definition	England (1999)	England (2007)	Hong Kong (1999 and 2000)	Singapore (2001 and 2007 where stated)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
subtraction – unlike denominators	**Low specificity** Not specified explicitly.	**Low specificity** Not specified explicitly.	**High specificity** Prescribed for a Year. Limits of challenge well defined – defines basic level by stating 'simple' fractions not exceeding denominators of 12, and for sums with not more than two operations. Problem-solving also included.	**High specificity** Prescribed for a Year. Topic broken down to define 2 levels of challenge over different Years. Limits of challenge well defined - Y5 basic level (related denominators); and Y6 is more challenging (*denominators not exceeding 12*).	**Low specificity** Same as above. Assumed covered in secondary as 'simple fractions' in primary suggests a lower level of challenge than this sub-domain.	**Low specificity** Same as above. Challenge not defined in terms of types of fractions (e.g. unlike denominators) or at a Year level.	**High specificity** Prescribed for a Year. Limits of challenge well defined (positive and mixed fractions with common related denominators). Simplification of answer also specified within limits.
Fractions: Addition & subtraction – mixed numbers	**Year 7-9**	**Year 7-9**	**Year 6**	**Year 6**	**Year 8-9**	**Year 5-7**	**Year 6**
	Low specificity Mixed numbers not specified explicitly but implicit in statements in Y7-9.	**Low specificity** Mixed numbers not specified explicitly but implicit in statements in Y7-9.	**Low specificity** Mixed numbers not specified explicitly but implicit in statements in Y6.	**High specificity** Prescribed for a Year. Limits of challenge well defined. (Denominators of given fractions should not exceed 12; Exclude calculations involving more than 2 different denominators).	**Low specificity** Same as above. Assumed covered in secondary as 'simple fractions'; in primary suggests a lower level of challenge than this sub-domain.	**Low specificity** Same as above.	**High specificity** Same as above.
Fractions: Multiplication	**Year 7-9**	**Year 7-9**	**Year 6**	**Year 5 & 6**	**Year 7**	**Year 5-7; 8-11**	**Year 6 & 7**
	Medium – high specificity	**Low specificity**	**Medium-high specificity**	**High specificity**	**Medium specificity**	**Medium specificity**	**High specificity**

Sub-domain definition	England (1999)	England (2007)	Hong Kong (1999 and 2000)	Singapore (2001 and 2007 where stated)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
	Not defined for a Year but specific about steps to cover within sub-topic (multiply by an integer, unit fraction and general fraction).	Not explicit, but implicit in high level statements about calculations with number in Y7-9.	Prescribed for a Year. Limits of challenge well defined – sums involving at most two operations and includes simple problems.	Topic broken down to define 3 levels of challenge at different Years. In 2007 curriculum nuances in relation to calculators are also specified. Covered in Y5 at basic level (proper/ improper fraction and a whole number); greater challenge in Y6 (proper fractions and a proper/ improper fraction; and with calculators - improper fraction and an improper fraction/ mixed number and a whole).	Defined explicitly within limits to reflect a basic level (simple fractions with whole numbers). But defined as an outcome of a large Key Stage rather than at a Year level.	Two levels of challenge defined over two Key Stages. Basic level in Y5-7 (with whole numbers) and full breadth of challenge in Y8-11 (fractions with fractions). Topic defined for a Key Stage rather than for a Year.	Prescribed for a Year. Topic broken down into 2 levels at different Years and limits of challenge well defined. Simple level in Y6 (positive fractions with whole numbers, simplification and problem solving); more challenging in Y7 (positive fractions, mixed numbers and simplification).
Fractions: Division	**Year 7-9**	**Not specified**	**Year 6**	**Year 6 & 8**	**Year 8-9**	**Year 5-7; 8-11**	**Year 7**
	Medium-high specificity Not defined for a Year, but specific about steps to cover within sub-topic (divide by an integer, unit fraction and general fraction).	**Low specificity** Not explicit, but implicit in high level statements about calculations with number in Y7-9.	**Medium specificity** Prescribed for a Year. Steps within sub-topic not broken down, but challenge limited to sums involving at most two operations. Problem-solving	**Medium specificity** Prescribed for a Year. Challenge limited in Y6 (to division by a whole number sums involving at most two operations and excluding more than 2 different	**Low specificity** Not defined for a Year and not specific about steps to cover within a sub-topic.	**Medium specificity** Not defined for a Year, but steps within sub-topic broken down over two Key Stages (Y5-7 divide by natural numbers; Y8-11 by fractions).	**Medium specificity** Prescribed for a Year. Challenge defined by limiting to division with positive fractions and mixed numbers. Sub-topic not broken down further.

Sub-domain definition	England (1999)	England (2007)	Hong Kong (1999 and 2000)	Singapore (2001 and 2007 where stated)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
			also included.	denominators). Further challenge for division with fractions is implicit in high level statements about calculations with number in Y8.			Simplification requirement also made explicit.

Table B6: Sub-Domain: Algebra and introduction to calculus

TOPIC	England (1999)	England (2007)	Hong Kong (1999 and 2000)	Singapore (2001)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
Introduction of algebraic symbols	**Y 3-6 & Y7-9**	**See 1999**	**Year 6**	**Year 7**	**Year 8-9**	**Year 5-7**	**Year 6**
	High specificity Not defined for a Year, but breaks down topic into two steps of challenge: Y3-6 in formulaic context only; Y7-9 different roles of symbols with exemplification.	**N/A**	**Medium-high specificity** Defined for a Year and explicit about introduction of elementary algebra through use of algebraic symbols to represent numbers, included in sentences. Exemplification provided. No mention of breadth of roles of symbols.	**Medium specificity** Defined for a Year and explicit about application (to represent generalisations and unknowns). No mention of breadth of roles of symbols.	**Medium specificity** Defined for a Year and explicit about use (to represent unknowns and generalisations). No mention of breadth of roles of symbols.	**Low specificity** No explicit reference to introduction of symbols/letters and not defined for a Year. Implicit within requirement to teach concept of algebraic expressions.	**Medium -high specificity** Defined for a Year. Roles of symbols is not referenced, but explicit about how to use (to replace variables with given values). Includes exemplification. No mention of breadth of roles of symbols
Linear equations	**Years 7-9**	**Years 7-9**	**Year 6**	**Year 8**	**Year 8-9**	**Year 5-7**	**Year 8**
	High specificity Not defined for a Year, but does break down topic to specify breadth and challenge (integer coefficients; negatives in equations and solution; unknowns on either or both sides). Exemplification provided.	**Low - Medium specificity** High level statement with some additional notes. Does not break-down topic into finer detail making progression less clear, but further detail included in level descriptors (e.g. L6 with whole number coefficients). No exemplification.	**Medium specificity** Defined for a Year. Does not break down topic significantly but does define challenge to some extent (integers and one step problems only).	**High specificity** Defined for a Year and breaks down topic to specify breadth and challenge (one unknown, fractional coefficients, simple inequality). Includes exemplification.	**Low specificity** Not defined for a Year. Topic specified, but does not break-down further and exemplification not provided.	**Low specificity** Not defined for a Year. Topic not broken down or specified explicitly in terms of linearity (only stating *"equations and inequalities"*). Exemplification not provided.	**Medium specificity** Defined for a Year, but topic not broken down significantly. Challenge defined to some extent (one or two variables). No exemplification provided.
Quadratic equations	**Y 10-11**	**Y 10-11**	**Y 11-12**	**Y9**	**Y 10-11**	**Y 8-11**	**Y8; 9; 10-11**
	Medium-High	**Low - Medium**	**Medium-High**	**Medium**	**Low - Medium**	**Low specificity**	**High specificity**

TOPIC	England (1999)	England (2007)	Hong Kong (1999 and 2000)	Singapore (2001)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
	specificity Not defined for a Year, but topic broken down in detail to specify breadth and challenge explicitly. Exemplification also provided.	**specificity** Not defined for a Year. High level statement with some additional notes. Does not break down topic into finer detail making progression less clear, but further detail included in level descriptors. No exemplification.	**specificity** Not defined for a Year, but topic broken down in detail to specify breadth and challenge explicitly. Underlined content statements also included to specify 'enrichment' content for the more able students (non-compulsory).	**specificity** Defined for a Year. Topic broken down to define key elements and challenge, but relatively parsimonious statements included. However, exemplification is provided.	**specificity** Defined for a 2 Year block. Sub-domain broken down to define key elements and challenge, but very parsimonious statements included that are short and concise.	Defined for a 4 Year secondary block. High level statements with no description or exemplification. Challenge is defined, but breadth of sub-domain is not.	Breaks down topic into two levels of challenge over different Years/stages to articulate progression. Y8 introduces topic through exploring in context of tables, graphs, and ICT, which continues in Y9. Y10-11 covers solving quadratic equations and breaks down topic to highlight range and challenge of content (factoring, completing the square, or using the quadratic formula). No exemplification provided.

TOPIC	England (1999)	England (2007)	Hong Kong (1999 and 2000)	Singapore (2001)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
Calculus	**Not covered pre-Y11**	**Not covered pre-Y11**	**Not covered pre-Y11**	**Not covered pre-Y11** * Calculus is covered in optional *Additional mathematics* curriculum in Y 10/11.	**Not covered pre-Y11**	**Not covered pre-Y11**	**Not covered pre-Y11** NB. Pre-calculus is indicated in narrative of curriculum to lay foundations for calculus

Table B7: Sub-Domain: Data, Statistics & Probability

TOPIC	England (1999)	England (2007)	Hong Kong (1999 and 2000)	Singapore (2001, 2002 and 2005)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
	Y3-6	**N/A - Secondary**	**Y 3**	**Y 2**	**Y 9**	**Y1-7**	**Y1-3**
Introduction of data handling and statistics: • tables • charts • graphs • mean, mode and median • standard deviation • range • data sets	**High specificity** Y3-6 heading *handling data* used throughout. Y3-6: "*Solve problems involving data; interpret tables, lists and charts used in everyday life; construct and interpret frequency tables, including tables for grouped discrete data; represent and interpret discrete data using graphs and diagrams, including pictograms, bar charts and line graphs, then interpret a wider range of graphs and diagrams, using ICT where appropriate; know that mode is a measure of average and that range is a measure of spread, and to use both ideas to describe data sets;*		**Medium specificity** Y3 heading *data handling* used throughout. Y3: "*Compare the quantity of three or more types of objects by arranging them in lines; Read and discuss simple pictograms; construct pictograms, using a one-to-one representation*".	**Medium specificity** Y2; heading *Statistics* used throughout - (in 2007 version *data analysis*; and *statistics and probability* used in primary and secondary respectively). Y2: *"make picture graphs of given data; read and interpret picture graphs."*	**Low specificity** Brief intro in Y8. Can calculate the arithmetical average and the median (for non-grouped data) from tables containing figures and derive relevant information from them.	**Low specificity** Expected standard in Y6, but first in programme of study in Y2-3. Looking for, collecting and storing data. Reading simple tables and diagrams. Presenting assembled data as a bar graph. Y5-7 introduction to the concepts of mode and median.	**Medium specificity** Y2-3; heading *Data Analysis, Statistics, and Probability* used throughout. - Use interviews, surveys, and observations to gather data about themselves and their surroundings. -- Organize, classify, represent, and interpret data using tallies, charts, tables, bar graphs, pictographs, and Venn diagrams; interpret the representations. - Formulate inferences (draw conclusions) and make educated guesses (conjectures) about a situation based on information gained from data.

TOPIC	England (1999)	England (2007)	Hong Kong (1999 and 2000)	Singapore (2001, 2002 and 2005)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
	recognise the difference between discrete and continuous data."						
	Y 3-6 & Y 7-9	**Y 7-9**	**Y 7 & 8**	**Y 6 + Y 9**	**Secondary**	**Y 7**	
	Medium to Low specificity Introduces mode in Y3-6: *"know that mode is a measure of average"*, but doesn't introduce mean/median until Y7-9: *"calculate mean, range and median of small data sets with discrete then continuous data; identify the modal class for grouped data'*; Y 7-9: *'find the median for large data sets and calculate an estimate of the mean for large data sets with grouped data."* Y7-9: *"...decide… what statistical analysis is needed'*; and *'select and organise the appropriate mathematics and resources to use*	**Medium to Low specificity** Statistics: a) the handling data cycle; b) presentation and analysis of grouped and ungrouped data, including time series am lines of best fit; and c) measures of central tendency and spread.	**Low specificity** Y7: *"find the average of a group of data"*. Cover all three measures in depth in Y7-9: data handling/analysis and interpretation of data/1 *"find mean, median and mode from a given set of ungrouped data."* Y8-10: data handling/analysis and interpretation of data/6 *"discuss the relative merits of different measures of central tendency for a given situation."*	**Low specificity** Y6 *"Calculate the average"*. Cover all the measures in depth in Y9: *"find mean, median and mode; distinguish between the purposes for which mean, median and mode are used; exclude grouped data."*	**Medium specificity** Y9-10 heading 'Statistics'. Y9: *"explain the importance of the representative character of a random sample to formulate statistical conclusions about the population, with the use of examples; are critical about the use of statistics in the media; formulate, calculate and interpret frequency and relative frequency both in individual and in grouped data in concrete situations; use the terms mean, mode, median, standard deviation, in order to interpret statistical data related to a concrete situation;*	**Low specificity** Y7 good performance description (more detail in programme of study): *data processing, statistics and probability*: *"Know how to gather data, organise, classify and present them as statistics; they will know how to read simple tables and diagrams".*	

TOPIC	England (1999)	England (2007)	Hong Kong (1999 and 2000)	Singapore (2001, 2002 and 2005)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
	for a task."				*use and interpret various graphic representations of statistical data, both as regards individual and as regards grouped data, always related to concrete situations."*		
Introduction of probability Basic concepts (e.g. via simple experiments and related vocabulary)	End of Primary	N/A	Introduced in Secondary	Introduced in late Secondary	Introduced in Secondary	Introduced end of Primary	Introduced early Primary
	Y3-6: *"draw conclusions from statistics and graphs and recognise when information is presented in a misleading way; explore doubt and certainty and develop an understanding of probability through classroom situations; discuss events using a vocabulary that includes the words 'equally likely', 'fair', 'unfair', 'certain'."*					**Low specificity** Y6: vocabulary, concept, likelihood, using language only. Y7: good performance description: *"Know how to clarify the number of events and numbers; and to judge which is an impossible or certain event."*	Y2-3: Exploring more likely, likely, and impossible outcomes and vocabulary. Y4-5: exploring situations that involve probabilities of equally likely events. Y4-5: - *"Represent the possible outcomes for a simple probability situation".* - *"List and count the number of possible combinations of objects from three sets."* -*"Classify outcomes as*

TOPIC	England (1999)	England (2007)	Hong Kong (1999 and 2000)	Singapore (2001, 2002 and 2005)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
							certain, likely, unlikely, or impossible by designing and conducting experiments using concrete objects such as counters, number cubes, spinners, or coins".
Probability	**Medium to high specificity Y 7-9** A number of developed statements are given covering simple experimental probability, equally likely outcomes and mutually exclusive events. *"Understand that... increasing sample size generally leads to better estimates of probability and population characteristics.'"* Y10-11 foundation/breadth of study *'[taught through] including using appropriate populations and representative*	**Medium specificity Y 7-9** Experimental and theoretical probabilities, including those based on equally likely outcomes. Includes explanatory notes Probabilities: This includes applying ideas of probability and risk to gambling, safety issues, and simulations using ICT to represent a probability experiment, such as rolling two dice and adding the scores.	**High specificity** Y7 *'read and discuss bar charts of large frequency counts'*. Sample is introduced in the context of probability. *"Calculate the theoretical probability by listing the sample space and counting".* Y8-10 Probability/simple idea of probability: *"explore the meaning of probability through various activities; compare the empirical and theoretical probabilities; calculate the*	**Medium specificity Y10-11** Y10-11: *"Calculate the probability of a single event as either a fraction or a decimal (not a ratio); calculate the probability of simple combined events, using possibility diagrams and tree diagrams where appropriate (in possibility diagrams outcomes will be represented by points on a grid and in tree diagrams outcomes will be written at the end of branches and probabilities by the side of the branches)".*	**Low specificity Y9 only** Y9: *'Interpret relative frequency in terms of probability'.* Y10-11: *"interpret relative frequency in terms of probability."*	**Low specificity** Y10: final assessment criteria (more detail in programme of study) *Statistics and probability.* Read various tables and diagrams to determine frequencies, average, median, and mode from the given material. Y10: final assessment criteria (more detail in programme of study): *"Determine the number of possible events and order a simple empirical investigation of probability; they will understand the*	**Low specificity Y6** Predicting outcomes using 0-1 scale. Predict the probability of outcomes of simple experiments (e.g., tossing a coin, rolling a number cube) and test the predictions. Extended throughout secondary.

TOPIC	England (1999)	England (2007)	Hong Kong (1999 and 2000)	Singapore (2001, 2002 and 2005)	Flemish Belgium (2010)	Finland (2004)	Massachusetts (2000 and 2004 addendum)
	samples' Y7-*9 'understand and use the probability scale; understand and use estimates or measures of probability from theoretical models, including equally likely outcomes, or from relative frequency; list all outcomes for single events, and for two successive events, in a systematic way'.* and 'identify *different mutually exclusive outcomes and know that the sum of the probabilities of all these outcomes is 1'.*		*theoretical probability by listing the sample space and counting."*			*meaning of probability and investigations in day-to-day life."*	

Appendix C: Science Curriculum comparison tables

Table C1: High-level organisation

	England (1999)	England (2007)	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
High level organisation of curriculum document **Definition of curriculum statements**	**'Science'** Statement type and Year groupings: Defines the curriculum by *learning outcomes* for each Key Stage: KS1 (Y1-2) KS2 (Y3-6) KS3 (Y7-9) KS4 (Y10-11) Typical statement stem: *'Pupils should be taught to…'* Attainment: Expected levels of attainment are set out in a separate section 'Attainment Target Level Descriptors' Organisation of content: Programme of study for Science (Knowledge, skills and understanding) is arranged into 4 key domains: -Scientific enquiry - Life processes and living things (biology)	**'Science'** Statement type and Year groupings: Defines the curriculum by *learning outcomes* for each Key Stage: KS1 (Y1-2) KS2 (Y3-6) KS3 (Y7-9) KS4 (Y10-11) Typical statement stem: *'Pupils should be able to…'/'The study of science should include…'* Attainment: Expected levels of attainment are set out in a separate section 'Attainment Target Level Descriptors' Organisation of content: The range and content of the programme of study for Science is arranged into 4 key domains: -Energy, electricity and forces (physics)	**Primary – embedded within 'General Studies' Y7-9 equivalent – 'Science' Y10-11 equivalent – separate disciplines.** Statement type and Year groupings: Defines the curriculum by *learning outcomes* on Key Stage basis: KS1 (Eng. Y1-3) KS2 (Eng. Y4-6) KS3 (Eng. Y7-9) KS4 (Eng. Y10-11) Typical statement stem: Primary: *'To recognise, to know etc…'* Y7-9: *'All pupils should….'* Y10-11: *'Pupils should learn…./Pupils should be able to….'* Attainment: The curriculum statements serve as expected levels of attainment for each Key Stage. Presentation varies by Key Stage.	**'Science'** Statement type and Year groupings: Defines the curriculum by *learning outcomes* specified Year by Year from P3 (Eng Y4) to Sec 2 (Eng Y9). Science is not taught before P3 (Y4). Y10-11 - separate science disciplines to O level. Typical statement stem: Primary: '*Students should be able to…'* Secondary: *'Students are expected to….'* Attainment: The curriculum statements serve as expected levels of attainment for each Year. Organisation of content: Primary-secondary Y9: Curriculum has 6	**'Science and technology/engineering'** Statement type and Year groupings: Defines the curriculum by *learning outcomes* specified for groups of grades from PreK to high school: PreK-G2 (Eng. EYFS-Y3) G3-5 (Eng. Y4-6) G6-8 (Eng. Y7-9) High school – one Year introductory courses to be studied in Y10 or 11 equivalent. Typical statement stem: '*Learning standard…'* Attainment: The curriculum statements serve as expected levels of attainment for each block of grades. Organisation of content:	**'Science'** Statement type and Year groupings: Defines the curriculum by *learning outcomes* which are specified Year-by-Year from G1 (Eng Y2) to G9 (Eng Y10). Senior high school unit Science 10 contains outcomes for first Year of senior high school (Eng Y11). Typical statement stem: *'Pupils will…'* Expected Attainment: The curriculum statements serve as expected levels of attainment (outcomes) for each Year. Organisation of content: Primary: Content organised into topics, 5 topics to be taught in each Year. Topics introduce basic

	England (1999)	England (2007)	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
	-Materials and their properties (chemistry) -Physical processes (physics) *Breadth of study.* The breadth of study specifies the increasing range of activities, contexts and purposes through which pupils should be taught knowledge, skills and understanding.	-Chemical and material behaviour (chemistry) -Organisms, behaviour and health (biology) -The environment, Earth and universe (Earth science) Cross-cutting scientific processes and scientific enquiry are specified under additional domains: -Key concepts; -Key processes; and -Curriculum opportunities. There are detailed guidance notes alongside the programme of study statements in the curriculum document.	Organisation of content: Varies by Key Stage: Primary: within General studies, two units mainly relevant, *'Health and living' (HL) and science and technology in everyday life'* (STE). Y7-9: science consists of 14 topic units covering basic concepts of biology, chemistry and physics plus one unit on *'introducing science.'* Scientific process and enquiry are included as objectives of the syllabus. Y10-11: organisation of content is discipline specific.	domains, covering all the basic concepts of biology, chemistry and physics: • Diversity; • Cycles; • Energy; • Interactions; • (Y8-9 only) Models and Systems; and • (Y8-9 only) Measurement. A seventh domain, '*science as an inquiry*', is to be integrated into the teaching of the other 6 domains. Y10-11: organisation of content is discipline specific.	The learning outcomes are organised into 4 domains: -Earth and Space Science -Life Science (Biology) -Physical Sciences (Chemistry and Physics); and Technology/Engineering (not included for purposes of curriculum mapping). *Inquiry, experimentation and design* is specified as a separate section, but to be taught integrated into the substantive content of the curriculum.	concepts across the disciplines biology, chemistry and physics. Each topic has either a 'science inquiry' or a 'problem solving through technology' emphasis. Y8-10 and Y11: Curriculum structured around 4 'foundations' of science. 'Knowledge' foundation divided into 3 domains: - Life science (biology) - Physical science (chemistry and physics); and - Earth and space science. Remaining 3 'foundations' cover scientific processes and inquiry: - 'science, technology and society'; - skills; and - attitudes.
Curriculum aims and principles Note: Many statements have been paraphrased for the purpose of this document. It is necessary to view the	<u>Primary and secondary</u> No specific aims for science curriculum, though science education is linked to various areas of learning across the	<u>Primary and secondary</u> Aim of science is to contribute to achievement of 3 aims of curriculum as a whole: • successful learners	<u>Primary</u> The aim of General studies STE is: *'To arouse pupils'* curiosity and interest in science and technology through hands-on and *minds-on activities.'*	<u>Primary</u> Aims of science curriculum are: • experiences that build on interest and stimulate curiosity; • Scientific concepts	<u>Primary and secondary</u> The Massachusetts science, technology and engineering curriculum has a single statement of purpose for primary	<u>Primary</u> Purpose is *'to encourage and stimulate children's learning by nurturing* their sense of wonderment, by developing skill and

	England (1999)	England (2007)	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
curriculum documents to see the aims in full.	curriculum: Promoting pupils' spiritual, moral, social and cultural development ; promoting key skills; promoting other aspects of the curriculum e.g. thinking skills, work-related learning. Importance of science specifically is: it stimulates pupils' excitement and curiosity about phenomena in the world; links practical experience with ideas; a spur to critical and creative thought; understanding link between science and technology; recognise cultural significance of science; learn to question and discuss science-based issues.	who enjoy learning, make progress and achieve; • confident individuals who are able to live safe, healthy and fulfilling lives; and • responsible citizens who make a positive contribution to society. Importance of science specifically is: firing curiosity about the world; finding explanations; practical aspects; explanation rooted in evidence; technology; understanding development of science worldwide and its significance.	The aim of General studies HL is: *'To arouse pupils' awareness of their growth and development, as well as helping them to develop a healthy lifestyle.'* Y7-9 Aims of curriculum include: 1. acquire basic scientific knowledge and concepts; 2. develop ability to enquire and to solve problems; 3. be acquainted with the language of science and be equipped with skills in communicating ideas in science; 4. develop curiosity and interest in science; 5. recognise usefulness and limitations of science; and 6. appreciate and understand the evolutionary nature of scientific knowledge. <u>Y10-11</u> Aims are discipline-specific.	to help understand themselves and the world; • Opportunities to develop scientific skills, habits of mind and attitudes; • Prepare to use scientific knowledge and skills in making personal decisions; and • Appreciate how science and technology influence people and environment. <u>Secondary</u> Aims of science curriculum are to develop: • understanding and knowledge to become confident citizens, recognise usefulness and limitations of scientific knowledge and prepare for further study; • abilities and skills (both specifically relevant for science and more widely); • attributes relevant to study and	and secondary. Investigations in science and technology/engineering involve a range of skills, habits of mind, and subject matter knowledge. The purpose of science and technology/engineering education in Massachusetts is to enable pupils to draw on these skills and habits, as well as on their subject matter knowledge, in order to participate productively in the intellectual and civic life of American society and to provide the foundation for their further education in these areas if they seek it.	confidence in investigating their surroundings, and by building a foundation of experience and understanding upon which later learning can be based.' <u>Y8-11</u> Goals are those for Canadian science education and include to: • encourage pupils to develop a critical sense of wonder and curiosity; • enable pupils to use science and technology to acquire new knowledge and solve problems; • prepare pupils to critically address science related societal, economic, ethical and environmental issues; • provide pupils with a foundation that creates opportunities to pursue higher levels of study etc; and • enable pupils to develop a knowledge

	England (1999)	England (2007)	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
				practice of science; • curiosity, interest and enjoyment in science and scientific inquiry; and • awareness of co-operative nature of science and the benefits and drawbacks of scientific advance. <u>Y10-11</u> Aims are discipline-specific.		of the wide spectrum of related careers.

Table C2: Sub-domain: Biology

Biology	England (1999) [Double award]	England (2007) [Core award]	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
Classification	Observable characteristics (Y1-2). Living/ non-living things (Y1-2). Use of keys (Y3-6). Intro to classification (Y3-6). Micro-organisms (Y3-6). Classification using major groups (Y7-9).	Classification of living things (Y7-9). Similarities and differences between species (Y10-11).	Observable characteristics (Y1-2). Living/ non-living (Y1-2). Classification using Five Kingdom (Y7-9).	Observable characteristics (Y4). Living / non-living (Y4). Classification using Five Kingdom (Y9).	Difference between living/ non-living things (EYFS-Y3). Use of keys (Y4-6). Observable characteristics (Y4-6). Classification using Six Kingdom (Y7-9 and Y10-11). Hierarchical taxonomic system (Y10-11).	Observable characteristics (Y2). Difference between living/ non-living things (Y2). Classification of common local plants and animals (Y2).
Interactions and interdependencies	Living things live in environments to which they are particularly suited (introduction in Y1-2 and Y3-6). Living things are interdependent (Y7-9) and interact with environment (Y7-9). Reasons for changes in population size (Y7-9).	Living things are interdependent (Y7-9). and interact with environment (Y7-9).	Living things live in environments to which they are particularly suited (Y1-2). How living things respond to their environment (Y7-9). Levels of organisations (Y10-11). Components of ecosystem (Y10-11). Functioning of ecosystem (Y10-11).	Different habitats support different communities (Y7). How living things respond to their environment (Y7). Carbon cycle (Y9).	Habitat provides for basic needs (EYFS-Y3). Living things respond to their environment and cause changes in their environment (Y4-6). Relationships in ecosystem (Y7-9 and Y10-11). Changes in ecosystems over time (Y7-9). Reasons for changes in population size and biodiversity (Y10-11). Functioning in an ecosystem (Y10-11). Cycling of water, carbon and nitrogen (Y10-11).	Living things live in environments to which they are particularly suited (Y2). Ecosystems (Y6, 7 and 8). Organisms effect, and are effected by, their environment (Y8). Energy flow in an ecosystem (Y8). Components of ecosystem (Y8). Habitat diversity (Y10). Niches (Y10). Relationships in ecosystem (Y10). Carbon and nitrogen cycles (Y11).

Biology	England (1999) [Double award]	England (2007) [Core award]	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
Structure and function - animals including humans	Body parts (Y1-2). Senses (Y1-2). Life processes (Y1-2 and 3-6). Life cycle (intro Y1-2; and main stages Y3-6). Internal organs (Y3-6 and Y7-9). Skeletons and muscles to support protect and enable movement (Y3-6 and Y7-9). Gaseous exchange system (Y3-6) and its functions (Y7-9). Digestive system in humans (Y3-6). Circulatory system (Y3-6) and blood (Y10-11). Breathing (Y7-9 and Y10-11). Respiration (introduction to word equation Y7-9) and anaerobic respiration (Y10-11). Reproductive system and reproduction (Y7-9). Health – effects of smoking, drugs; bacteria and replication of viruses (Y7-9). Central nervous	Reproductive cycle (Y7-9). Impact of diet, drugs and disease (Y7-9). Life processes (Y7-9). Body's response to internal/ external changes and maintaining optimal state (Y10-11). Health impacts of drugs and medical treatment (Y10-11).	Skeletons and muscles to support, protect and enable movement (Y1-2). Human respiratory and circulatory systems (introduction Y1-2.*)* Functions of gaseous exchange system in humans (Y3-6). Effects of smoking on the respiratory and other systems (7Y-9). Reproductive system and reproduction (Y7-9). Methods of birth control and sexually transmitted diseases (Y7-9). Structure and function of the eye (Y7-9). Structure and function of the ear (Y7-9). Central nervous system (Y10-11). Hormonal coordination and endocrine system (Y10-11). Homeostasis (Y10-11).	Life processes (Y4). Life cycles that include birth, growth, development, reproduction and death (Y4). Skeletons and muscles to support, protect and enable movement (Y4). Digestive system in humans (Y4). Gaseous exchange system (Intro Y4, Y5 Y6). Respiration (Y6). Circulatory system (Intro Y4, Y5) and heart, blood etc (Y10-11). Reproductive system and reproduction (Y9). Sexual and asexual reproduction (Y9). Methods of birth control and sexually transmitted diseases (Y9). Central nervous system (Y10-11). Hormones (Y10-11).	Life cycles that include birth, growth, development, reproduction and death (EYFS-Y3 and Y4-6). Senses (EYFS-Y3). Sexual and asexual reproduction (Y7-9). Functions of major systems (digestion, respiration, reproduction, circulation, excretion, protection from disease, movement, control and coordination) (Y7-9 and Y10-11). Central nervous system (Y10-11). Homeostasis (Y10-11).	Senses (Y2). Life cycles that include birth, growth, development, reproduction and death (Y4). Human body systems - respiration, circulation, digestion, excretion and sensory awareness (Y9). Role of organs, tissues and cells in supporting healthy functioning of human body (Y9).

Biology	England (1999) [Double award]	England (2007) [Core award]	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
	system (Y10-11). Hormonal control (Y10-11). Homeostasis and removal of waste products (Y10-11). Immune system (Y10-11).					
Structure and function – cells	Structure and function (Y7-9 and Y10-11). Organisation of cells into tissues and organs (Y7-9). Fertilisation (Y7-9). Differences between plant and animal cells (Y10-11). Transport (diffusion, osmosis and active transport) (Y10-11). Mitosis and meiosis (Y10-11).	Organisation of cells into tissues, organs and body systems (Y7-9).	Cells – structure and function (Y7-9). Unicellular (Y7-9). Sub-cellular structure and functions (Y10-11). Cell cycle and processes (Y10-11).	Cells as building blocks (Y6). Cell structure and function (Y6 and Y9). Differences between plant and animal cells (Y8).	Cells – structure and function (Y7-9 and Y10-11). Unicellular to Multicellular (Y7-9). Differences between plant and animal cells (Y7-9). Sub-cellular structure (Y7-9). Organisation of cells into tissues and (Y7-9) and organs (Y10-11). Cell processes (growth, maintenance and reproduction) (Y10-11). Transport (diffusion, osmosis and active transport) (Y10-11). Prokaryotic and eukaryotic cells (Y10-11). Metabolism (Y10-11) Mitosis and meiosis (Y10-11).	Structure and function (Y9). Cells as basic unit of life (Y9). Unicellular to Multicellular (Y9). Difference between plant and animal cells (Y9). Diffusion and osmosis (Y9). Cell theory (Y11). Sub-cellular structure and functions (Y11). Specialisation (Y11). Transport (Y11).
Energy – animals including humans	Requirements for life (Y1-2). Importance of diet and exercise for health (Y1-2, 3-6 and 7-9).		Humans and other animals need food, water and air to stay alive (Y1-2). Digestion (Y7-9).	Digestion (Y9). Energy in a food chain (Y9).	Food chains – energy transfer, interdependence (Y7-9). Energy transfer (Y10-11).	Humans and other animals need food, water and air to stay alive (Y2). Basics of a food chain (Y3).

Biology	England (1999) [Double award]	England (2007) [Core award]	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
	Functions of teeth (Y3-6). Digestion (Y7-9 and Y10-11). Respiration (Y7-9). Food chains – relationships (Y3-6); quantification and food webs (Y7-9).					
Evolution	Adaptation to environment (Y3-6). Variation (Y7-9). Heredity (Y7-9). Causes of evolution (Y7-9). Chromosomes, genes and DNA (Y10-11). Causes of variation (Y10-11). Asexual and sexual reproduction (Y10-11). Sex determination (Y10-11). Inheritance and disease (Y10-11). Mutations and causes (Y10-11). Fossils as evidence of evolution (Y10-11). Variation and selection as causes of evolution/ extinction (Y10-11).	Variation (Y7-9). Adaptation to environment (Y10-11). Variation within species (Y10-11). Genes (Y10-11). Impact of inherited factors on health (Y10-11).	Adaptation to environment (Y2-6). Variation (Y10-11). Sex determination (Y10-11). Inheritance – Mendel (Y10-11).	Adaptation to environment (Y7). Heredity (Introduced Y4, Y9). Variation (Y10-11). Asexual reproduction, clones (Y10-11). Sexual reproduction, genetic variation (Y10-11). Pollination (Y10-11). Sex determination (Y10-11).	Offspring resemble their parents (EYFS-Y3). Fossils as evidence of evolution (EYFS-Y3). Adaptation to environment (Y4-6). Chromosomes and genes (Y7-9). Sexual and asexual reproduction (Y7-9). Heredity (Y7-9). Extinction (Y7-9). Evidence for evolution (Y7-9 and Y10-11). Causes of evolution (Y7-9). Variation (Y7-9). DNA and inheritance (Y10-11). Mutations (Y10-11). Mendel (Y10-11). Natural selection (Y10-11).	Introduction to adaptation (Y1). Adaptation to environment (Y 3-6). Heredity (Y10). Chromosomes, genes and DNA (Y10). Cell division (Y10). Sexual and asexual reproduction (Y10). Extinction (Y10). Causes of evolution (Y10). Variation (Y10). Natural selection (Y10).
Structure and function – plants	Recognise parts of plant (KS1). Functions of different			Functions of different parts of plants (Y4). Life cycles (Y4). Reproduction (Y4).	The functions of the different parts of plants: leaf, flower, stem and root (Y4-6)	Life processes (growth, nutrition and reproduction) (Y5). Life cycles (birth,

Biology	England (1999) [Double award]	England (2007) [Core award]	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
	parts of plants (Y3-6 and Y7-9). Life cycles (birth, growth, reproduction and death) (Introduction Y1-2 and Y3-6). Life processes (growth, nutrition and reproduction) (Y3-6). Reproduction in plants (Y7-9).				Life cycles (birth, growth, reproduction and death) (EYFS-Y3, Y4-6)	growth, reproduction and death) (Y5). Structure and function (Y8).
Energy - plants	Requirements for life (Y1-2 and Y3-6). Transportation of nutrients, water and oxygen (Y3-6 and Y10-11). Respiration and word equation (Y7-9). Photosynthesis and word equation (Y7-9) – reactants in/ products of; how its products used; and effect of varying factors (Y10-11).		Requirements for life (Y3-6). Nutrition (Y3-6). Respiration and word equation (Y7-9). Photosynthesis (Y7-9). Diffusion, osmosis and transport (Y7-9).	Nutrition (Y4) Requirements for life (Y4). Transportation of nutrients, water and oxygen (Y5) Respiration (Y5, 8 and 10-11) and word equation (Y8). Photosynthesis (Y9 and Y10-11) and word equation (Y9). Diffusion, osmosis and transport (Y8). Effect of varying factors on rate (Y10-11). Materials and water transport (Y10-11).	Requirements for life (EYFS-Y3 and Y4-6). How plants use energy from sun (Y4-6). Transfer of energy in food chain (Y4-6). Photosynthesis (Y7-9) and relationship with respiration (Y10-11).	Requirements for life (Y1). Processes of diffusion, osmosis, transport photosynthesis and gas exchange (Y8).

Table C3: Sub-domain: Chemistry

Chemistry	England (1999) [double award]	England (2007) [core award]	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
Nature of matter and energy • conservation of matter and energy • particulate nature of matter • classifying	Atoms, molecules and elements (Y7-9). Chemical formula (Y7-9). Conservation of mass in chemical and physical change (Y7-9). Model of the atom (Y10-11). Quantitative interpretation of balanced equations (Y10-11). Conservation of energy when bonds broken/made during reactions (Y10-11).	The particle model related to behaviour of matter (Y7-9).	Atoms, molecules and elements (Y7-9). Model of the atom (Y10-11) Quantitative interpretation of balanced equations (Y10-11).	Matter is what has mass and occupies space (Y5). Atoms, molecules and elements. Chemical formula (Y8). Model of the atom introduced (Y9). Model of the atom revisited (Y10-11). Conservation of energy when bonds are broken/made during chemical reactions (Y10-11). Quantitative interpretation of balanced equations (Y10-11).	Atoms, molecules and elements (Y7-9). Conservation of mass in chemical and physical change including weight, mass and density (Y7-9). Model of the atom (Y10-11). Chemical formula (Y10-11). Conservation of matter and energy during physical change, in terms of kinetic molecular theory (Y10-11). Nuclear chemistry (Y10-11). Quantitative interpretation of balanced equations (Y10-11).	Atoms, molecules and elements (Y10). Model of the atom (Y11). Chemical formula (Y11). Conservation of mass in chemical change (Y10-11). Quantitative interpretation of balanced equations (Y11).
Physical change • change of state • mixtures	Some materials change when heated or cooled (Y1-2). Liquids, solids and gases as states of matter, including temperature and change of state of water. Mixtures, including dissolving. Substances retain their properties in mixtures. Ways of	The particle model related to different physical properties and behaviour of matter (Y7-9).	Some materials change when heated or cooled (Y1-2). Distinguish between changes that can and can't be easily reversed (Y3-6). The water cycle. States of matter in terms of particles and energy transfer (Y7-9). Dissolving (Y7-9).	Water existing in three states; freezing, melting, boiling etc and the temperatures at which these happen (Y5). Interaction of water with different materials (Y5). States of matter in terms of particles and energy transfer (Y9). Solutions (Y8). More advanced	Identifying liquids, solids and gases (EYFS-Y3). Comparing liquids, solids and gases, and relating change of state to temperature (Y4-6). Mixtures (Y7-9). Distinguish between physical and chemical change (Y10-11).	Some materials change when heated or cooled (Y4). Mixtures; Dissolving; Interaction of water with different materials (Y6). Distinguish between changes that can and can't be easily reversed (Y6). States of matter in terms of particles and energy transfer (Y9).

Chemistry	England (1999) [double award]	England (2007) [core award]	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
	separating out mixtures (Y3-6). States of matter in terms of particles and energy transfer (Y7-9, elaborated Y10-11). Solutions (Y7-9). More advanced methods for separating mixtures (Y7-9, elaborated Y10-11). Solutions (Y10-11).		Separation of mixtures (introduced Y9, elaborated Y10-11).	methods for separating mixtures (Y8).	States of matter in terms of particles and energy transfer (Y10-11). Solutions (Y10-11).	Fluids and solutions (Y8-9).
Chemical change **-** reactions - bonding - predicting	Chemical change results in formation of new materials with new properties, and it is usually more difficult to recover the original materials than in the case of mixtures (Y3-6). Periodic table. Rearrangement of atoms in chemical change, compounds, patterns of reaction (Y7-9). Energy transfer and chemical reaction (Y7-9). Acids and alkalis (Y7-9). Different types of chemical reaction: combustion, thermal decomposition,	Elements and atoms combine in chemical reactions to form compounds (Y7-9). Elements and compounds show characteristic chemical properties and patterns in their behaviour (Y7-9). Chemical change takes place by rearrangement of atoms in substances (Y10-11). Patterns in the chemical reactions between substances (Y10-11).	Acids and alkalis (Y7-9). Burning and oxygen (Y7-9). Neutralisation (Y7-9). Different types of chemical reaction: combustion, thermal decomposition, oxidation and neutralisation (Y10-11). Model of the atom and how it relates to the periodic table and predicts how a substance will react (Y10-11). Different kinds of chemical bonds (Y10-11).	Rearrangement of atoms in chemical change, compounds (Y8). Acids and alkalis (Y8). Oxidation (Y9). Different types of chemical reaction: combustion, thermal decomposition, oxidation and neutralisation (Y10-11). Model of the atom and how it relates to the periodic table and predicts how a substance will react (Y10-11). Different kinds of chemical bonds (Y10-11).	Rearrangement of atoms in chemical change, compounds (Y7-9). Different types of chemical reaction: combustion, thermal decomposition, oxidation and neutralisation (Y10-11). Model of the atom and how it relates to the patterns of the periodic table and predicts how a substance will react (Y10-11). Energy transfer and chemical reaction (Y10-11). Different kinds of chemical bonds (Y10-11).	Rearrangement of atoms in chemical change, compounds (Y10-11). Patterns of chemical reactions - different types of chemical reaction: combustion, thermal decomposition, oxidation and neutralisation (Y10-11). Periodic table in relation to atomic structure/model of the atom (Y11). How use of periodic table predicts how a substance will react (Y11). Energy transfer and chemical reaction (Y10-11).

Chemistry	England (1999) [double award]	England (2007) [core award]	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
	oxidation and neutralisation (Y10-11). Model of the atom, and how it relates to the periodic table and predicts how a substance will react (Y10-11). Different kinds of chemical bonds (Y10-11). Energy transfer in reactions (Y10-11).					Different kinds of chemical bonds (Y10-11)
Properties of materials • properties of materials related to use • properties related to chemical properties • making new materials	Properties of materials related to their uses; sorting materials based on their properties (Y1-2). Comparing materials based on their properties (Y1-2, elaborated Y3-6). Varying properties of different elements (Y7-9). Reaction of metals with oxygen, water, acids and metal salts to make new substances (Y7-9). Rock formation (Y7-9). Sources of materials, including metals and products from crude oil (Y10-11). Nitrogen and Amonia (Y10-11).	The particle model related to different physical properties and behaviour of matter (Y7-9). Geological activity caused by chemical processes (Y7-9). New materials made from natural resources by chemical reactions (Y10-11) Properties of a material determine its uses (Y10-11) Surface and atmosphere have changed since Earth's formation (Y10-11).	Properties of materials related to their uses (Y1-2, elaborated Y3-6). Varying properties of different elements and compounds (Y7-9). Reaction of metals with oxygen, water, acids and metal salts to make new substances (Y7-9). Properties, extraction and purification of metals; alloys (Y7-9). Plastics as materials made from crude oil (Y7-9). Composite materials (Y7-9). Atmosphere, oceans, rocks and minerals (Y10-11). Sources of materials, including metals and	Properties of materials related to their uses; sorting materials on the basis of their properties (Y4) including thermal and electrical conductivity (Y5). Comparing materials based on their properties (Y5). Varying properties of different materials, elements and compounds (Y8). Metals (Y8). Sources of materials, including metals and products from crude oil (Y10-11). Use of balanced equations and quantitative analysis to determine yields (Y10-11).	Sorting materials based on their properties (EYFS-Y3). Comparing materials based on their properties (Y4-6). Identifying materials that are electrical conductors, magnetic (Y4-6). Rocks and their properties (Y4-6). Rock formation and weathering (Y7-9, elaborated Y10-11). Use of balanced equations and quantitative analysis to determine yields (Y10-11). Controlling rate of reaction – catalysts (Y10-11). Bio-chemistry (Y10-	Properties of materials related to their uses (Y3). Buoyancy and magnetism (Y4). Properties of rocks and minerals (Y4). Properties and relation to use elaborated, particularly gases and fluids (Y9). Physical and chemical properties of substances and materials (Y9). Rock formation and weathering (Y8). Varying properties of different elements (Y10-11). Properties of elements related to position in periodic table (Y10-11). Metals and non-

Chemistry	England (1999) [double award]	England (2007) [core award]	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
	Formation and weathering of rocks, including evidence and dating (Y10-11). Use of balanced equations and quantitative analysis to determine yields (Y10-11). Controlling rate of reaction – catalysts (Y10-11).		products from crude oil (Y10-11). Important processes: chlorine and sulphuric acid (Y10-11). Use of balanced equations and quantitative analysis to determine yields (Y10-11). Controlling rate of reaction – catalysts (Y10-11).	Controlling rate of reaction – catalysts (Y10-11).	11).	metals (Y10-11). Reaction of metals with oxygen, water, acids and metal salts to make new substances (Y10-11). Bio-chemistry (Y11).

Table C4: Sub-domain: Physics

Physics	England (1999) [double award]	England (2007) [core award]	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
Forces & Motion	Movement; pushes and pulls as examples of forces (Y1-2). Magnetic attraction and repulsion, gravitational attraction; forces act in pairs; measuring forces (Y3-6). Linear motion – speed, distance & time; gravitational attraction; balanced and unbalanced forces; friction. Moments (Y7-9). Force, area and pressure (Y7-9). Force and acceleration - distance, time and speed; speed and velocity, acceleration, velocity and time, force, mass and acceleration, equal and opposite forces (Y10-11). Force and non-uniform motion (Y10-11).	Forces are interactions between objects and can affect their shape and motion – pressure; linear motion; turning moments (Y7-9).	Properties of movement (Y1-2). Patterns and phenomena related to movement (Y 3-6). Forces and motion; measuring forces; friction; gravity and weight; action and reaction (Y7-9). Position, distance and displacement; scalars and vectors; speed and velocity; uniform motion; acceleration; vertical motion under gravity (Y10-11). Objects at rest or in uniform motion; addition and resolution of forces; force, mass and acceleration; action and reaction pair of forces; mass and weight; the principle of moments (Y 10-11). Momentum (Y10-11).	Pushes and pulls as examples of forces (Y3-6). Characteristics of simple machines (Y3-6). Different types of forces; effects of forces (Y7-9). Effects of forces; measuring forces (Y7-9). Speed, velocity and acceleration, graphical analysis of motion, free-fall (Y10-11). Balanced and unbalanced forces; friction (Y10-11). Mass and weight; gravitational field and field strength (Y10-11). Turning effect of forces (Y10-11). Pressure (Y10-11).	Movement of objects; balancing objects (Y1-2). Weight and mass; gravitational attraction (Y7-9). Motion of objects - position, direction of motion, and speed; distance, time and speed (Y7-9). Displacement, velocity, acceleration force, linear momentum (Y10-11). Distance, speed, energy, mass, work (Y10-11). Gravitational attraction; circular motion (Y10-11).	How simple machines are used to change the speed or force of movement (Y3-6). Aerodynamics – friction, pressure, gravity (Y7-9). Force and mass; measuring forces; frictional forces; stress; direction of forces (Y7-9). Pressure as a force (Y7-9). Transmission of force and energy between parts of a mechanical system (Y7-9). Scalars and vectors; displacement and velocity; acceleration; equal and opposite forces (Y10-11).
Light, Sound and Waves	Light and dark (Y1-2). Making and detecting sound (Y1-2).	Communication through radiation waves (Y10-11).	Patterns and phenomena related to light and sound (Y3-6).	Luminous and non-luminous objects; shadows (Y3-6).	Vibration; pitch and loudness; sound travels through a medium (Y3-6).	Creating colour (Y1-2). Vibration; pitch and

Physics	England (1999) [double award]	England (2007) [core award]	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
	Light travels from a source; shadows; reflecting light; seeing (Y3-6). Vibration; pitch and loudness; sound travels through a medium (Y3-6). Rays; non-luminous objects; reflection; refraction; dispersion of white light; colour filters (Y7-9). Speed of light/sound; vibration, amplitude and frequency (Y7-9). Characteristics of waves (Y10-11). Electromagnetic spectrum (Y10-11). Sound and ultrasound (Y10-11). Seismic waves (Y10-11).		Rays; luminous and non luminous objects (Y7-9). Reflection and angle of incidence (Y7-9). Colour - dispersion of white light; the colour spectrum; colour filters (Y7-9). The other parts of the electromagnetic spectrum (Y7-9). Nature of waves; motion and propagation (Y10-12). Reflection, refraction, diffraction and interference (Y10-12). Further development of the electromagnetic spectrum; lenses (Y10-12). Audible frequency range musical notes; noise (Y10-12).	Light travels faster than sound; reflection; refraction; dispersion of white light; colour (Y7-9). Vibration; pitch; sound travels through a medium; hearing (Y7-9). General wave properties (Y10-11). Reflection; refraction; lenses (Y10-11). Electromagnetic spectrum (Y10-11). Sound waves, speed of sound and ultrasound (Y10-11).	Light travels in a straight line; light can be reflected, refracted and absorbed (Y3-6). Properties, types and motion of waves (Y10-11). Electromagnetic spectrum (Y10-11).	loudness; making sound; sound travels through a medium; hearing (Y3-6). Sources of light, non-luminous objects; reflection; refraction; dispersion of white light (Y3-6). How light is reflected, transmitted and absorbed; angles of reflection; refraction; lenses (Y7-9). Electromagnetic spectrum (Y10-11). Application of electromagnetic spectrum in technologies and communication systems (Y10-11). Seismic waves (Y10-11).
Electricity & Magnetism	Electrical appliances; components of simple circuits (Y1-2). Constructing simple circuits; diagrams and symbols (Y3-6). Parallel circuits;	Electric current in circuits (Y7-9). Electrical power is readily transferred and controlled (Y10-11).	Patterns and phenomena related to electricity (Y3-6). Closed circuits; conductors and insulators (Y7-9). Current, voltage, and	Characteristics and uses of magnets; difference between magnets and non magnets (Y3-6). Components of circuits; closed circuits (Y3-6).	Closed circuits; conductors and insulators; making electromagnets (Y3-6). Properties of magnets (Y3-6).	Characteristics and uses of magnets; difference between magnets and non magnets (Y3-6). Household electricity, Introduction to electricity and

Physics	England (1999) [double award]	England (2007) [core award]	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
	current and voltage; energy transfer in electrical circuits (Y7-9). Magnetic fields; electromagnets (Y7-9). Resistance, voltage current and power relationships, mains electricity; electrical charge (Y10-11). Electromagnetic effects (Y10-11).		resistance; circuit diagrams and symbols; series and parallel circuits (Y7-9). Fuses & household electricity (Y7-9). Resistance, voltage current and power; series and parallel circuits; domestic electricity; electric charge and electric fields (Y10-11). Electromagnetism (Y10-11).	Constructing simple circuits; diagrams and symbols; electrical conductors and insulators; electrical safety (Y3-6). Current, resistance, voltage, power; circuit diagrams and symbols; chemical, heating and magnetic effects of an electric current; electrical safety (Y7-9). Electrical charge; resistance, voltage current and power relationships; practical electricity (Y10-11). Magnetism and electromagnets (Y10-11). Introductory Electronics (Y10-11).	Electric charge; current, voltage, resistance; series and parallel circuits; diagrams and symbols (Y10-11). Electromagnetism (Y10-11).	electromagnets; magnetic fields; conductors and insulators; resistance (Y3-6). Constructing electrical circuits – series and parallel (Y3-6). Potential danger of electrical devices; current and static electricity; electrical conductors and insulators; current, resistance and voltage; circuits; diagrams and symbols (Y10-11).
Energy and matter	Energy resources (Y7-9). Conservation of energy – temperature and heat; transfer of energy (conduction, convection and evaporation & radiation) (Y7-9). Energy transfer and efficient use of energy	Energy can be transferred usefully, stored, or dissipated, but cannot be created or destroyed (Y7-9). Energy transfers can be measured and their efficiency calculated (Y10-11). Radiations, including	Sources of energy (Y1-2). Patterns and phenomena related to energy (Y3-6). Forms of energy; energy changes; fuels; generating electricity, energy sources (Y7-9).	Energy is required to make things work or move (Y3-6). The Sun is our primary source of light and heat energy (Y3-6). Sources of heat; temperature and heat; energy transfer; heat gain/loss; conductors	Sun as a source of light and heat (Y1-2). Basic forms of energy; energy transfer (Y3-6). Density (Y7-9). Potential and kinetic energy (Y7-9). Heat and temperature;	Floating [informal introduction to density] (Y3-6). Thermal energy; particle model of matter; temperature; thermal expansion; change of state; heat transfer; insulation and thermal conductivity; thermal energy sources;

Physics	England (1999) [double award]	England (2007) [core award]	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
	(Y10-11). Work, power and energy (Y10-11). Radioactivity (Y10-11).	ionising radiations, can transfer energy (Y10-11).	Properties of matter - gas pressure; density, floating and sinking; thermal expansion and contraction (Y7-9). Temperature, heat and internal energy; heat capacity and specific heat capacity (Y10-11). Conduction, convection and radiation (Y10-11). Melting and freezing, boiling, and condensing; latent heat; evaporation (Y10-11). Work, energy and power (Y10-11). Radioactivity (Y10-11). Atomic model (Y10-11). Nuclear fission and fusion (Y10-11).	of heat (Y3-6). Various forms of energy; energy can be converted from one form to another (Y7-9). Sources of energy and storage of energy (Y7-9). Expansion and contraction; conduction, convection and radiation (Y7-9). Density; conservation of energy, work and power; kinetic model of matter; heat and temperature; properties of matter (Y10-11). Radioactivity (Y10-11).	energy transfer (Y7-9). Conservation of Energy (Y10-11). Work, power and energy (Y10-11). Heat and heat transfer (Y10-11).	energy conservation (Y7-9). Density (Y7-9). Efficiency of energy conversions; work, power and energy (Y10-11). Conservation of energy resources; sustainability of energy resources (Y10-11). Evidence for the presence of energy; kinetic and potential energy; gravitational potential energy (Y10-11). Energy conservation and conversion; “useful” energy (Y10-11).
Earth and Space	Sun, Earth and Moon features and periodic changes (Y3-6). The solar system and artificial satellites (Y7-9).	The nature and observed motions of the sun, moon, stars, planets and other celestial bodies (Y7-9).	Features and patterns of day and night; basic patterns of objects in the sky (Y1-2). Weather and seasonal changes (Y3-6).	Composition of the solar system; regularity in the movements of the Earth and the Moon; artificial satellites (Y3-6).	Weather changes, seasons (Y1-2). Periodic changes (Y1-2). Weather and climate	Weather and seasonal changes (Y1-2). Weather phenomena (Y3-6). Motion, location and

Physics	England (1999) [double award]	England (2007) [core award]	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
	The wider Universe (Y10-11).	The surface and the atmosphere of the Earth (Y10-11). The solar system as part of the universe (Y10-11).	Patterns of changes/phenomena observable on Earth caused by movement of the Earth and the Moon (Y3-6). Life of an astronaut in space (Y7-9).		(Y3-6). The Earth and the solar system (Y3-6). The Earth; the solar system; the wider universe (Y7-9). The Earth; the origin and evolution of the Universe (Y10-11).	characteristics of stars, moons and planets; seasonal changes; length of the day and night; phases of the moon; Earth, the Sun and the Moon are part of a solar system (Y7-9). Surface of the Earth (Y7-9). Space exploration (Y10-11). Climate (Y10-11).

Table C5: Scientific processes – primary (Singapore on p191)

Aspect of scientific enquiry	England (1999)	Alberta (2003)	Hong Kong (1999)	Massachusetts (2006)	Victoria (2008)
Science is about generating explanation that is supported by evidence	Y3-6 - thinking creatively about explanation and testing ideas through observation and measurement.		Y4-6 - scientific ideas being used to explain phenomena and importance of evidence for claims.		Y4-5 – learn to describe evidence in support of simple scientific ideas. Y6-7 – understand some questions are open to investigation, some require reason and discussion. How science has changed and developed through evidence, including work of some Australian scientists. Cause and effect. Introduce use of models in science.
Scientists ask questions that can be answered through carrying out investigations	Introduced Y1-2. Elaborated Y3-6 - asking questions that can be investigated scientifically and decide how to find answers.	Introduced Y2, elaborated Y6-7 with introduction of hypothesis testing and identifying ways of finding answers.		EYFS-Y3 – ask questions about objects, organisms and events in the environment.	Introduced Y2-3, as beginning to generate questions and suggest observations/measurements, make predictions. Elaborated Y6-7 – Frame and investigate questions that interest them; develop skills in identifying evidence needed.
To explore their world using sense data	Y1-2 – use first hand experience and sense data as sources.		Y1-3 – demonstrate interest in exploring environment.		Rec-Y1 – Use their senses to explore the world around them.
To make simple predictions	Y1-2 – Think about what might happen before deciding what to do.	Y2 – predict what might happen, elaborated later in Y6-7 to identify one or more possible answers, which may take form of prediction or hypothesis.		EYFS-Y3 – make predictions. Y4-6 – ask questions/make predictions that can be tested.	
Describe objects and phenomena and sort	Y1-2 – make simple comparisons and identify				EYFS-Y1 – sort objects. Y2-3 – observe and

Aspect of scientific enquiry	England (1999)	Alberta (2003)	Hong Kong (1999)	Massachusetts (2006)	Victoria (2008)
them according to basic criteria	simple patterns.				describe.
Participate in designing and carrying out investigations	Y1-2 - carrying out complete investigations including recording observations and measurements. Y3-6 - elaborated to include considering for themselves sources of information needed, deciding what might happen, making a fair test, what evidence to collect, selecting equipment and materials etc.	Y2 – manipulating materials and making relevant observations, recognise and describe steps taken. Y4 – identify with guidance, and carry out procedures to find answers to questions. Y5 – fair test introduced. Y6 – identify variables to hold constant for fair test, select materials, modify procedures as needed, and carry them out. Y7 – plan a fair test, identifying all variables.	Y1-6 – plan and conduct simple investigations. Y4-6 –use focused exploration and investigation to acquire scientific understanding and skills.	EYFS-Y3 – name and use simple equipment and tools, record observations and data. Y4-6 – select and use appropriate tools and technology; keep accurate records; conduct multiple trials.	R-Y1 – participating in very simple investigations including observation and measurement and recording data. Y2-3 – repeating measurements over time. Y4-5 – plan, design, conduct and report on experiments, in selecting and using simple measuring equipment, and describing and developing fair tests and explaining how variables were controlled. Y6-7 – design simple experiments, draw conclusions and describe their purpose. Approach data collection systematically, understand error in measurement, use a range of measuring instruments.
Have regard to health and safety when carrying out investigations	Y1-2 – follow simple instructions to control risk and recognise hazards, assess risks and take action. Y3-6 – use equipment correctly, recognise and take action to reduce risks.				Rec-Y1 become aware of and continue to practice safe procedures. Y4-5 – describe safety procedures as with experiments, elaborated at Y6-7 to include considering their own responsibilities and safety requirements.
Interpret the findings of investigations	Y1-2 – communicate what happened, compare what	Y2 – describe what was observed.	Y1-3 – discuss observations and make	EYFS-Y3 – Discuss observations.	R-Y1 – make generalisations from data.

Aspect of scientific enquiry	England (1999)	Alberta (2003)	Hong Kong (1999)	Massachusetts (2006)	Victoria (2008)
	expected, and try to explain it. Y3-6 –to include comparing, identifying associations, concluding and explaining.	Y3 – describe and explain. Y4 – identify patterns and order. Y6-7 – state an inference based on observation. Y6-7 – cause and effect.	simple interpretations.	Y4-6 – Compare results with predicted results; recognise simple patterns and use data to create an explanation; communicate findings to others.	Y2-3 – recognise and describe simple patterns in data. Y4-5 – comment on trends in data. Y6-7 – reflect on data presentation, begin to design and build models, use understanding of error to consider their inferences.
Begin to use scientific language and terminology correctly	Y1-2 – use simple scientific language. Y3-6 – use appropriate scientific language and terms including SI units.				Y2-3 – use and expand simple scientific vocabulary. Y4-5 – use scientific language in place of everyday language. Y6-7 – explain science using symbols, diagrams and simple equations. Use terms such as relationships, models, systems, cause and effect correctly and appropriately.
Consider their investigation critically and think about the next stage in the investigative cycle	Y1-2 – review their work; recognise when a test or comparison is unfair. Y3-6 – review work and describe it significance and limitations.	Y3 – identify new questions that arise from what was learned/the investigation. Y6-7 – evaluate procedures used and identify possible improvements.			

Singapore introduces science later in primary level (Years 4 to 7). A section of the curriculum identifies the skills and processes that pupils should learn in science. These are:

1. Basic Process Skills
    - Observing
    - Comparing
    - Classifying
    - Measuring and using apparatus
    - Communicating
    - Analysing
    - Generating
    - Evaluating; and

2. Integrated Processes
    - Creative problem solving
    - Decision-making
    - Investigation.

Table C6: Scientific processes - Lower secondary level

Aspect of scientific enquiry	England (1999) Y7-9	England (2007) Y7-9	Alberta (2003) Y8-10	Hong Kong (1999) Y7-9	Massachusetts (2006) Y7-9	Singapore (2001) Y8-9	Victoria (2008) Y8-9
Science is about generating explanation that is supported by evidence **Scientists ask questions that can be answered through carrying out investigations**	Interplay between empirical questions, evidence and scientific explanation. Importance of testing explanations by using them to make predictions and collecting evidence. How scientists (have) work(ed), including roles of experimentation, evidence and creative thought.	Scientific thinking as a concept: - using scientific ideas to explain phenomena, generate and test theories; and - critically analysing and evaluating evidence from investigations.	'Nature of science' concepts, including goal of science; how knowledge develops; collaboration; changes in response to both new evidence and new interpretations; the process of scientific investigation.	What is science? The work of a scientist; Realising the limitations of scientific knowledge.		Scepticism for generalisations not based on verifiable observation. Recognise products of science are tested data collected over a long time, and explain how scientists have formulated concepts, principles and theories.	Nature of scientific thinking is not static. Expand pupils' knowledge to include abstract concepts, theories, principles and models drawn from traditional and emerging sciences.
Participate in designing and carrying out investigations – decide on the questions to be investigated	Turn ideas into a form that can be investigated and decide on appropriate approach; choose data sources; carry our preliminary work and make predictions.	Use scientific methods and techniques to develop and test ideas/ explanations.	Identify questions to investigate; define and delimit questions; state a prediction and hypothesis.	Identifying the problem to be investigated; identifying factors involved; and proposing a hypothesis.	Formulate a testable hypothesis.	Define problem/ask question that can be verified by experiment; suggest possible hypothesis (tentative explanation); make a verifiable prediction based on known data.	
Participate in designing and carrying out investigations – design the investigation	Consider key factors that need to be taken into account, including contexts in which variables can't be controlled; decide extent and range of data to collect and techniques,	Plan practical/ investigative activities.	Select appropriate methods and tools for collecting data and information.	Design an investigation.	Design and conduct an experiment specifying variables to be changed, controlled and measured; control variables to ensure a fair test.	Determine variables to be measured and controlled; design simple experiments.	Justify selection of equipment and procedures, etc. Controlled studies using appropriate experimental tools. Basic sampling procedures in fieldwork.

Aspect of scientific enquiry	England (1999) Y7-9	England (2007) Y7-9	Alberta (2003) Y8-10	Hong Kong (1999) Y7-9	Massachusetts (2006) Y7-9	Singapore (2001) Y8-9	Victoria (2008) Y8-9
	equipment and materials to use.						
Participate in designing and carrying out investigations – carry out the investigation, including correct use of equipment and taking and recording measurements	Use range of equipment and materials appropriately. Make observations and measurements to appropriate degree of precision, and sufficient to reduce error and obtain reliable evidence.	Carry out practical/ investigative activities.	Carry out procedures, controlling the major variables. Use appropriate instruments effectively and accurately, and organise data using an appropriate format.	Proper handling of simple apparatus. Observing and recording the results.	Select appropriate tools and technology. Make quantitative observations and carry out several measurements to minimize sources of error.	Acquire and use scientific practical skills; make careful observations and repeated measurements.	Technical uses of a range of instruments and chemicals and procedures. Develop skills in measuring. Use standard laboratory instruments and equipment and methods. Make systematic observations.
Have regard to health and safety when carrying out investigations	Use equipment and materials appropriately and take action to control risks to themselves and others. Recognise that there are hazards an assess risks and take action.	Assess risk and work safely.	Use apparatus safely.	Laboratory safety rules; safety measures to be observed; coping with common laboratory accidents.	Safe laboratory practices.	Observe laboratory rules at all times.	Practice safe, responsible and ethical behaviour when conducting investigations.
Interpret the findings of investigations and communicate their conclusions	Use diagrams, charts and graphs to show data; use observations, measurements and data to draw conclusions; decide to what extent conclusions support a prediction; use scientific knowledge to explain and interpret; consider	Obtain, record and analyse data; use findings to provide evidence for scientific explanations.	Interpret patterns and trends in data and infer and explain relationships. State a conclusion based on experimental data and explain how evidence supports of refutes an idea; recommend an appropriate way of summarising and interpreting	Interpreting data; drawing conclusions.	Present and explain data. Draw conclusions based on data and make inferences.	Describe trends in data, even when patterns are not exact; infer from data. Advance an explanation and state limits within which it holds.	Present data. Use a range of tools to explain and interpret observations. Justify conclusions drawn against prediction or hypothesis investigated. Prepare and present reports using appropriate diagrams and symbols.

Aspect of scientific enquiry	England (1999) Y7-9	England (2007) Y7-9	Alberta (2003) Y8-10	Hong Kong (1999) Y7-9	Massachusetts (2006) Y7-9	Singapore (2001) Y8-9	Victoria (2008) Y8-9
	whether findings support conclusions or interpretations; and communicate findings.		findings.				
Use scientific language and terminology correctly	Use scientific language, conventions and symbols where appropriate.	Use appropriate methods, to communicate scientific Information.	Convention of nomenclature and notation. Scientific language terms specific to each field of study.		Communicate using appropriate science and technology terminology.	Use appropriate units.	Use appropriate diagrams and symbols.
Consider their investigation critically	Consider anomalies in observations/ measurements and try to explain them. Suggest improvements to methods.	Evaluate scientific evidence and working methods.	Identify and suggest explanations for discrepancies in data.		Offer explanations of procedures and critique and revise them.		

Table C7: Comparison of upper secondary science (Year 10-11)

	England	Singapore	Hong Kong	Alberta	Massachusetts	Victoria
Phase of education corresponding most closely to England Y10-11	Years 10 and 11	England Y10-11 corresponds to Secondary 3-4. 'Special/express' pupils sit O levels at end Y11 (aged 15/16 years). This is the route followed by the majority of pupils. 'Normal academic' pupils sit N levels at end Y11 and may progress to O level end Y12 (age 16/17). 'Normal technical' pupils complete Y10-11. For majority of pupils (60%), route is directly comparable with England Y10-11.	Until 2009, followed UK pattern of 3 yr KS3 (England Y7-9, sec 1-3) plus 2 yrs KS4 (England Y10-11, sec 4&5). Since 2009: 3 yr KS3 (England Y7-9), then 3 yr pre-university qualifying (England Y10-12) ending age 17. University is then 4 Years. There was direct comparison between England Y10-11 and Hong Kong until 2009, but not since.	Junior high (England Y8-10, 12/13 yrs – 14/15 Years) ends halfway through UK KS4. Senior high (England Y11-13, 15/16 Years – 17/18 yrs) is equivalent to A level. There is no direct comparison between Alberta and UK.	Junior High School is equivalent to KS4, (England Y10-11 age 14/15-15/16 years.) Senior high school is equivalent to A level, (England Y12-13, age 16/17-17/18 years.) Directly comparable with England Y10-11.	Y7&8 (England Y8-9, ages 12/13 and 13/14 years) is equivalent to KS3, and Y9&10 (England Y10-11, 14/15 and 15/16 years) is equivalent to KS4. Victoria Years 9 and 10 correspond directly to England Y10-11.
Is some science compulsory in upper secondary?	Yes	Only for pupils on the 'special/express' route.	Yes at lower secondary Y7-9. No at senior secondary, previously Y10-11, since 2009Y10-12. Compulsory schooling ends at Y9. Senior secondary sciences are identified in curriculum docs as 'electives'.	Yes, required through to England Y13 (A level equivalent and necessary to achieve High School Diploma), although compulsory schooling ends at 16 years so compulsion only applies strictly to Y11, consistent with end England KS4 .	Yes	Yes

What is stipulated?	National Curriculum core content equivalent to one GCSE.	'Special/express' pupils must study one science subject from: • biology or human and social biology; • physics; • chemistry; • science/integrated science. Science is not compulsory for 'normal academic' or 'normal technical' routes.	At senior secondary science is not a requirement, but pupils can choose from: Separate study of biology, chemistry or physics; Integrated science (scientific literacy); Combined science (single qualification made up of aspects of any two of the main disciplines studied in combination).	England Y8-10 organised as general science (and used as our KS3 equivalent). England Y11-13 pupils select science options required to build up a necessary number of credits. Route is usually a general science course in Y11 followed either by specialist courses (in biology, chemistry or physics) or another general science course in Y12 and Y13. Pupils are required to study for 15 credits in science subjects out of a required total of 100 credits.	The high school learning standards are for 'High School Introductory courses', and 'express the learning standards for a full first-Year course.' The learning standards are grouped into 4 strands: Earth and Space Science; Life Science (Biology); Physical Sciences (Chemistry and Physics); and Technology/Engineering. Pupils take one of four state-mandated tests in science (biology, chemistry, introductory physics or technology/engineering) at the end of England Y10 or Y 11. Their Y11 Science, Technology and Engineering score is based on their best result on any test taken in Y10 or Y11.	Victorian Essential Learning Standards (VELS) for Y9 and Y10 (England Y10-11) are expressed as Level 6. Expressed as general science.
What qualification is awarded at end KS4 equivalent?	GCSE or alternative	Pupils sit O levels or N levels at end Sec 4 (England Y11). A proportion of those who sit N levels go on to convert them to O levels in Y12 equivalent.	Until 2009, pupils sat Hong Kong Certificate of Education Examination (HKCEE) at end England Y11. Since 2009, no qualification is awarded at this stage.		Pupils are required to take Massachusetts Comprehensive Assessment System (MCAS) tests by end England Y11. Senior high school graduation (England Y13) depends on passing at least one science test.	

Comparison with England National Curriculum KS4	Core science compulsory for all pupils.	Science is only mandatory for pupils on 'special' and 'express' courses (60% of pupils). Pupils are not required to study across all disciplines, only to take one science subject, which can be a single science discipline or integrated science.	Until 2009, Y10-11 ended with HKCEE, analogous to GCSE. However, science was elective, options included single sciences and combined science. Since 2009, Hong Kong senior secondary includes equivalent Y10-12. Science is elective and pupils can choose either separate sciences or a single qualification in general science or combined science.	Alberta school stages cut across the middle of England KS4 (Y10-11). At Y10 equivalent the curriculum is mandatory and expressed as general science. In Y11 equivalent pupils take a general science course as preparation for specialized study of separate disciplines or more advanced general science at A level equivalent standard. Credits in science are required to graduate senior high school.	Pupils have to do science throughout Y10-11 equivalent and be tested on it, but are only required to pass one of four science tests to achieve senior high school graduation.	Pupils must study science throughout Y10-11 equivalent, and the curriculum is stated in the form of general science.

Table C8: Earth sciences

Earth sciences	England (1999)	England (2007 Y7-9 and Y10-11 only)	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
Seasons and weather		Changes in the atmosphere since Earth's origin and at present (Y10-11).	Simple weather changes (Y1-2). Effects of weather and seasonal changes (Y3-6). Air and atmosphere (Y3-6). Further development of the atmosphere – oxygen and fractional distillation (Y10-11).		Air and wind (Y1-2). Weather changes and seasons (Y1-2). Types of weather and global patterns (Y3-6).	Seasonal changes in atmosphere, plants and animals (Y1-2). Weather phenomena and methods for studying weather (Y3-6).
Rocks and minerals	Properties and groupings of rocks; soil (Y3-6).	Geological activity caused by chemical and physical processes – rock cycle and rock formation (Y7-9).	Rocks as sources of minerals; tests to separate constituent minerals (Y10-11).		Rocks, soil and living organisms (Y1-2). Minerals; rock categories; how soil is formed and soil's properties (Y3-6).	Simple classification of rocks and minerals and constituents of soil (Y3-6).
Changing earth	Physical weathering (Y7-9). Rock formation over different timescales; igneous, metamorphic and sedimentary rocks (Y7-9).	Weathering (Y7-9). Changes to the surface of the earth since its origin and at present (Y10-11).	Features of the natural environment (Y1-2). Changes in the earth's surface –continents and oceans (Y3-6).		Fossils (Y2-3). Introduction to erosion, weathering, earthquakes and volcanoes (Y3-6). Mapping Earth's common physical features (Y7-9). Heat transfer in the Earth's system (Y7-9). Introduction to plate tectonics (Y7-9). Fossilisation; further development of erosion and	Geological landforms; earth's surface and interior; metamorphic, igneous and sedimentary rock (Y7-9). Weathering and erosion (Y7-9). Further develop earth's internal structure including plate tectonics, earthquakes, fossilisation (Y10-11 and beyond).

Earth sciences	England (1999)	England (2007 Y7-9 and Y10-11 only)	Hong Kong (1998; 2002; 2007)	Singapore (2001; 2005)	Massachusetts (2006)	Alberta (1996; 2003; 2005)
					weathering; sedimentation; glaciation (Y7-9). Earth's internal and external sources of energy and impact on humans; gravity and electromagnetism of Earth; impact of these processes on ocean currents, weather, Earth and life systems and seasonal variations (Y10-11). Physical and chemical weathering; nitrogen cycle; processes in rock formations; further develop convection currents, lithospheric plates and relation to earthquakes and volcanoes (Y10-11).	
Water systems	The water cycle – evaporation and condensation (Y3-6).		The water cycle (Y7-9). The ocean – composition of sea water; test for components of seawater (Y10-11).		Water cycles both in the atmosphere and underground (Y3-6). Processes of the hydrologic cycle (Y10-11).	Characteristics of saltwater and freshwater systems (Y7-9). Aquatic ecosystems and human impact (Y7-9).

Ecosystems	Relation of life processes to animals and plants (Y1-2). Food chains and feeding relationships in habitats (Y3-6). Microorganisms (Y3-6). Food webs and further development of food chains (Y7-9).	Variation of living things; interaction with each other and environment (Y7-9).	Features of living things and interaction with nature; life processes (Y1-2). Interdependence of living things and their environment (Y3-6). Relationship between plants and the atmosphere (Y3-6). Adaptation of living things to the environment (Y3-6). Plant and animal diversity (Y7-9). Food chains (Y7-9). Biodiversity (Y10-11). Ecosystems – levels; types; components; functioning; biotic and abiotic factors (Y10-11).	Organisms and their environment - energy flow; food chains and food webs; carbon cycle (Y10-11).	Living things in the natural world; life cycles; habitats (Y2-3). Detailed lifecycles of the frog/butterfly (Y7-9). Adaptation of plants and animals to their environment (Y7-9). Biodiversity; changing ecosystems through time (Y7-9). Food webs (Y7-9). Ecology – organisms and population levels (Y10-11).	Living things and what they need to grow (Y1-2). Food chains in relation to small animals (Y3-6). Life cycles of animals (Y3-6). Wetland ecosystems (Y3-6). Forest ecosystems (Y7-9). Further develop ecosystems – components, interactions and interdependencies (Y7-9). Habitat diversity (Y7-9). Food chains and webs; carbon an nitrogen cycle; trophic levels (Y10-11 and beyond). Biotic and abiotoc characteristics of ecosystems; population and ecosystem structure (Y10-11 and beyond).

Earth and beyond	Sun, Earth and Moon relationships (Y7-9) The solar system (Y7-9). Origins of the Universe, other bodies in the universe e.g. black holes, stars (Y10-11).	Nature and observed motion of the Sun, Moon, stars planets and other celestial bodies (Y7-9). The solar system as part of the Universe, early and long term changes (Y10-11).	Basic patterns of objects in the sky (Y1-2). Patterns of movements of earth and moon (Y3-6). Space exploration (Y7-9).	Position of Earth, Sun and Moon; composition of solar system (Y3-6).	Earth and the solar system (Y3-6). Earth Sun and Moon relationships (Y10-11). Further develop the solar system (Y10-11). Origins of the Universe (Y10-11).	Sun, earth and moon relationships (Y7-9). The solar system (Y7-9). Space exploration (Y10-11). Further develop the solar system (Y10-11). The Universe (Y10-11). Development of technologies to understand the Earth and space (Y10-11).

[i] Alberta (2000) relates to Years 1-10 and Alberta (2003) relates to Year 11
[ii] New South Wales (2001) relates to Years 1-7 and New South Wales (2003) relates to Years 8-11
[iii] Y = Year as defined in the National Curriculum
[iv] Eng. = England
[v] R = Reception Year
[vi] The asterisk denotes that these specific curricula were not analysed as part of this report.
[vii] KS = Key Stage
[viii] Y = Year as in Key Stage equivalent
[ix] EYFS = Early Years Foundation Stage in England (0 to 5yrs)
[x] English National Curriculum 2007 not applicable

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