





**Cambridge
Assessment**



**The Cambridge Approach
*to Textbooks***



Principles for designing high-quality textbook and resource materials

March 2016 – revised April 2017

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Reading this document

We have divided this document into sections to make it easy to read.

Sections 1 to 5 provide background to the Cambridge Approach.

Section 6 gives details of the principles which make up the Cambridge Approach.

Section 7 is an annex providing examples of the principles in practice.

The Cambridge Approach was drawn up by Tim Oates CBE, Group Director of Assessment Research and Development. Any queries relating to this document should be addressed to him.

Acknowledgements and thanks

The first phase of the research on textbooks across the world was undertaken with the support of the Ministerial team working on the review of the National Curriculum in England – they did a great job in locating and bringing together a library of textbooks. Ministerial engagement with the issue of textbook quality has been an important element of the work.

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Section 1

The Cambridge Approach

Cambridge Assessment has contributed to fundamental work on the educational role of high-quality learning materials, and its exam boards naturally are involved in collaborative work with educational publishers. Our wide-ranging international analysis of high-quality materials has led to a better understanding both of the link between assessment and learning materials and of the principles and criteria which we should use in our discussions with publishers.

Cambridge is very aware of the extent to which assessment can determine the pattern and content of learning, and our work on 'curriculum coherence' emphasises the importance of alignment between curriculum aims, pedagogy, learning materials and assessment. This document is designed to contribute to this process of positive alignment.

The principles and criteria we outline here are evidence driven, deriving from analysis of hundreds of textbooks and other resources from around the world. Throughout the research and creation of these guidelines we constantly have been in discussion with publishers and authors whose support has greatly strengthened the criteria – we thank them for their support and their commitment to collaboration.

This Cambridge Approach offers a route to higher quality, to a better linkage between learning and assessment, and thus promises gains in learning – a key ambition for all of us involved in education and educational improvement.

Simon Lebus
Group Chief Executive

**'The Cambridge Approach
offers a route to higher quality,
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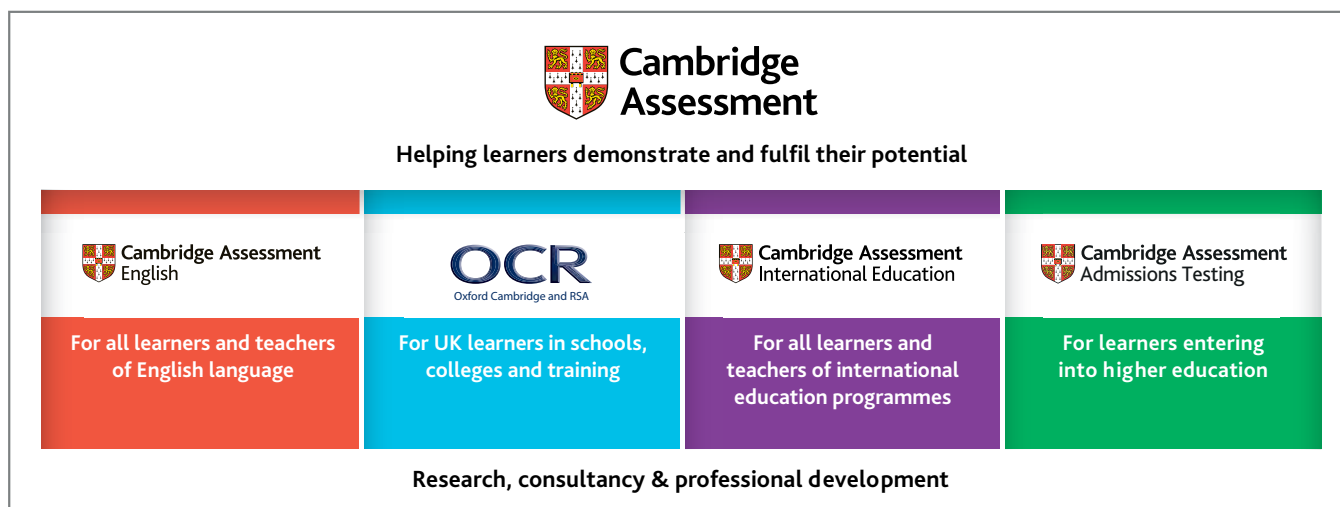
2 *Section 2* Cambridge Assessment, our principles and values

At Cambridge Assessment, our purpose is to help learners demonstrate and fulfil their potential. We care about making a difference for every learner.

As a department of the University of Cambridge, we provide education programmes and exams in over 170 countries offering global recognition. We unlock the power of education for millions of learners of all ages and abilities.

We have unrivalled depth of experience in national education systems, international education and English language learning. We are an international not-for-profit organisation with unique strengths and 160 years of expertise. Our qualifications are backed by the largest research capability of its kind.

We support and learn from teachers, schools and governments. Together, we are shaping education and creating a confident future for learners and a real and lasting impact on the world.



Organisational structure of the Cambridge Assessment Group

Our research underpins all our qualifications and education programmes. Across Cambridge Assessment we have a team of more than 100 researchers, which makes our research capability the largest of its kind. It is this research strength that enables us to help teachers, learners and governments stay at the forefront of education and unlock its power.

But our research is not just about ensuring our qualifications and services are the very best for learners. It's also designed to add to knowledge and understanding about assessment in education, both nationally and internationally. We also carry out research for governments and agencies to inform their education reform programmes. It's all with one goal in mind – helping learners.

We strive to open doors for learners, to unlock the power of education and give them the confidence to thrive. We work with many national educational organisations and ministries through our international organisations, Cambridge English Language Assessment and Cambridge International Examinations. We work to improve standards of education, creating opportunity for learners around the world.

Cambridge Assessment has a high number of experts, with proven experience in curriculum and assessment design, and as a part of the University of Cambridge has access to world-leading resources, skills and research. We work in collaboration with institutions such as University of Cambridge Faculty of Education, Cambridge University Press and Fluentify to offer a comprehensive service to our partners.

In the UK we have been working with industry leaders to develop real industry projects for our Cambridge Technical and Cambridge National qualifications to give learners a head start in their chosen career.

3 *Section 3* **Introduction to the Cambridge Approach**

Cambridge Assessment has undertaken a wide-ranging analysis of textbooks and learning materials from a set of high-performing jurisdictions around the world. This examined not only the form and features of the materials, but also their role in supporting effective learning and assessment. The work made clear the role of textbooks in supporting the school curriculum – helping sequence learning in schools and supporting teachers in understanding the depth of treatment of each topic. It made clear the role of textbooks in improving equity in education – providing clear, varied and well-researched materials which help a wide range of students gain insight into subjects.

The work revealed important examples of how textbooks and allied materials can draw on the best lessons in schools and make these widely available; can reduce teacher workload; can use assessment to better prepare children for the next block of learning; can enhance home–school links; and can stimulate deep, secure learning.

The insights from the research have been used not only to develop more deliberate strategy on textbook development and use in various nations, but to create a new generation of clear, well-structured materials which combine carefully key features and 'information elements': pre-assessment, intense focus on core concepts, exemplification and worked examples, practice activities, review and reflection on learning.

A number of discussions around the world have highlighted the structural role of textbooks in arrangements, and on occasion policy-makers and commentators have mentioned the difficulties and delays in effecting improvement in textbooks. Our recent work with publishers suggests that enhancement of textbooks can in fact be effected relatively rapidly, in comparison with many other forms of improvement strategy. One UK publisher took the detailed recommendations from our international research and

developed a highly innovative set of GCSE textbooks and linked digital materials in under two years – an impressive achievement, managing carefully the balance between quality and timeframe.

Throughout these criteria, we emphasise the importance of accumulation of evidence and insights, combined with sustainable supply of high-quality materials. We examined market forms and approval mechanisms in a range of jurisdictions, and used these in drawing up this document.

These criteria are focussed on partnership working with publishers. However, Cambridge Assessment recognises that supply-side attention to quality is enhanced by demand-side pressures for quality – from teachers, pupils and parents.

In our work around the world, we found that Reynolds' and Farrell's¹ insight from their transnational comparisons of 1996 still holds true: that it is the best teachers who are the most supportive of the use of high-quality textbooks and materials. These principles follow the Cambridge Assessment commentary on the role and function of high-quality textbooks in enhancing learning and system performance – *Why Textbooks Count*. This is available on the Cambridge Assessment website.

4 *Section 4* Using the principles

The principles presented here are the result of forensic dissection of the elements of high-quality material, highlighting the 'information elements' and design features upon which Cambridge Assessment and its partner publishers should focus.

These principles are laid out as a series of criteria and questions. They support publishers in reflecting on those things which should be considered when materials are being conceived and commissioned, and enable Cambridge Assessment to engage in productive discussions with publishers. The principles do not assume that materials can be of only one type or form – they are not an overly rigid or restrictive set of rules.

As emphasised above, the principles have been derived from extensive transnational study of high-quality materials. Analysis by Cambridge Assessment has shown that high-quality learning materials have played a key role in improvement of education arrangements and in sustaining quality. Even when apparently simple in form, learning materials carry complex functions – from ensuring transmission of best practice, to encouraging effective acquisition and development, by pupils, of key ideas and core content.

These principles focus on paper-based materials. They apply to aspects of digital materials, but are not designed comprehensively to determine all aspects of high-quality digital materials and the potential they offer. Cambridge Assessment is developing further principles that apply to digital materials.

¹ Reynolds, D. and Farrell, S. (1996) *Worlds Apart?: A Review of International Surveys of Educational Achievement Involving England*. H.M. Stationery Office.

The principles are based on the study of the highest quality materials around the world, brought together into a coherent list. We recognise that the principles are both demanding and extensive. Depending on the specific form and function of materials being developed, not all the criteria will apply. But publishers readily can work through the list to examine which features they are including in their materials, and those they are not.

We recognise that materials go through processes of development and refinement, and that they legitimately can change shape as they are being developed – adding a student workbook, increasing links to online resources, and so on. Not all the criteria have to be fully met from day one. But we believe that materials should be developed in full light of all the criteria we present here, as a means to securing a well-managed and deliberate development process.

We looked not only at textbooks around the world, and their development, but also the state of textbook research. Until recently, textbook research essentially has fallen out of favour in the UK, although there continued some isolated strands of work and rich seams of intensive research in certain subjects such as mathematics. But this 'ley period' contrasts with the situation globally, where approval centres and active evaluation programmes have remained vigorous. These principles have been developed in the light of, and can be used alongside the more subject-specific research on task design in specific subjects, subject progressions, core knowledge, vocabulary and definitions, etc.

Brief note on terms

Throughout this document, for brevity we have used the terms *schools*, *pupils* and *teachers*. By using *schools* we would include the full range of institutions involved in learning: early years settings, colleges, training centres and all other settings throughout formal and continuing learning. By using *pupils* we would include all learners, at all phases of education and training. By using *teachers* we would include all those involved in supporting, managing and enhancing the learning process.

5 Section 5 **Systematic accumulation of best practice – evidence-based and research-based materials**

We believe in both innovation and stability – these genuinely can co-exist in a carefully managed way. Materials should represent accumulating knowledge of high quality in learning and assessment, and be refined through systematic monitoring and evaluation. Those elements of materials which can be improved should be, within appropriate schedules, and those which function well and represent high-quality practice should be retained. Faddish and arbitrary change should be resisted. New developments – a guide to parents, a new practice book, some new online activities – can of course be added where they show promise. In Singapore, maths textbooks constantly are evaluated and refinements are discussed with the office responsible for textbook approval. In

Shanghai, outstanding, model lessons are identified by teacher research groups and a small set of the best selected for inclusion in the next edition of the textbooks. Our historical and transnational analysis shows that this careful balance of stability and innovation is a feature of materials development in a range of high-performing and rapidly improving systems.

The principles are designed to apply to materials which are apparently simple in form, right through to those which are both complex in themselves and are part of complex suites of paper and digital materials, and to materials right across all phases of learning.

Example: a highly refined, apparently simple but intensively research-based series of books to support early reading

The materials we analysed included a book to support reading, consisting of a collection of very short 30–50-word stories. Apparently simple in form, every element of the book – including picture–text relation, layout and size of print – is based on decisions which derive from research on acquisition of reading. Of particular importance, the specific text is based on a particular model of attention duration and persistence regarding initial reading; each book is part of a research-based progression across initial acquisition to more advanced stages of reading; and in every instance, all language is carefully located at the same level of demand regarding decoding. The picture–text relation is controlled through a specific model which emphasises interest rather than substitution of text decoding.

Example: complex suites of materials for secondary school provision

Our analysis included very large secondary texts, complex in form and part of large suites of materials: a teacher handbook, a textbook, a student workbook, with linked online assessment and learning resources. As with the apparently simple materials outlined above, the function, order and clarity of these complex materials is determined by an underlying learning model, and a strong research base to each of the information elements and devices in the text.

Example: a reader to support a specific course of study and examination

In secondary education, an apparently simple reader (selected texts in a discipline), with texts chosen by subject experts, to explain and illustrate core ideas in the discipline. This can provide a very clear and well-structured textbook, designed to support careful accumulation of essential concepts. Its function deliberately is very focussed – acquisition and understanding of very specific ideas. The text is deliberately parsimonious – a selection of 'essential background reading' to underpin classroom and other learning activities.

These examples emphasise the importance of 'organising principles' for all materials, clarity in purpose, and the need for evidence-based decisions in respect of all aspects of the materials.

Clear statement of purpose and use: a 'supporting statement' by publishers, as part of the development process

The exam boards in the Cambridge Assessment Group work closely with publishers in order to ensure that examinations are supported by high-quality materials. This 'principles' document is designed to support collaborative activity with publishers. Individual exam boards may have more detailed and subject-specific 'endorsement' requirements which will be applied in conjunction with these principles. The criteria outlined here presuppose the production of two things: the learning materials themselves and a supporting statement on the form, content and proposed use of the materials. The 'supporting statement' is important: it enables scrutiny of the models, evidence and processes used for developing the materials.

Clear statement of purpose and use in the materials themselves

The criteria do not determine the extent to which the materials themselves include clear statements of purpose. However, high-quality materials typically include a 'how this should be used and how this should be read' walk-through section. These 'walk-through statements' give clear guidance on how the materials should be used, and how the different information elements should be used and interpreted – e.g. worked examples, practice activities, etc.

6 *Section 6* The principles

SECTION A	Aims and purposes
SECTION B	Domain and construct – content specification
SECTION C	Broader educational models driving the materials
SECTION D	Approach to assessment
SECTION E	Physical characteristics of materials, and production values
SECTION F	Training and support – Continuous Professional Development (CPD) alongside the materials
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SECTION K	Regulatory compliance and conflicts of interest

Section A

Aims and purposes

Clear statement of aims and purposes

The materials should be clearly targeted and their intended patterns of use made clear – both aim and purpose. This does not mean that they need to be narrow in scope. A set of resources might be intended to 'support teachers to deliver the current OCR GCSE specification in Geography'; another set might be aimed at 'supporting Physics practicals in Cambridge International A Level'; and yet another aimed at 'development of writing extended pieces of text'. It is not a question as to whether a specific text has a narrow aim or a broad aim, or is closely tied to a specific qualification or supports learning, over time, in a broad range of subjects. Rather, it is a question of producing a clear statement for each specific set of materials as to which aims and purposes underpin them.

The statement of aims and purposes should include a clear statement as to which group(s) the materials are aimed at:

- teachers/trainers/educators
- pupils/learners
- parents
- technicians
- learning assistants
- other

Multiple purposes and multiple target groups

It is possible that a given resource could have multiple target user groups, and that different materials in a 'suite' of related materials are aimed specifically at different users.

Example: materials aimed at multiple target groups

A reference book on economics which is used by teachers and pupils alike; and in which parents can see which topics and bodies of knowledge learners are working through, giving support in the home by ensuring that learners read and watch related materials from the media, on contemporary economic affairs.

Example: a suite of materials

A teachers' guide to a 11–16 science scheme
A teachers' textbook with model lessons and a teaching sequence
A set of pupil workbooks which include homework and practice activities
A guide for running practical activities, providing a list of model experiments
Linked online learning activities and enrichment materials
Linked online assessment

Intended patterns of use

The specification regarding aims and functions should include a statement of the way in which it is envisaged that the materials will be used; e.g. as a flexible resource to be used in a variety of ways, or to provide tight sequencing of the scheduling and content of learning. There should be specification of the extent to which the materials are designed to:

- 1 Provide a series of activities and content specifications which specify the sequence of learning and condition the learning activities
- 2 Supply reference material and/or activities which can be used in a highly flexible way by teachers
- 3 Provide structured activities which support or replace a very specific segment or segments of a learning programme
- 4 Extend and supplement learning and be used outside contact time – do they structure and support home learning, learning beyond 'timetabled' time on the subject, etc.?

Matching form and function

The degree of structuring and prescription of learning activities should be clear and justified or underpinned by evidence – including information available from evaluation, feedback from users, educational research, international studies and suchlike.

The aims and purposes of materials should inform every stage of the process from conceptualisation through to product design. All information elements such as examples, contextualisation and other scaffolding should be appropriate to the intended users. It is not unusual to find materials where there has been a breakdown in coherence during different stages of design and production – where photographs have been added without due care to purpose, or where designers have introduced confusing formats and fonts. These discontinuities should be avoided through good control of end-to-end coherence, guided by the aims and purposes. All information elements should be consistent with the stated aims and purposes.

Statements of purpose aimed at users

Our international research shows that materials can be used in a very structured way by teachers – as 'handbooks', helping build the sequence and focus of learning activities. There also are settings in which highly structured materials are used flexibly by teachers – omitting activities which are not optimal for their learners, supplementing materials, moving in a different sequence through sections, and so on. But two things are clear from our research: clear statement of purpose and use is important. High-quality materials typically include a 'how this should be used and how this should be read' walk-through section. These 'walk-through statements' give clear guidance on how the materials should be used, and how the different information elements should be used and interpreted – e.g. worked examples, practice activities, etc. Secondly, the fact that materials may be used flexibly by teachers does not remove the need to apply very high levels of discipline to ensuring that all aspects and elements of materials are consistent with the aims and purposes of the materials.

Explicit and implicit 'messages' about focus and function

The aims and purposes should also be realised in the explicit and implicit 'messages' about the focus and function of the materials which are given by their content, title and promotional comments. For example: 'this is a fully comprehensive programme of learning for GCSE Physics'; 'this extends learners, giving them deep insight into the subject'; 'this prepares you for the assessment'; 'this is a guide to sequenced learning through key blocks of content'; 'this brings you to an understanding of both making and meaning in poetry'.

Section B

Domain and construct – content specification

The concepts 'domain' and 'construct' are essential to the development of materials and provide the basis of the content specification.

Domain

'Domain' refers to the 'area of interest', the 'sphere of knowledge', the 'territory of learning' to be covered in the materials.

Construct

'Construct' refers to the specific concepts, principles, fundamental operations and key knowledge which comprise the domain covered in the materials. We consider it more helpful to use the term 'construct' than the more general 'content', since 'construct' conveys better the idea of 'key things which need to be learned' – thus introducing better focus into development and use of materials.

High-quality materials are marked by clarity and precision in presenting the key 'constructs' which are the focus of each section: e.g. 'the properties of circles'; 'physical processes in river basins'; 'the sonnet form'; 'power relations'. The key constructs are highlighted in margin notes, clearly stated in headings and organisational devices; all images ground and reinforce the key constructs included in the materials.

Constructs – useful classification of discipline-focussed constructs:

- concepts (conservation of mass; constitutional monarchy, etc.)
- principles (scientific laws; logical relations, etc.)
- fundamental operations (the four operations in maths; extended writing, etc.)
- key knowledge (the order of planets in the solar system; 'the Glorious Revolution', etc.)

Constructs – associated with approaches to learning. Learning materials also can emphasise and support the development of dispositions and traits such as:

- persistence
- reflection
- development of 'learning habits'
- memorisation and recall

All of these variously have been referred to as 'learning objectives', 'outcomes', 'learning goals' and similar. We refer to them as 'constructs'. This is a term well established in assessment. It describes anything which is both the focus of learning and the thing in which we are interested – something acquired or developed by learners. Such things – which can vary in type and form depending on what aspect of human knowledge or performance we are interested in – are referred to as 'constructs'; they are the deliberate focus of learning. They are things about which we wish to find evidence; the aim of assessment is to make an inference that a specific construct or constructs are being acquired or developed by learners.

Constructs and language

Research on oracy in subjects and development of secure conceptual understanding emphasises the crucial role of: accumulating vocabulary; precise definition and use of key terms; and extended writing. The ability to use complex language – of cause and effect; of explanation; of deduction – is important in growing sophistication of understanding and action. Research on the age-related nature of key concepts and related language, including work on learning progressions, is essential to development of materials, and should be used where relevant and available.

Domain and construct – the foundation of learning and assessment

The materials should specify clearly the domain which is covered:

Focus: specific discipline focus; cross-curriculum focus, etc.

Scope: specification of the 'domain' covered by the materials

Construct base: clear expression of the concepts, principles, fundamental operations and knowledge which is the focus of learning

Organising principles for the content: 'big ideas in the subject'; 'topics'; 'related ideas', etc.

Other structuring principles: use of practice; extended reading, etc.

Technical language is used with precision, introducing learners to the meaning, application and use of language intrinsic to effective working in the discipline.

Clarity in the construct base and domain specification is a key to high-quality materials and high-quality assessment. This clarity should be a feature of the design process as well as the final materials themselves. Very clear expression of key constructs and reinforcement of key constructs by all information elements (e.g. margin notes, headings, illustrations and graphic material) are features of high-quality materials.

Linking to curriculum and assessment specifications – extending beyond the requirements and assessment specifications

Where the materials link to a curriculum specification or qualification specification, the relationship to these should be made clear, with depth of treatment and scope fully described. In particular, the materials should state the nature of the link to any examinations or assessments to which they are designed to relate. This statement should make clear the manner in which the materials provide preparation for the demands of examinations and assessments and any ways in which they go beyond the requirements of the examinations and assessments. This criterion is not intended to suggest that materials should be limited to the requirements of the examinations and assessments to which they may be specifically linked. On the contrary, research by Cambridge on advanced-level study points to the association of extending beyond the exam specification – with resulting higher performance on assessments. Again, it is a question of purpose and deliberate design of specific materials: extension may be appropriate in some instances, and not in others.

Models of learning

The originators of the materials should be prepared to state the evidence and model(s) used to determine the construct base, to determine the domain, to sequence or order the content, to determine the 'language set' used throughout the material, and to determine key elements such as practice activities, formative assessment, etc.

This is referred to as 'the model of learning'.

In Singapore Maths, a deliberate model of learning was used to underpin key maths texts – a Brunerian model based on 'concrete, iconic, abstract' – where learners are shown concrete representation of mathematical concepts; then the means of representing and manipulating these mathematically; then development of formal mathematical understanding at the levels of relations and principles, where pupils generalise and widely apply the ideas. Alongside this, in these materials there is a commitment to high levels of rich practice, extracting maths from verbal problems, performing maths calculations and operations, and then applying the solutions back into the problems. A 'spiral curriculum' concept then drives a progression in learning which focuses on application in increasingly demanding settings, plus additional learning of new ideas and processes. This model was adopted deliberately, and carefully evaluated and refined.

Equivalent transparency in underlying models can be achieved in all subjects, with due recognition of the distinctive nature of different fields and sub-fields.

***Research, expertise
and credentials***

A deliberate approach to purpose and aims, coherence, domains and constructs, underpinning models and learning activities all pointing to the expertise and credentials of authors, editors and production staff is important. Deep subject knowledge, informed by research, is essential to high-quality materials, matched to an understanding of the needs of educators, pupils and parents.

The originators of the materials should be prepared to establish and state the authority and credentials of the authors and of those determining the surface features of the materials, the credentials of any reviewers of the materials, and the credentials of series editors and specific editors. The processes used to check and validate the approaches used should be stated. Any unusual or innovative features of the materials should be justified by evidence.

Section C

Broader educational models driving the materials

Ideas regarding ability and progression can exert a powerful influence on the form and content of materials. These criteria list a few important models, but more may apply to specific materials:

Deep learning

Learning which ultimately leaves no trace in knowledge or behaviour is simply a fleeting experience. Deep learning results in prolonged retention of information, the ability to synthesise information, and to apply and re-apply knowledge, understanding and skills. Deep learning involves practice, consolidation and reflection. What features of the materials support deep learning?

Deep learning is the essential goal of most education systems, and is the result of complex interactions of all aspects of learning and assessment. This complexity does not mean it should be ignored in the production of materials – far from it, our analysis shows the important role which materials can assume in these complex relations. This role therefore needs to be a deliberate part of the production process for materials.

***Ability –
differentiation***

What is the explicit model of ability driving the materials? Do the materials presuppose the model of ability or differentiation in the settings in which the materials will be used? Do the materials imply or assume setting and streaming, segmentation of content, tiering, different 'routes' through the materials for learners of putatively different ability and attainment? Does the material assume a 'Confucian' model of ability, where all children are considered capable of learning curriculum content, depending on how the content is presented to them, and the effort which they put into learning? Do the materials include approaches to grouping learners and to differentiation? How sensitive are the materials to the needs of different learners? Do the materials include catch-up material?

The importance of the model of ability cannot be underestimated. Transnational comparisons repeatedly draw attention to the crucial differences which originate in different societal and national assumptions regarding ability, and the links to patterns of attainment and participation. Cambridge Assessment is not asserting that it is always right to operate mixed-ability teaching, nor is it asserting that setting and streaming is an optimum way to organise education. Failing to recommend one against the other is not the result of indecision. From around the world, there are examples of highly effective 'tracked' systems and examples of highly effective 'inclusive' systems. What this analysis suggests is that it is essential to be conscious and deliberate about model of ability.

Practice

What is the approach to application and practice of the key concepts, operations and knowledge in the material? How extensive are the rehearsal and practice activities included? What drives the selection and variation of practice activities and problems included?

Recent research on 'practice' has highlighted its role in both ensuring deep learning and supporting greater equity in attainment. Practice should be rich, varied and engaging. Repeated application allows consolidation and reflection, and in addition allows pupils to feel confident about the growth of their skills and knowledge. The variation in practice activities – for example through the variation of context in maths and science, range of text in language study, location in geography and so on – allows different contexts to appeal to different students, increasing the chances that one of these contexts will unlock insights and consolidate learning for a specific learner. Breakdown in generalisation across contexts can reveal misconceptions in understanding which can provide helpful feedback to teachers in supporting learners.

Production

What approach is taken to asking learners to 'produce' text, drawings, etc. in order for them to reflect on the way in which they are learning and what they are learning; to allow teachers to gain access to how they are thinking; and to allow learners to share and discuss ideas?

Varied practice activities, tasks in pupil workbooks and other productive activities are vital for both learning and assessment. Things written, said and made allow pupils to 'externalise' their thinking, making it visible to themselves, to other pupils and to teachers. 'Production' is present in the high rate of interactive questioning in Shanghai classrooms, which stimulates high rates of verbal production in learners – generating discussion, encouraging thinking, and allowing very high levels of reflection on concepts and ideas by all pupils. Research has also highlighted the importance of quiet, reflective periods with deliberate recording of 'what has been learned' during a period of learning – the Singapore 'learning journals' included in their textbooks are consistent with this research.

Exposure

In what way do the materials introduce learners to new ideas and over what time period? In what ways are learners expected to move from initial exposure to key ideas and content, to deep secure understanding – from initial grasp of an idea to the ability to apply and to generalise it? Notable in some texts were small text boxes of 'interesting facts' and 'did you know that...', which excited pupils' interest in subjects, encouraging discussion and engagement among pupils – variations in the contexts in these information elements were deliberately designed to engage pupils with different interests and preferences.

Where dependable evidence is available, materials should be informed by research regarding effective learning in general, and by research on effective learning in specific subjects, on school improvement, and on the structure of knowledge in specific domains.

Section D **Approach to assessment**

Purpose, variation in assessment and quality of assessment

The transnational research highlighted the importance of assessment. High-quality questions at the end of sections not only checked pupils' learning, they indicated depth of treatment of the material to both teachers and pupils. 'Quick concept checks' aided teachers' and pupils' focus on key ideas and techniques, while varied problems and contexts in questions enabled assessment to contribute to pupils' understanding. For secondary-phase pupils, example exam questions helped acquaint pupils with the types of questions which they would face in formal examinations. In Singapore Maths, grappling with carefully varied, verbally based problems is an intrinsic part of the learning model, increasing pupils' depth of understanding of techniques and concepts, and preparing them for the unfamiliar problems which will occur in formal examinations.

Of particular importance was the 'pre-assessment' present in some Hong Kong textbooks. This presented a short series of well-designed and tightly focussed questions which allowed the pupil and the teacher to see if the pupil was ready to tackle the material in the new chapter on which they were embarking. This was not a simple reassessment of the material from the last chapter, which had already been assessed through the end-of-chapter assessment. Rather, it was a tightly focussed assessment of prerequisites, which may have been covered in learning some time previously.

Educators from Hong Kong emphasised that this was extremely important in respect of the overall learning model. Pupils may have had fragile learning from previous work, residual misconceptions or may simply have forgotten certain things – if they proceeded straight into the chapter without necessary prerequisites, this may feed an inappropriate perception that they are 'bad at the subject' and the lack of facility in the work would add significantly to teacher workload in managing the pupil group.

Quality issues in assessment

The quality of assessment in learning materials is governed by the same technical criteria which are applied to formal assessment – there should be careful matching of purpose and form of assessment; item form (question type) should be carefully chosen; demand should be pitched at the right levels; and marking frames and schemes should function well. Construct focus should be maintained, and construct-irrelevant variation carefully contained – the assessment should focus on those things which are the focus of instruction and learning. Not only should the assessment measure well, it should provide information which is useful to teachers, pupils and others – including parents. Increasingly, assessment is provided by digital resources linked to paper-based materials, providing assets of automated marking and feedback, and collation of results. This in turn can provide valuable data, to publishers, regarding attainment of pupils on specific elements of materials, as well as insights into the way in which assessment is behaving.

Publishers should manage carefully the balance of different types of assessment, and the balance between learning and assessment.

Assessments included in, or linked to, materials should be dependable – they should meet routine quality criteria regarding reliability, validity, construct integrity, consequential validity and utility/manageability. In constructing and evaluating assessment, publishers can refer to quality criteria such as *The Cambridge Approach to Assessment: Principles for designing, administering and evaluating assessment*² and the American Psychological Association's *Standards for educational and psychological testing*³. There should be no crude assumptions that 'assessment in learning materials is low stakes, so quality is not as important as with high-stakes testing'. Formative assessment – seemingly low stakes – can give vital signs and signals back to pupils as to their attainment and progress. It can contribute to learning in fundamental ways – through practice and varied application. It therefore is of great importance, and should be engaging, well designed and measure well. The use of carefully selected 'spent' examination questions is an important approach; while learning materials should not be dominated by assessment or reductively focussed on examinations, this enables publishers to include carefully designed questions and tasks with known measurement properties, and allows pupils to become familiar with the kinds of items that they will encounter in formal examinations, providing vital, systematic preparation.

² Oates, T., Dowling, M., Gray, E., Saville, N., Marshall, J., Bramley, T., Green, S., Shaw, S., Palmer, D., Dawson, A., Khalifa Louhichi, H. and Mills, E. (2009) *The Cambridge Approach to Assessment: Principles for designing, administering and evaluating assessment*. Cambridge Assessment.

³ American Psychological Association (2014) *Standards for educational and psychological testing*. American Educational Research Association.

Key development questions regarding assessment

Particular questions to consider when planning assessment within resources include:

- What is the approach to assessment which is supported by the materials?
- How is the assessment scheduled in the materials?
- Who undertakes the assessment?
- How formal is the assessment?
- What is the purpose of assessment?
- What is the approach to standards setting/facility estimations/age standardisation?
- How are the assessments marked; are marks externally validated; are mark schemes provided?
- How are results collated and provided for pupils?
- Does the assessment produce information of value to the teacher and to the learner – is there guidance on how to interpret the outcomes of assessment?
- Is there guidance on how teaching and learning might be directed in response to assessment outcomes?
- Is there any facility for collecting data from assessments? How are these treated and managed? What action is taken in response to these data?

Varied applications of assessment

The research revealed innovative and important applications of assessment within materials, including:

- assessment of prerequisites for each segment of learning
- 'quick concept checks' to highlight key constructs and give rapid feedback
- assessment approaches which encourage learner reflection – e.g. 'learning journals' and 'short reflections'
- worked-through examples and assessment questions
- example exam questions to help the learner become accustomed to question form and content.

Section E

Physical characteristics of materials, and production values

High-quality materials are characterised by production values and by formats which are consistent with underpinning models of learning. They tend to be very clear, uncluttered and sharply focussed on key constructs. This does not produce shallow or narrow content coverage. It does mean an avoidance of unnecessary variation in font size, font type, page layout and orientation of material. Justification is provided for each information element and activity. Any feature which adds unnecessary cognitive workload to learners – gratuitous features which add barriers to clarity and comprehension – should be avoided.

Style criteria and writing frames

This area tends to be governed by style criteria and writing frames developed by publishers, typically engaging with:

The relation between aims, authoring process and design, and editorial processes

Templates which are consistent with the structure of knowledge and the aims of the materials

Surface features consistent with the learning model and other key principles

Size and format, consistent with aims, etc.

Durability, consistent with intended patterns of use

Ethical and cultural considerations

It is also necessary to ensure that the materials have been developed with all necessary cultural considerations in mind to ensure compliance with national guidelines on language, images, etc.

Accessible features and disability

Consideration should be given to compliance with any guidelines on 'accessible features' or supplementary versions for those with disabilities.

Section F**Training and support – Continuous Professional Development (CPD) alongside the materials**

The importance of CPD

Growing sophistication in the form, content and patterns of use of materials has demanded greater understanding on the part of teachers. Our analysis of high-performing jurisdictions highlights the importance of CPD to accompany materials; it is important for teachers to understand underpinning model(s), principles and practices, as a prerequisite for the most effective deployment of the materials.

CPD increasingly is seen as part of a 'package of service' – as part of the business model for materials – but is included not principally for commercial reasons, but because of the essential support which teachers need to optimise use of the materials.

Determining the form and function of CPD

The following considerations are fundamental to the development of effective CPD provision:

What model of CPD is used in the supporting CPD – what is the scheduling, content, etc.?

What is being done regarding CPD scope, content, underlying assumptions and models – is the content of CPD consistent with the models in the materials?

Is CPD available to all consumers of the materials – what are the proposed patterns and modes of provision?

What is the costing model for the CPD, including territory variations?

Are there means of evaluating the impact of CPD?

CPD is costly to develop, difficult to monetise and demanding to deliver. However, jurisdictions such as Singapore see it as an essential accompaniment to high-quality resources, vital for explaining the subtlety of the models and approaches highlighted in the materials. In England, CPD increasingly is integral to some of the most effective suites of materials – from early reading programmes through to materials dedicated to specific examination specifications.

To fully realise the benefit of well-evidenced and carefully designed materials, accompanying CPD is seen as essential.

Section G

Scheduling and production

Curriculum coherence: high quality and lead times

Our research and work with publishers strongly suggests that over-compressed development and production schedules have an adverse effect on quality. Publishers rightly have complained of the lack of lead time for creation of high-quality material, brought about by the scheduling of changes to curricula and examinations. While due pace in processes is necessary, and co-ordination of availability of materials with new/ revised qualifications is essential, undue pace in production is to be avoided.

Trialling and other work with schools and pupils

Trialling can be an important part of the development process, and not only may comprise trialling of specific materials but can include general trials of characteristics of materials (use of formative questioning; types of diagrams and presentation; use of case studies, etc.) that might have application across a range of materials. Trialling need not consist of elaborate pilot work with completed materials – key segments or activities, or revised elements of well-established materials can be the focus of highly focussed, manageable trialling.

Often due to constraints on time and process, publishers depend on authors' understanding of learners' and teachers' needs and contexts. This can, on occasion, be restricted – more open work with teachers, learners or other users and interests can enhance quality.

Considerations in developing trialling:

- Space and opportunity in the overall development schedule – the time allotted to the development process

- The extent to which the development is a refinement of prior materials and application of evaluation findings

- The form of the development process – single author, authoring team, etc.

- Cost – which can be reduced by using established relations with teachers and institutions

- Trialling in development – with whom, how managed, what analysis and application of findings

- Lead time, publication/availability dates

The time pressures frequently present in production, and thus reducing the opportunity to trial materials, can be eased by ensuring that all necessary permissions for material have been obtained; and all legal agreements with authors regarding intellectual property (IP), etc. been put in place

The importance of overall schedule

In approving materials and working with publishers, Cambridge Assessment will require clarity in availability dates for all contingent and ancillary products/processes – marketing drive, availability of CPD, availability of online support, etc. – since these all have an effect on the impact of materials. Ideally, considerations for trialling and the scheduling of release of supporting elements will determine the overall lead time and publication dates, rather than the reverse.

Section H **Evaluation and revision**

Managed enhancement and accumulation of good practice

As emphasised in earlier sections, processes of continual refinement have been in place in high-performing jurisdictions and this has led to both desirable levels of stability, and to accumulation of quality. In Singapore and Shanghai, carefully developed processes of refinement have brought protracted periods of managed enhancement.

The possibilities of low-intensity refinement

We recognise that evaluation can be resource intensive, but low-intensity, constant gathering of evaluation evidence or insights from lesson observation can be a considerable asset, with useful information accumulated prior to revision and production of subsequent editions or new materials.

Incorporating evaluation into the life cycle of materials

Consideration of evaluation and revision strategy – scope, scale, schedule and methods, including ethical permissions – at the outset of resource development may help support an efficient and manageable process of evaluation. Evaluation can engage with:

Contrasts and congruities in intended and actual patterns of use

Impact analysis – including examination of impact on pedagogy and learner outcomes

Analysis of standards of assessment and performance of learners

Examination of learner performance – enhancement of attainment

With evaluation come reporting responsibilities, and commitments and constraints regarding use of evaluation outcomes. As with trialling and other research, specific evaluation work on materials requires consideration of, and compliance with, all applicable regulations on ethical permissions and holding/use of data.

Section I

Market and marketing

A balance of supply- and demand-side interests in quality

Cambridge is concerned not only to enhance the 'supply side' in materials, but also stimulate 'demand-side' pull for high-quality materials. Marketing strategy and allied communication therefore is a vital element of overall strategy associated with establishing optimum take-up and use of a specific set of materials. This area may exhibit or be subject to necessary sectorial/territory variations.

Conditions for continued supply of high-quality materials

Where publishers are partner organisations and independent entities, projected sales volumes need to be viable for a resource to be sustainable. We recognise that, in some settings and circumstances, philanthropic funding or state funding can support the development and adoption of materials.

Our research has looked at jurisdictions with approval mechanisms and those without, and examined patterns of choice and state support in selection and choice of materials. We have looked at patterns of control which ensure that publishers are operating in market conditions which allow sustained provision and development of high-quality materials.

When working with publishers, Cambridge Assessment will examine:

- marketing strategy
- projected sales volumes – the estimation of the market
- nature of market and market competition – the existence of multiple suppliers, etc.
- market differentiation and distinctive features of materials
- viability of costing model
- relation to linked/parent qualification and location in a 'ladder' of provision
- endorsement strategy by government, awarding body, etc. including nature of links with ministries/approval agencies.

Choice

We believe that it is important to support our schools with a choice of resources where candidate numbers support this.

Territorial variation

We recognise that different markets have different expectations of price and format and that publishers will have a variety of pricing models to suit different regions of the international markets they serve.

Supporting parents

The enhancement of home–school links has been highlighted repeatedly in research as an element in educational improvement. Increased practice, wider reading and focussed study all can be supported through well-designed materials and suites of materials. We recognise the importance of supporting learning assistants and parents with resources, where possible and appropriate.

Supporting transitions

Cambridge Assessment emphasises the importance of curriculum coherence – both the integrity and interaction between elements of the education system (pedagogy, assessment, materials, and so on) and the integrity of progression through the education system. The link between materials at different stages of education should be considered, as well as materials which recognise and support the transition from one phase of education to another. It can be important to ensure that materials are not seen as totally isolated elements of a specific phase, but are located in a specific part of overall educational progression.

Section J**Underlying financial performance of the publisher – financial models**

Resilience and continued supply of high-quality materials

Cambridge is anxious to support the development of high-quality materials, ensure that they are used optimally, and encourage arrangements which mean that they can remain available to users. This demands a viable underlying financial model, and reasonable resilience and stability in producers. This area is of particular importance when considering new entrants or new contracts which represent a substantial increase in scale.

Sustainable models

In referring to financial models, we have examined varying models of markets, approval, etc., including arrangements where materials have sections in which pupils write, thus preventing materials from being re-used. While this appears restrictive, in the context used it delivers a series of public goods. Publishers are guaranteed a level of income, the income levels are relatively predictable year on year, the surplus is available for evaluation and investment in systematic improvement of editions – a beneficial spiral of accumulation and quality which carries mutual benefit for publishers, learners, the state and parents.

In working with publishers, Cambridge Assessment will consider:

- Standard audit issues regarding capacity and resilience, including capacity for continued production and support

- Resilience of distribution systems and payment systems

- Market presence, geographical coverage

- Established reputation

While we operate an open door policy to allow a range of publishers to have their materials approved/endorsed, we retain the right to consider the financial capacity of the publishers with whom we work.

Section K

Regulatory compliance and conflicts of interest

Regulatory requirements

Materials and the development and marketing processes should comply with regulatory requirements obtaining within the jurisdictions in which the materials will be used.

Conflicts of interest

The nature and extent of conflicts of interest should carefully be considered; these introduce risk and potential instability. Conflicts of interest should be considered at all levels of production and supply, from the level of 'non-competition' agreements to authors' conflicts of interest.

Cambridge Assessment will expect a clear statement of:

Approach to mitigation of conflicts, including compliance with awarding body criteria and regulatory requirements

Approach to ensuring that all necessary legal agreements are in place at the appropriate point in the development–production–distribution cycle.

7 Section 7 Annex

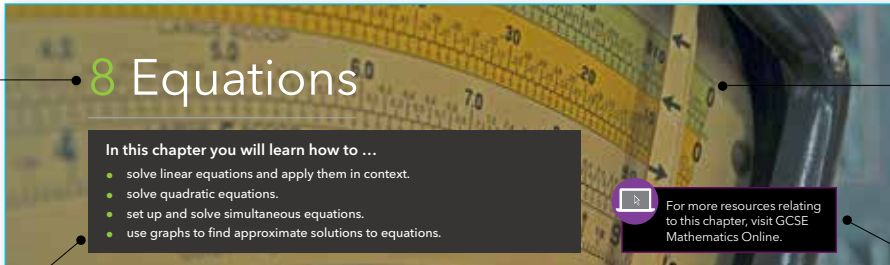
This annex gives an indication of the kind of information analysis which was used in the research for these principles. It includes analyses of two textbooks with important features, one from Singapore and one from Hong Kong. These appear at the end of the annex.

We also include an 'information element analysis' of selected pages from an 800-page GCSE textbook in mathematics by kind permission of Cambridge University Press⁴. These provide direct illustration of some of the key elements which we include in the principles.

Highly precise chapter title

Clear outline of focus

Carefully chosen image linking tightly to real-life application, plus description of relevance of chapter content



8 Equations


In this chapter you will learn how to ...

- solve linear equations and apply them in context.
- solve quadratic equations.
- set up and solve simultaneous equations.
- use graphs to find approximate solutions to equations.

For more resources relating to this chapter, visit GCSE Mathematics Online.

Using mathematics: real-life applications

Accounting involves a great deal of mathematics. Accountants set up computer spreadsheets to calculate and analyse data. Programs such as Microsoft Excel[®] work by applying different equations to values in columns or cells, so you need to know what equations or formulae to use to get the results you need.



"Although the computer does the actual calculations, I have to insert different equations to tell it what operations to perform and in which order to perform them."

(Accountant)

Before you start ...

Ch 3, 7	Apply your skills in using the conventions of algebraic notation to form equations.	1 Which of the equations below correctly represent this problem? a y is one half the size of x b y is 2 more than x c y is the same as x multiplied by x d y is the square root of x A $y = x^2$ B $y - 2 = x$ C $y = \pm\sqrt{x}$ D $y = \frac{1}{2}x$
Ch 3	Check you can write an equation to represent a problem mathematically.	2 Which of the equations below correctly represent this problem? "I think of a number, multiply it by 6 and add 1. The answer is 37. What is my number?" A $6x + 1 = 37$ B $y \times 6 = 37 + 1$ C $6a = 37$ D $(6x + 1) - 37 = 0$
Ch 1	You should be able to recognise and apply inverse operations.	3 Complete the following statements. a $7 + \square = 0$ b $\square - 8 = 0$ c $-4a + \square = 0$ d $5 \times \square = 1$ e $\frac{1}{6} \times \square = 1$ f $\square \times 12x = x$
Ch 7	You need to know how to factorise quadratic expressions.	4 Match each expression to its factors. a $x^2 - 5x + 6$ b $x^2 + 3x$ c $x^2 - 25$ d $x^2 - 5$ A $x(x + 3)$ B $(x + 5)(x - 5)$ C $(x - 2)(x - 3)$ D $(x + \sqrt{5})(x - \sqrt{5})$
Ch 7	You should be able to complete the square on a quadratic expression.	5 Complete the square on each expression: a $x^2 + 4x + 10 = (x + \square)^2 + \square$ b $x^2 - 8x - 5 = (x - \square)^2 - \square$

Find answers at: cambridge.org/ukschools/gcsemaths-studentbookanswers

Relevant background image

Link to online resources

Pre-assessment, checking pre-requisites

⁴ Morrison, M., Smith, J., McLean, P., Horsman, R. and Asker, N. (2015) *GCSE Mathematics for OCR Higher Student Book*. Cambridge University Press.

**Construct –
single, focussed labelling**



Key vocabulary

variable: a letter representing an unknown number.
linear equation: an equation where the highest power of the unknown is 1, for example $x + 3 = 7$. There are no fractional or negative powers and the resultant graph of the equation is a straight line.

**Clear construct focus
and definition**

Section 1: Linear equations

An equation is a mathematical statement that contains an equal sign. For example:

$$3 + 2 = 5 \quad 3 + x = 5 \quad 3 + 2 = x \quad 2x + 3 = 6$$

The unknown value is called a **variable** and can be represented by any letter but x and y are used most often.

The same letter can represent different values in different equations.

For example: in the equation $x + 1 = 4$, the value of x is 3, but in the equation $x + 2 = 3$, the value of x is 1.

When the highest power of the unknown is 1, and there are no negative or fractional powers, the equation is a **linear equation**.

Solving an equation means finding the value of the unknown letter.

In simple equations like $x + 3 = 7$ you can solve for x by inspection.

In more complex equations you can find the solution by carrying out inverse operations on both sides of the equation.

Worked example 1 shows how an equation can be changed without altering the solution (the value of x) if you carry the same operation on both sides.

WORKED EXAMPLE 1

Solve for x .

a $5x - 5 = 3x + 1$ **b** $2y + 17 = 5 - 6y$ **c** $2(3x - 1) = 2(x + 1)$

a $5x - 5 - 3x = 3x + 1 - 3x$

To find the value of x , you need to apply inverse operations to both sides of the equation so that you end up with x on its own on one side. Subtract $3x$ from each side. Simplify by collecting like terms.

$$2x - 5 = 1$$

Add 5 to each side. Simplify.

$$2x - 5 + 5 = 1 + 5$$

Divide both sides by 2.

$$2x = 6$$

$$\frac{2x}{2} = \frac{6}{2}$$

$$x = 3$$

b $2y + 17 + 6y = 5 - 6y + 6y$

Add $6y$ to both sides (this helps you get rid of negative signs). Add like terms.

$$8y + 17 = 5$$

Subtract 17 from each side.

$$8y + 17 - 17 = 5 - 17$$

Simplify.

$$8y = -12$$

Divide both sides by 8.

$$\frac{8y}{8} = \frac{-12}{8}$$

Reduce the fraction to its simplest terms.

$$y = -\left(\frac{3}{2}\right)$$

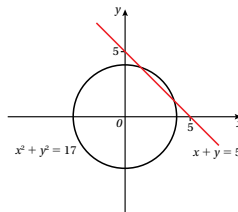
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**Worked examples
with supportive and
detailed explanation**

Substantial number of tasks, to ground the technique and ensure construct is understood and applied

- 2 Find the coordinates of the point(s) of intersection of the following graphs:
- a $y = x^2 + 3x + 3$ and $y = x + 2$ b $y = x^2 + 5x + 2$ and $y = x + 7$
 c $y = x^2 + 2x + 4$ and $y = x + 6$ d $y = 2x^2 + 3x + 1$ and $y = 2x + 1$
 e $y = 3x^2 + x + 2$ and $y = 3x + 3$ f $y = 6x^2 + 9x + 5$ and $y = 2x + 3$
- 3 The diagram shows the circular graph plotted from the equation $x^2 + y^2 = 17$ and the graph $x + y = 5$ which cuts the circle in two places. Find the coordinates of the points of intersection of the graphs.

Tip
 You will learn more about the equation of circles in Chapter 19. Here, apply what you know about the points where two graphs intersect.



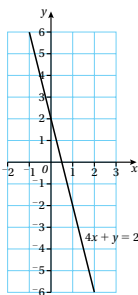
Tip
 You will work with graphs and equations again in Chapters 18 and 19.

Section 4: Using graphs to solve equations

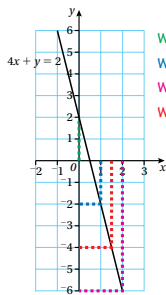
If you have a graph you can use it to solve an equation or to answer questions based on the equations.

WORKED EXAMPLE 12

This is the graph of the equation $4x + y = 2$.



- a Use the graph to estimate the value of y when:
- i $x = 0$
 - ii $x = 1$
 - iii $x = 2$
- b What is the value of x when $y = -4$?



When $y = 2$, $x = 0$
 When $y = -2$, $x = 1$
 When $y = -6$, $x = 2$
 When $y = -4$, $x = 1\frac{1}{2}$

Each point on the graph represents a value of x and y that work in this equation.

To find the solutions for different values of x or y , you need to use the value you have been given as one of the coordinates of a point. If you take a line from this point to the graph you can estimate the value of the other coordinate.

Find answers at: cambridge.org/ukschools/gcsemaths-studentbookanswers

Links across different areas of maths domain

Worked examples with supportive and detailed explanation

Launchpad continued ...

STEP 4




- 4 Write down the name of a four-sided shape that has:
- a opposite sides equal.
 - b all sides equal.
 - c two pairs of parallel sides.
 - d four equal angles.
 - e one pair of parallel sides only.
 - f no parallel sides.



GO TO
Section 4:
Quadrilaterals

STEP 5

5 Copy and complete this table.

Solid	Mathematical name	Number of faces	Number of edges	Number of vertices
				
				
				



GO TO
Chapter review



GO TO
Section 5:
Properties of 3D objects

Clear constructs
Engaging and clear task

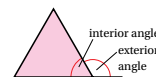
Key vocabulary

- plane shape:** a flat, two-dimensional shape.
- polygon:** a closed plane shape with three or more straight sides.
- regular polygon:** a polygon with equal sides and equal angles.
- irregular polygon:** a polygon that does not have equal sides and equal angles.

Clear and precise definition of all key focus terms – very clear construct focus

Section 1: Types of shapes

Flat shapes are called **plane shapes** or two-dimensional (2D) shapes. A **polygon** is a closed plane shape with three or more straight sides. Circles and ellipses (ovals) are plane shapes, but they do not have straight sides, so they are not classified as polygons. If the sides of a polygon are all the same length and the angles between the sides (interior angle) are equal, then the polygon is a **regular polygon**. This equilateral triangle is a regular polygon.



If a polygon is regular, the angles formed by extending the sides (exterior angles) are also equal.

If a polygon does not have equal sides and equal angles it is called an **irregular polygon**.

Link to resources

GCSE Mathematics for OCR (Higher)



For additional questions on the topics in this chapter, visit GCSE Mathematics Online.

Completing the square

- Completing the square is a technique that turns a quadratic into an equivalent expression containing a perfect square and another (usually constant) term. The completed square form is $a(x \pm h)^2 + k$.

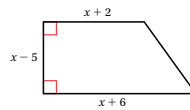
Algebraic fractions

- Algebraic fractions can be simplified using the same rules that apply to arithmetic fractions.



Chapter review

- Expand and simplify.
a $(y + 1)^2 + (y + 2)^2 + (y + 3)^2$ b $(x + 1)(x + 2)(x - 3)$
- Factorise.
a $2x^2 - 11x - 21$ b $6x^2 - 14x - 8$
- Use the difference of two squares identity to calculate $1999^2 - 1998^2$.
- The diagram shows a trapezium.
The lengths of three of the sides of the trapezium are $x - 5$, $x + 2$ and $x + 6$.
All dimensions are in centimetres.



The area of the trapezium is 36 cm^2 .
Show that $x^2 - x - 56 = 0$.

- Write as single fractions in simplest form:
a $\frac{(x + 3)}{4} + \frac{(x - 5)}{3}$ b $\frac{1}{(x + 4)} + \frac{2}{(x - 4)}$
c $\frac{2x}{(3x - 3)} \div \frac{4y}{(x^2 - x)}$ d $\frac{3}{(4p + q)} + \frac{3}{(p - 2q)}$
e $\frac{1}{x - 2} + \frac{5}{x - 2} + \frac{1}{1 - 3x}$ f $\frac{2}{x + 5} + \frac{1}{x - 5} + \frac{5}{x^2 - 25}$



- a Write $x^2 - 6x + 2$ in the form $(x + a)^2 + b$. (3 marks)
b Hence write down the minimum value of $x^2 - 6x + 2$. (1 mark)

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Clear construct focus and repetition of constructs

Well-designed end assessment and limited number of sample exam questions

Exemplar 1 Summary

Hong Kong – secondary maths textbook

Elements

Statement of prerequisites
Review activity to determine whether pupil is ready for the chapter
Different forms of the equations of circles
Features of circles from the equations
Equations of circles from the different given conditions
Intersection of a straight line and a circle
Inclusion of a series of problems
Check through assessment: six problems, one practice exam Q1, lively maths problem

Key features

Important evaluation of student readiness at the outset of each section
Extremely clear statement of concepts/constructs
Good elaboration through application
Checking of understanding at key points
Spiral curriculum model

Exemplar 2 Summary

Singapore – secondary maths textbook

Elements

Chapter overview – narrative regarding concepts and ideas – engagement
Discover – learning outcomes
Use of diagrams explained
Key ideas – concepts/constructs – margin notes – focus on concepts
Worked examples
Did you know – interesting facts
Guidance on the use of a calculator
Exercises
'Time out activity'
Journal writing task
Summary – recap and revision – checking main concepts
Revision paper
Ten-minute concept check
Review paper
Enrichment maths

Key features

Extremely clear statement of concepts/constructs
Constant reinforcement of concepts/constructs
Good elaboration through extended application
Requirement for self-reflection through use of journal task
Checking of understanding at key points
Extension of application and understanding through enrichment element
Structured use of calculator accords with King's College research
Worked examples to clearly show concept and operations

Exemplar 1 Analysis

Hong Kong – secondary maths textbook

The textbook is for 12 year olds, and consists of 200 pages. There is an accompanying book of problems and activities – a student workbook in which they write answers to the problems set.

Elements

Statement of prerequisites

This is an important element, which enables both teachers and students to see what necessary prior knowledge, etc. is assumed in the section. Rather than starting a section, struggling, and assuming 'I am bad at maths', the learner understands how a given set of activities depends on secure understanding of specific concepts, knowledge, etc. This can be true of subjects other than maths, for example, literary analysis.

Review activity to determine whether pupil is ready for the chapter

This is a 'stand out' feature of these texts; pre-assessment which systematically probes necessary prior understanding and knowledge. This is highly supportive, helping both learners and teachers address misconceptions and gaps in understanding in an effective way.

Clear statement of 'construct'

The language of the text is technically precise. The material is arranged in a well-evidenced sequence. The domain is well described, and consists of closely related concepts, for example:

- Different forms of the equations of circles
- Features of circles from the equations
- Equations of circles from the different given conditions
- Intersection of a straight line and a circle

The text has margin notes and small paragraphs which constantly draw learners' attention to the key concepts and their application. Nothing distracts from the key concepts which they should be acquiring and understanding. They are 'exposed' to the concepts throughout the section, and to the technical terms associated with the concepts.

Inclusion of a series of problems

Learners are encouraged to apply the concepts and techniques which they are developing through carefully designed sets of problems. The problems are varied and challenging, and encourage extensive application through practice. The problems are carefully varied to offer changing contexts of application, not dull repetition.

For example – Check through assessment, six problems, one practice exam Q1, a lively maths problem

Each section includes well-designed assessments which meet criteria for high-quality assessment. The problems are verbally based, but the language provides a parsimonious context, not a distraction, or unnecessary demand from the language – the assessment should measure the learners' attainment of the key constructs, not present 'construct-irrelevant variation'.

The assessment is for 12 year olds, and is not dominated by the national exam which they will be taking at 16. However, each section includes one practice exam question, to familiarise learners with the questions which they will be presented with in national exams. Lack of familiarity with exam questions again introduces 'construct-irrelevant variation' in assessment; this careful and limited exposure to exam questions is a very sound approach.

Key features

Important evaluation of student readiness at the outset of each section
Extremely clear statement of concepts/constructs
Good elaboration through application
Checking of understanding at key points
Spiral curriculum model

Exemplar 2 Analysis

Singapore – secondary maths textbook

The textbook is for 12 year olds, and is one book of two which they will work through in the year. It includes an excellent set of opening pages on the information elements in each section – an 'exploded diagram' of what is in each section and the purpose of each element. This opening includes clear advice on 'how this book should be used'.

Elements

Chapter overview – narrative regarding concepts and ideas – engagement

All images and text are tightly focussed on the key constructs. The images reinforce the application and social relevance of the maths in the section; for example, an image of a jet engine (a collection of circles) for this section on properties of circles, indicating the importance of the application of the maths – it implies 'this maths is needed for this kind of technology; this is what you can go on to understand and do if you master the maths in this section...'. The materials are all based on a Brunerian model of movement from initial concrete settings, through iconic modes of working, to abstract understanding and working.

Discover – learning outcomes

The section opens with a very clear 'conceptual orientation' section – short paragraphs which explain the focus of the learning in the section and make sure the learner understands what the learning outcomes are intended to be. The language is very clear and straightforward – it explains what terms the learner will come to understand by working through the section. It reinforces focus on the key constructs.

Use of diagrams explained

The section includes an explanation of how the diagrams are used in the section and how they should be used to gain understanding.

Key ideas – concepts/constructs – margin notes – focus on concepts

The section reinforces the key constructs throughout. All text, layout and content focuses on the key constructs. Margin notes list the constructs and highlight to the learner the specific construct which each part of the section is focussed on.

Worked examples

This is a distinctive and important part of the Singapore approach – examples of problems which are fully worked through, so that learners can trace the rationale, technique, mathematical relations and ideas.

Did you know – interesting facts

Reinforcing relevance, small notes outline why this maths is important and interesting facts about the origins and application of the ideas.

Guidance on the use of a calculator

Hodgen's work on the Trends in International Mathematics and Science Study (TIMSS)⁵ shows that countries which ban the use of calculators and those that allow the unfettered use of calculators both do far worse than those which carefully structure and control their use. The use of calculators is carefully controlled through the guidance in each section, and based on sound research and evaluation.

Exercises

Verbally framed problems are a very important part of the learning model – involving learners in mathematising (taking a real problem and understanding and 'extracting' the maths in it); working mathematically (undertaking the formal mathematical operations); and de-mathematising (turning the outcomes of the formal work into an answer to the original question in context).

The exercises are carefully and deliberately varied, and encourage practice and application. The practice is not dull repetition, but demanding and engaging.

'Time out activity'

This is an interesting element – introducing learners to the idea that they need to work by themselves and not just in 'contact time'. This deliberate encouragement of self-study and reflection derives from sound learning theory.

Journal writing task

Another interesting and distinctive element – encouraging learners to reflect on what they are learning and the way in which they are engaging with the material, and what they are learning from it.

Summary – recap and revision – checking main concepts

An element which brings together the different strands of thought, application and learning which learners have tackled and worked through in the section. It brings together the learning and checks whether the learner is understanding the key constructs.

Revision paper

Further encouragement to practise and apply the maths, working over the material to reveal and check both understanding and misconceptions.

⁵ Askew, M., Hodgen, J., Hossain, S. and Bretscher, N. (2010) *Values and variables: A review of mathematics education in high-performing countries*. The Nuffield Foundation.

Ten-minute concept check

Further, different means of checking understanding of key concepts – these different takes on the understanding of learners are deliberate and important; they provide different 'takes and angles' on learners' understanding, a crucial approach to revealing misconceptions and identifying any needs which require additional support.

Review paper

A further take on checking understanding, again with careful elaboration and control of contexts – further practice and checking which is beyond 'dull repetition'.

Enrichment maths

Extension activities which enable any learner to be stretched and engage in more demanding, and/or more varied activities. Crucially, these all link back to the main constructs in the section. The variation in problems does not take the learners into different or more elevated fields of mathematics. The 'learning model' is based on keeping all learners focussed on the same constructs, not accelerating learners. This enables all learners to engage in productive collaborative work and discussion – making all learners' understandings and working available as support to all the group.

Key features

- Extremely clear statement of concepts/constructs
- Constant reinforcement of concepts/constructs
- Good elaboration through extended application
- Requirement for self-reflection through use of journal task
- Checking of understanding at key points
- Extension of application and understanding through enrichment element
- Structured use of calculator accords with King's College research
- Worked examples to clearly show concept and operations

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