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# Audit of existing resources to support the development of mathematical reasoning in the GCSE classroom

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# Audit of existing resources to support the development of mathematical reasoning in the GCSE classroom

## **Audience**

Schools and teaching practitioners in Wales; school improvement officers; challenge advisors in consortia and local authorities.

## **Overview**

The new GCSE course places an increased demand on students' ability to reason mathematically. The purpose of this audit is to provide useful information about a manageable number of resources that can make an immediate difference.

## **Action required**

Teachers are asked to use this guidance as a reference document to help determine which existing resources they can use to support the development of mathematical reasoning in the GCSE classroom.

## **Further information**

Enquiries about this document should be directed to:

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## **Additional copies**

This document can be accessed from the Learning Wales website at [www.learning.gov.wales](http://www.learning.gov.wales)

## **Related documents**

Information about all the new and revised GCSEs, AS and A levels to be introduced in Wales for teaching from 2015 and beyond is available on the Qualifications Wales website at [www.qualificationswales.org](http://www.qualificationswales.org)

This document is also available in Welsh.

# An audit of existing resources to support the development of mathematical reasoning in the GCSE classroom

## Introduction

The new GCSE course places an increased demand on students' ability to reason mathematically, but it is not always easy to know how to get started when teaching this fundamental area of mathematical behaviour.

The number of resources available that purport to help can seem overwhelming, so the purpose of this audit is to provide useful information about a manageable number of resources that can make an immediate difference.

The type and scale of the chosen resources varies significantly. For example, several short books are discussed, while some of the recommended websites contain an enormous amount of information – not all of it focused specifically on reasoning. The consistency is in the general underpinning principles and beliefs about mathematics on which the resources are based, and the difference such approaches can make in the classroom.

The resources are arranged in alphabetical order to avoid giving the impression of a hierarchy of importance, relevance, age or value to them. All free resources have extra supporting information.

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| <ul style="list-style-type: none"><li>• Adapting and Extending Secondary Mathematics Activities</li><li>• Autograph</li><li>• Bowland Maths</li><li>• Embedded Formative Assessment</li><li>• Formulator Tarsia</li><li>• Gapminder</li><li>• Geometer's Sketchpad</li><li>• Improving Learning in Mathematics</li><li>• Kangaroo Maths</li><li>• Mathematical Team Games</li><li>• Mathematics Assessment Project</li><li>• Mathematics Inside the Black Box</li><li>• National Centre for Excellence in the Teaching of Mathematics</li></ul> | <ul style="list-style-type: none"><li>• National STEM Centre</li><li>• Questions and Prompts for Mathematical Thinking</li><li>• NRICH</li><li>• Solve My Maths</li><li>• Suffolk Maths</li><li>• Thinkers</li><li>• We can work it out</li><li>• What Kind of Game is Algebra?</li><li>• WJEC Mathematics resources</li><li>• WJEC Online Exam Review</li><li>• WJEC Question Bank</li><li>• WJEC Secure Website</li></ul> |
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Title & Target Year Group	Publication details	Further details and comments
<p><b>Adapting and Extending Secondary Mathematics Activities: New Tasks For Old</b></p> <p>Years 7 to 11</p>	<p>Prestage, S. and Perks, P. (2001)            David Fulton Publishers            ISBN-10: 185346712X            ISBN-13: 978-1853467127            Price: £21.59</p> <p>Amazon website:  <a href="http://www.amazon.co.uk/Adapting-Extending-Secondary-Mathematics-Activities/dp/185346712X">http://www.amazon.co.uk/Adapting-Extending-Secondary-Mathematics-Activities/dp/185346712X</a></p>	<p>Prestage and Perks explore the greater range of mathematical challenge and reasoning that emerges when standard questions are adapted in some way.</p> <p>This book is relevant for all teachers at any stage in their career in teaching mathematics. It will be especially useful in helping teachers consider how they may develop numerical reasoning in their classrooms as part of every lesson.</p>
<p><b>Autograph</b></p> <p>Years 7 to 13</p>	<p>Eastmond Publishing Ltd            1990 (version 1)            2000 (version 2)            2003 (version 3)  <a href="http://www.autograph-maths.com/">http://www.autograph-maths.com/</a>            Price: from £59</p> <p>Free trial: <a href="http://www.autograph-maths.com/download/index.shtml">http://www.autograph-maths.com/download/index.shtml</a>            Autograph resources at Kangaroo Maths:  <a href="http://kangaroomaths.com/kenny5.php">http://kangaroomaths.com/kenny5.php</a></p>	<p>Autograph is dynamic graphing software that allows students to make connections and reason algebraically and graphically. Users can plot graphs of functions instantly and accurately, and then explore the effect of 'dynamic constants' that can be varied with a controller. Geometrical situations can also be set up and explored within using this graphing functionality. Autograph includes statistics features too: data can be entered and explored dynamically with a wide range of statistical graphs and measures available.</p>

<p><b>Bowland Maths</b> Years 7 to 9</p>	<p>Bowland Charitable Trust (2007 onwards)  <a href="http://www.bowlandmaths.org.uk/index.html">http://www.bowlandmaths.org.uk/index.html</a>  Free</p> <p><i>Further details:</i>  Classroom projects:  <a href="http://www.bowlandmaths.org.uk/projects/index.html">http://www.bowlandmaths.org.uk/projects/index.html</a>  Assessment tasks:  <a href="http://www.bowlandmaths.org.uk/assessment/index.html">http://www.bowlandmaths.org.uk/assessment/index.html</a>  Professional development:  <a href="http://www.bowlandmaths.org.uk/pd/index.html">http://www.bowlandmaths.org.uk/pd/index.html</a></p>	<p>Bowland Maths is an organisation that aims to make mathematics relevant to secondary students through thinking, reasoning and problem-solving activities. Although the apparent focus is Key Stage 3, the ideas are applicable to many students in Key Stage 4 and can be easily adapted.</p> <p><i>Comments:</i>  The Bowland Charitable Trust was set up in 2006 to address the concern that many secondary students started to lose interest in mathematics during Key Stage 3. The strategy has three specific foci, all of which are of interest to teachers aiming to develop reasoning in their classrooms.</p> <p><b>Case Studies:</b> These are open-ended, context-rich tasks (or ‘case-studies’) that students should find interesting and/or relevant. For example, they can explore the crash testing of vehicles or the environmental threat to rainforests. Each of the 26 that now exist is a substantial project that could take between three and five hours in a typical classroom. Substantial teacher notes and examples of pupils’ work are available for each of the projects.</p> <p><b>Assessment tasks:</b> This title is also a little misleading as in reality they are similarly designed tasks that should take between twenty minutes and an hour in a typical classroom. An additional feature of these assessment tasks is detailed guidance that helps teachers to make judgments, and offer formative feedback, about progression in mathematical process skills (which include reasoning). Note that the structure for this is sourced from the 2010 National Curriculum for England.</p> <p><b>Professional Development:</b> The trust has also devised some professional development modules that each last about one hour and involve some action-research. For example:</p> <ul style="list-style-type: none"> <li>• Questioning and reasoning (How can I get my pupils to think, reason and explain?)</li> <li>• Assessing the key processes (How do I assess problem-solving and mathematical reasoning?)</li> </ul> <p>These can be carried out individually, although are probably best worked on together in a team.</p>
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<p><b>Embedded Formative Assessment</b></p> <p>All ages</p>	<p>William, D. (2011)          Solution Tree Press          ISBN-10: 193400930X          ISBN-13: 978-1934009307          Price: £19.77</p> <p><i>Further details:</i>          Embedded Formative Assessment:  <a href="http://www.amazon.co.uk/Embedded-Formative-Assessment-Dylan-Wiliam/dp/193400930X">http://www.amazon.co.uk/Embedded-Formative-Assessment-Dylan-Wiliam/dp/193400930X</a>          Mathematics Inside the Black Box:  <a href="http://www.amazon.co.uk/MATHS-INSIDE-THE-BLACK-BOX/dp/0708716873/ref=pd_cp_b_3">http://www.amazon.co.uk/MATHS-INSIDE-THE-BLACK-BOX/dp/0708716873/ref=pd_cp_b_3</a></p> <p>Dylan Wiliam's website:  <a href="http://www.dylanwiliam.org/Dylan_Wiliams_website/Welcome.html">http://www.dylanwiliam.org/Dylan_Wiliams_website/Welcome.html</a></p>	<p>Dylan Wiliam was one of the authors of <i>Mathematics Inside the Black Box</i> in 1990, which first introduced the notion of 'assessment for learning' and became an influential piece of work. Now referring instead to 'formative assessment', this book returns to those principles and introduces approaches it inspired. <i>Embedded Formative Assessment</i> is structured around five key strategies:</p> <ul style="list-style-type: none"> <li>• Clarifying, sharing and understanding learning intentions and criteria for success;</li> <li>• Engineering effective classroom discussions, activities and learning tasks that elicit evidence of learning;</li> <li>• Providing feedback that moves learners forward;</li> <li>• Activating learners' instructional resources for one another;</li> <li>• Activating learners as the owners of their learning.</li> </ul> <p>The book is written for all teachers, but Wiliam's own teaching background is in mathematics and the book offers practical observations and strategies for developing practice.</p>
<p><b>Formulator Tarsia</b></p> <p>All ages</p>	<p>Hermitech Laboratory (2003 onwards) Latest version 3.9  <a href="http://www.mmlsoft.com/index.php/products/tarsia">http://www.mmlsoft.com/index.php/products/tarsia</a>          Free</p> <p><i>Further details:</i>          NCETM departmental workshop:  <a href="https://www.ncetm.org.uk/resources/12930">https://www.ncetm.org.uk/resources/12930</a></p> <p>mrbartonmaths:  <a href="http://www.mrbartonmaths.com/jigsaw.htm">http://www.mrbartonmaths.com/jigsaw.htm</a></p>	<p>A piece of software that creates jigsaw puzzles. Many ready-made activities have been created by people and made available online. The software is only needed to create and modify jigsaws, as the output is in PDF format.</p> <p>This is a very useful piece of software that allows users to enter calculations and their answers, matching expressions, or even images. Unlike many programmes, Tarsia allows correct mathematical notation through an easy-to-use equation editor. Once a set of matching pairs has been entered, the user chooses an output form for their puzzle. Typically, this is a set of equilateral triangles with entries along each of the three sides. The jigsaw puzzle then requires students to create a larger triangle by joining edges with matching expressions. It is also possible to create a set of dominoes or follow-me cards.</p> <p>However, this does not necessarily lead to a rich mathematical activity and effective reasoning. There are many ready-made activities available on the internet, and it is worth taking the time to identify those that have been carefully crafted. As an example, the first two resource sheets in the NCETM departmental workshop referenced below highlight a poorly designed and a well-designed</p>

		<p>Tarsia jigsaw. Both focus on rearranging formulae, but the best one requires careful reasoning due to the embedded misconceptions, while the other simply requires students to find matching letters. The poorly designed activity involves reasoning of a sort, but not connected to the intended learning, and not at the depth required. On his website (see below), Craig Barton provides bundles of Tarsia jigsaws that have been provided by teachers from around the UK. He also offers some very good advice, or 'possible twists'. It is when these ideas are used within the jigsaws that the most effective mathematical thinking and reasoning takes place.</p>
<p><b>Gapminder (website)</b> All ages</p>	<p>Gapminder Foundation (2005 onwards) <a href="http://www.gapminder.org/">http://www.gapminder.org/</a> Free</p> <p><i>Further details:</i> Gapminder World: <a href="http://bit.ly/1Fony5f">http://bit.ly/1Fony5f</a></p>	<p>A website displaying and animating time series of statistical developments across the world</p> <p><i>Comments:</i> The gapminder world collection is a unique and powerful way of enabling students to engage in statistical reasoning. The 'Trendalyzer' allows a typical scatter graph to be animated over time with a further attribute assigned to each data point (country). In reality this means that you can view, for example, a scatter graph of income per person against life expectancy, with the size of the plotted circle also showing population. Clicking the 'play' button animates over time, and the changes can be viewed over a 200-year period. The animation can be paused at any point, and countries can be selected so that the trendalyzer traces their development. The result is dramatic, and it is almost inevitable that students will pose questions and want to explore in more detail. A number of example graphs are available, and others include CO<sub>2</sub> emissions over time, deaths due to flooding and even achievement in mathematics.</p>

<p><b>Geometer's Sketchpad</b> Years 7 to 13</p>	<p>McGraw-Hill (2001, version 4) <a href="http://www.dynamicgeometry.com/">http://www.dynamicgeometry.com/</a> Price: from £42</p> <p><i>Further details:</i> Free trial: <a href="http://info.mheducation.com/sketchpad.trial.html">http://info.mheducation.com/sketchpad.trial.html</a> Sketchpad Resources: <a href="http://www.keycurriculum.com/sketchpad-resources">http://www.keycurriculum.com/sketchpad-resources</a></p> <p>101 Project Ideas: <a href="http://www.dynamicgeometry.com/Documents/GSP4-101Projects.pdf">http://www.dynamicgeometry.com/Documents/GSP4-101Projects.pdf</a></p>	<p>Geometer's Sketchpad is dynamic software that enhances conceptual understanding in mathematics. Complex geometrical diagrams can be constructed and explored, and the way in which diagrams are built means that it is possible to select and move points and observe the effect on the diagram as a whole. Sketchpad's geometrical capabilities can also be applied to exploration of transformations and algebraic graphs. Users are supported by an online resource centre which hosts resources to support teachers, teaching resources and links to other publications based on the software.</p>
<p><b>Improving Learning in Mathematics</b> Years 10 to 13</p>	<p>DfES (2005) ISBN: 1-84478-537-X <a href="https://www.ncetm.org.uk/resources/1442">https://www.ncetm.org.uk/resources/1442</a> Free</p> <p><i>Further details:</i> Improving Learning in Mathematics: challenges and strategies: <a href="https://www.ncetm.org.uk/public/files/224/improving_learning_in_mathematicsi.pdf">https://www.ncetm.org.uk/public/files/224/improving_learning_in_mathematicsi.pdf</a> (an introduction to the resource written by Malcolm Swann) Mostly number: <a href="http://tlp.excellencegateway.org.uk/resource/su_mat_5822/screens/math_004_002_005/page.html">http://tlp.excellencegateway.org.uk/resource/su_mat_5822/screens/math_004_002_005/page.html</a> Mostly algebra: <a href="http://tlp.excellencegateway.org.uk/resource/su_mat_5822/screens/math_004_003_005/page.html">http://tlp.excellencegateway.org.uk/resource/su_mat_5822/screens/math_004_003_005/page.html</a> Mostly shape and space: <a href="http://tlp.excellencegateway.org.uk/resource/su_mat_5822/screens/math_004_004_005/page.html">http://tlp.excellencegateway.org.uk/resource/su_mat_5822/screens/math_004_004_005/page.html</a> Mostly statistics: <a href="http://tlp.excellencegateway.org.uk/resource/su_mat_5822/screens/math_004_005_005/page.html">http://tlp.excellencegateway.org.uk/resource/su_mat_5822/screens/math_004_005_005/page.html</a></p>	<p>This publication includes professional development modules and teaching resources. It was originally made available to schools as a box set. It is now only available online.</p> <p><i>Comments:</i> Improving Learning in Mathematics was designed by the DfES Standards Unit as a response to the Smith Report of 2004 (Making Mathematics Count). Produced in collaboration with Susan Wall and Dr Malcolm Swan of Nottingham University, it draws on many years of research in mathematics classrooms. Based on the underlying principles of open questioning, mathematical discussion, co-operative learning and the need to expose and explore misconceptions, the teaching resources offer excellent support and guidance for teachers aiming to develop skills of mathematical reasoning with their students. Although originally designed for Post-16 learners, they are now widely used across the secondary phase. Over 40 fully resourced lessons (some of which require more than one hour) are available, categorised under the old National Curriculum headings of number, algebra, shape and space, and statistics. Improving Learning in Mathematics also contains a set of professional development modules that can be effectively used in departmental sessions. These focus on:</p> <ul style="list-style-type: none"> <li>• Getting started (beliefs about mathematics and principles for</li> </ul>



	<p>The professional development guide:  <a href="http://tlp.excellencegateway.org.uk/resource/su_mat_5822/screens/math_004_010_005/page.html">http://tlp.excellencegateway.org.uk/resource/su_mat_5822/screens/math_004_010_005/page.html</a></p>	<p>effective teaching);</p> <ul style="list-style-type: none"> <li>• Learning from mistakes and misconceptions;</li> <li>• Looking at learning activities;</li> <li>• Managing discussion;</li> <li>• Developing questioning;</li> <li>• Using formative assessment.</li> </ul>
<p><b>Kangaroo Maths (website)</b>  Reception to Year 13</p>	<p>Kangaroo Maths Ltd (2004 onwards)  <a href="http://kangaroomaths.com/index.php">http://kangaroomaths.com/index.php</a></p> <p>Price: Many free resources; ‘Bring on the Maths’ packages start at £45</p> <p><i>Further details:</i>  Kenny’s Pouch:  <a href="http://kangaroomaths.com/kenny.php">http://kangaroomaths.com/kenny.php</a>  Schemes of work:  <a href="http://kangaroomaths.com/kenny2.php?page=Ksche meks3">http://kangaroomaths.com/kenny2.php?page=Ksche meks3</a>  Stick on the Maths:  <a href="http://kangaroomaths.com/kenny14.php">http://kangaroomaths.com/kenny14.php</a>  Build-a-Mathematician:  <a href="http://kangaroomaths.com/kenny3.php?page=Kasse ssKS3#bamt">http://kangaroomaths.com/kenny3.php?page=Kasse ssKS3#bamt</a>  Bring on the Maths:  <a href="http://kangaroomaths.com/botm.php">http://kangaroomaths.com/botm.php</a></p>	<p>A website that shares a range of planning, teaching and assessment resources for free. Kangaroo Maths also provides the paid-for resource packages, ‘Bring on the Maths’.</p> <p><i>Comments:</i>  The Kangaroo Maths website should be seen as two separate and distinct sources of materials.  <b>Kenny’s Pouch</b> contains an enormous range of free resources covering mathematics from Year 1 to Year 13.</p> <ul style="list-style-type: none"> <li>• The schemes of work, although designed for the new secondary curriculum in England, provide much useful information. In particular, every unit of work includes a ‘reasoning opportunities and probing questions’ section that suggests exemplar material for teachers looking to develop reasoning skills in their classrooms.</li> <li>• Within the teaching area, a resource package called ‘Stick on the Maths’ can be found. This is a style of activity that aims to improve mathematical dialogue in the classroom. Although based on the structure of the old National Curriculum levels in England, the mathematics is highly relevant.</li> <li>• Assessment resources for the new secondary curriculum include ‘Build-a-Mathematician’ tasks, each of which includes a specific reasoning question or problem. This is just one of five question types in each task, the others being fluency, problem-solving, application and misconception.</li> </ul> <p><b>Bring on the Maths</b> is the only paid-for section of the Kangaroo Maths website.</p>

<p><b>Mathematical Team Games</b></p> <p>Years 7 to 11</p>	<p>Tarquin (2000)  ISBN-10: 1899618562  ISBN-13: 978-1899618569  Price: £5.95</p> <p><i>Further details:</i>  Team Games:  <a href="http://www.tarquingroup.com/product.php?SKU_Code=484">http://www.tarquingroup.com/product.php?SKU_Code=484</a>  Mini Murder Mysteries:  <a href="http://www.amazon.co.uk/More-Mini-Mathematical-Murder-Mysteries/dp/1907550259/ref=pd_bxgy_b_img_z">http://www.amazon.co.uk/More-Mini-Mathematical-Murder-Mysteries/dp/1907550259/ref=pd_bxgy_b_img_z</a>  Treasure Hunts:  <a href="http://www.tarquingroup.com/product.php?SKU_Code=483">http://www.tarquingroup.com/product.php?SKU_Code=483</a></p>	<p>A collection of photocopiable mathematical games for teams of students to engage with. Each team will need to work co-operatively to find a solution, as an individual is unable to solve the problem using the information they are provided with. Tarquin publishes a number of similar resource collections including treasure hunts and murder mysteries, all of which require students to reason mathematically.</p>
<p><b>Mathematics Assessment Project (MAP)</b></p> <p>Years 5 to 13</p>	<p>Shell Centre for Mathematical Education (2007 onwards)  <a href="http://map.mathshell.org/materials/index.php">http://map.mathshell.org/materials/index.php</a>  Free</p> <p><i>Further details:</i>  Summative assessment materials:  <a href="http://map.mathshell.org/materials/background.php?subpage=summative">http://map.mathshell.org/materials/background.php?subpage=summative</a>  Classroom Challenges:  <a href="http://map.mathshell.org/materials/lessons.php">http://map.mathshell.org/materials/lessons.php</a>  Professional Development:  <a href="http://map.mathshell.org/materials/pd.php">http://map.mathshell.org/materials/pd.php</a></p>	<p>A joint venture between the University of Nottingham and the University of California at Berkley, MAP aims to support teachers in delivering the Common Core State Standards for Mathematics (CCSSM) in the USA</p> <p><i>Comments:</i>  The MAP materials offer an interesting source of resources and ideas for teachers aiming to develop reasoning in their mathematics classrooms. The project has three specific foci:  <b>Summative assessment materials (or tasks):</b> these are provided at three levels; novice, apprentice and expert. All levels incorporate assessment of reasoning at various levels of proficiency.  <b>Classroom challenges:</b> These are specifically designed to support teachers with formative assessment and moving students' reasoning forward. There are two types of challenge: concept development, focusing on conceptual understanding, and problem-solving, which requires students to apply concepts in non-routine ways.  <b>Professional development:</b> The changes to the CCSSM in the USA require significant shifts in the way in which mathematics is taught in schools. To support teachers with these challenges,</p>

		professional development modules have been designed. These modules are linked to the <i>Bowland Maths</i> materials, and the <i>Improving Learning in Mathematics</i> materials, both of which are discussed in their own sections within this audit.
<b>Mathematics inside the black box</b> All ages	Hadgen, J. and Wiliam, D. (2006) GL Assessment Limited ISBN-13: 978-1853467127 Price: £6.15  <i>Further details:</i> GL Assessment: <a href="http://www.gl-assessment.co.uk">www.gl-assessment.co.uk</a> Customer services: +44 (0)845 602 1937	Part of the Black Box Assessment for Learning series from the Department of Education and Professional Studies, King's College London.  This book, written by Jeremy Hodgen and Dylan Wiliam, offers advice for teachers about classroom dialogue, questioning and assessment in order to promote effective learning of mathematics. The book sets out the research into formative assessment, and links these with the aims of mathematics teaching. It then offers practical guidance in using formative assessment in the mathematics classroom.
<b>NCETM (website)</b> All ages	National Centre for Excellence in the Teaching of Mathematics (Government Agency) (2006 onwards) <a href="https://www.ncetm.org.uk/">https://www.ncetm.org.uk/</a> Free  <i>Further details:</i> About the portal: <a href="https://www.ncetm.org.uk/ncetm/about-the-portal">https://www.ncetm.org.uk/ncetm/about-the-portal</a> NCETM Essentials: <a href="https://www.ncetm.org.uk/resources/ncetm-essentials">https://www.ncetm.org.uk/resources/ncetm-essentials</a> Developing rich tasks: <a href="https://www.ncetm.org.uk/resources/37471">https://www.ncetm.org.uk/resources/37471</a> Self-evaluation tool (browse): <a href="https://www.ncetm.org.uk/self-evaluation/browse">https://www.ncetm.org.uk/self-evaluation/browse</a> Self-evaluation tool (KS4 reasoning): <a href="https://www.ncetm.org.uk/self-evaluation/browse/strand/1570">https://www.ncetm.org.uk/self-evaluation/browse/strand/1570</a> Twitter chat (How to get pupils to develop their reasoning skills in maths lessons): <a href="https://www.ncetm.org.uk/resources/45729">https://www.ncetm.org.uk/resources/45729</a>	An institution set up in 2006 to improve the teaching of mathematics in England, the NCETM is an organisation that focuses on continuing professional development for teachers. It is primarily web-based and therefore hosts resources and advice available to all. <i>Note: Teachers may need to register (for free) in order to access some of the links and resources described below.</i>  <i>Comments:</i> The NCETM 'portal' is an enormous resource. Teachers wishing to develop reasoning in their classrooms may find that the following sections contain valuable advice and ideas: <b>NCETM Essentials:</b> There is so much content that it can be difficult to know where to start. The NCETM have helpfully put together an essentials page to direct users to key content. One example within this is a substantial set of CPD resources about developing rich tasks in secondary schools. <b>Self-evaluation tool:</b> Selecting the 'browse' option allows users to access a wealth of ideas for teaching every concept within mathematics, and many of these ideas promote reasoning and problem-solving. The subject specific pedagogy section also has a reasoning section at each Key Stage, including post-16.

		<p><b>#mathscpdchat:</b> The NCETM advertises and facilitates weekly Twitter chats on set topics. At the time of writing these take place every Tuesday from 7pm till 8pm. The specific themes covered each week are always focused on up-to-date issues or concerns, and are steered by members of the mathematics education community. The highlights of each Twitter chat are then posted on the portal as an ongoing CPD tool.</p>
<p><b>National STEM Centre (website)</b> All ages</p>	<p>National STEM Centre (2009 onwards) <a href="http://www.nationalstemcentre.org.uk/">http://www.nationalstemcentre.org.uk/</a> Free</p> <p><i>Further details:</i> Overview: <a href="http://www.nationalstemcentre.org.uk/what-we-offer/overview">http://www.nationalstemcentre.org.uk/what-we-offer/overview</a> Mathematics eLibrary: <a href="http://www.nationalstemcentre.org.uk/elibrary/?facet%5B0%5D=subject%3A%22Mathematics%22">http://www.nationalstemcentre.org.uk/elibrary/?facet%5B0%5D=subject%3A%22Mathematics%22</a></p>	<p>The UK's largest collection of teaching and learning resources for STEM subjects – science, technology, engineering, and mathematics.</p> <p><i>Comments:</i> Teachers have to register to be able to download resources from this site, but it is free. Resources are available for children aged 5 to post-16, and are constantly being added, from an extensive range of sources. There are many types of resources for teachers and learners: activity sheets, videos, spreadsheets, research articles, games and presentations, for use in the classroom and to support planning. Searches can be filtered by age range, subject and type of resource, and age of the resource – from the 1960s through to the present day. The sources are too numerous to list here, but searching the resources for keywords such as 'problem-solving', 'collaboration in mathematics', 'low attainers', 'able mathematicians' 'language in mathematics', or even 'teaching', 'learning' or 'assessing mathematics' may provide teachers with a rich starting point of sources to explore.</p>

<p><b>NRICH (website)</b> Reception to Year 13</p>	<p>University of Cambridge (1997 onwards) <a href="http://nrich.maths.org/frontpage">http://nrich.maths.org/frontpage</a> Free</p> <p><i>Further details:</i> Information for teachers: <a href="http://nrich.maths.org/teachers">http://nrich.maths.org/teachers</a></p>	<p>The NRICH project aims to ‘enrich the mathematical experience of all learners’, and the website shares a range of teaching resources for free. Professional development for teachers wishing to develop their use of rich mathematical tasks is also offered.</p> <p><i>Comments:</i> Four of NRICH’s stated aims are:</p> <ul style="list-style-type: none"> <li>• Enrich the experience of the mathematics curriculum for all learners</li> <li>• Offer challenging and engaging activities</li> <li>• Develop mathematical thinking and problem-solving skills</li> <li>• Show rich mathematics in meaningful contexts</li> </ul> <p>A consequence of these aims underpinning the design of the website’s content is that all the resources and activities available are excellent for developing reasoning skills. Each activity comes with additional notes for ‘getting started’ in the classroom, and many also offer ideas of how to move the learning on in the future. Schools can also submit their own solutions, and users can view these by following links. This can itself be a good source of material for developing reasoning as students can compare their ideas with those of other people and be asked to identify similarities and differences.</p>
<p><b>Questions and Prompts for Mathematical Thinking</b> Key Stages 3 and 4</p>	<p>Watson, A. and Mason, J. (2006) ATM ISBN-10: 1 898611 05 X Price: £14.00 (£10.50 for members of ATM)</p> <p><i>Further details:</i> ATM Shop: <a href="http://www.atm.org.uk/Shop/Questions-and-Prompts-for-Mathematical-Thinking/dis002">http://www.atm.org.uk/Shop/Questions-and-Prompts-for-Mathematical-Thinking/dis002</a> This volume is also available for download, Non-Member Price: £12.00, Member Price: £9.00: <a href="http://www.atm.org.uk/shop/Questions-and-Prompts-for-Mathematical-Thinking---PDF/dnl094">http://www.atm.org.uk/shop/Questions-and-Prompts-for-Mathematical-Thinking---PDF/dnl094</a></p>	<p>This book, written by Anne Watson and John Mason examines good mathematical questions and their structures, to secure deep understanding of mathematics concepts. They present a framework for teachers to generate their own questions, enabling teachers to respond to the current work of learners to challenge them further.</p>

<p><b>Solve My Maths</b> Years 10 and 11</p>	<p>2014 <a href="http://solvemymaths.com/">http://solvemymaths.com/</a> Free</p> <p><i>Further details:</i> Solve My Maths: <a href="http://solvemymaths.com/category/solve-my-maths/">http://solvemymaths.com/category/solve-my-maths/</a> About: <a href="http://solvemymaths.com/about/">http://solvemymaths.com/about/</a></p>	<p>A collection of challenging puzzles and problems aimed at GCSE students</p> <p><i>Comments:</i> This website has a number of categories, each of which is regularly updated. These include some useful and entertaining ideas, and the section of greatest interest is 'Solve My Maths' itself. This is a collection of problems created by the owner of the site. In the 'About' section he explains that many of the problems are based on geometry, but that the underlying mathematics often requires algebraic thinking and reasoning. None of the problems specify a method, and students will have to find their own way to start and work through them. No answers are provided in order to encourage resilience. None of the mathematics required is beyond GCSE level, and while the problems are designed to be challenging they have proved successful with many students.</p>
<p><b>Suffolk Maths (website)</b> Years 7 to 13</p>	<p>Mark Greenaway (2004 onwards) <a href="http://www.suffolkmaths.co.uk/">http://www.suffolkmaths.co.uk/</a> Free</p> <p><i>Further details:</i> Suffolk Maths MPA: <a href="http://www.suffolkmaths.co.uk/pages/1MPA%20-%20Inquiry.htm">http://www.suffolkmaths.co.uk/pages/1MPA%20-%20Inquiry.htm</a> Inquiry Maths: <a href="http://www.inquirymaths.com/">http://www.inquirymaths.com/</a></p>	<p>A website maintained by Mark Greenaway, a Maths AST in Suffolk.</p> <p><i>Comments:</i> Mark's stated aim is to support high quality teaching and learning in mathematics, and to provide information on the latest developments in mathematics education. For teachers aiming to develop reasoning in their classrooms, one page in particular is of some interest. It is entitled 'Mathematical Processes and Applications (MPA), and Mathematical Inquiry'. MPA was a significant addition to the 2010 National Curriculum in England, and although this curriculum has been superseded and the strand of mathematics renamed, this page remains a useful collection. One part of MPA was 'analysing using mathematical reasoning'. The discussion of, and links to, 'Inquiry Maths' provide information about findings of educational research. Although the examples given relate to classes of Year 7 students the ideas are easily adapted.</p>

<p><b>Thinkers</b> Years 3 to 13</p>	<p>ATM (2004) ISBN: 1-898611-26-2 Price: £14 (£10.50 for members of the ATM)</p> <p><i>Further details:</i> ATM Shop: <a href="http://www.atm.org.uk/shop/Thinkers/act057">http://www.atm.org.uk/shop/Thinkers/act057</a></p>	<p>A book containing a collection of ideas and activities designed to stimulate mathematical thinking. The described activities cover a broad range of mathematical content and age-appropriateness. However, even the theoretically easier content may be valuable when looking to develop the reasoning abilities of older students.</p>
<p><b>We can work it out</b> Years 5 to 9</p>	<p>ATM (2004) ISBN-10: 1898611319 ISBN-13: 978-1898611318 Price: £22 (£16.50 for members of the ATM)</p> <p><i>Further details:</i> ATM Shop: Volume 1: <a href="http://bit.ly/1C4mwMq">http://bit.ly/1C4mwMq</a> ATM Shop: Volume 2: <a href="http://bit.ly/1HAVfpK">http://bit.ly/1HAVfpK</a></p>	<p>This photocopiable spiral-bound book, which is also available as a PDF download, contains a compilation of problem-solving activities which are designed to be used by small groups of students. Each of the 25 problems contains a set of cards on which are printed a variety of clues and a number of distractors (or 'red-herrings'). Although originally designed for upper Key Stage 2 and Key Stage 3, these activities could be used with those students in Key Stage 4 who need to revisit earlier learning and start to develop their ability to reason mathematically.</p>
<p><b>What Kind of Game is Algebra?</b> Years 7 to 11</p>	<p>ATM (2004) ISBN-10: 1898611254 ISBN-13: 978-1898611257 Price: £22 (£16.50 for members of the ATM)</p> <p><i>Further details:</i> ATM website: <a href="http://www.atm.org.uk/Shop/Books/Books--Hardcopy/What-Kind-of-Game-is-Algebra/act055">http://www.atm.org.uk/Shop/Books/Books--Hardcopy/What-Kind-of-Game-is-Algebra/act055</a></p>	<p>This photocopiable resource, including over 40 games, provides activities covering a range of algebraic concepts from solving simple equations to factorising quadratic expressions. The games are organised by type, for example;</p> <ul style="list-style-type: none"> <li>• Whole class games</li> <li>• Loop games</li> <li>• Target games</li> <li>• Equation card games</li> <li>• Simultaneous equation games</li> <li>• Sequence games</li> </ul> <p>Teachers wishing to develop the use of these games are provided with detailed advice about introducing them in their classrooms.</p>



<p><b>WJEC Mathematics Resources (website)</b></p> <p>Years 9 - 13</p>	<p>2014</p> <p><a href="http://resources.wjec.co.uk/Pages/ResourceByArgs.aspx?subId=38&amp;lvlId=0">http://resources.wjec.co.uk/Pages/ResourceByArgs.aspx?subId=38&amp;lvlId=0</a></p> <p><a href="http://adnoddau.cbac.co.uk/Pages/ResourceByArgs.aspx?subId=38&amp;lvlId=0">http://adnoddau.cbac.co.uk/Pages/ResourceByArgs.aspx?subId=38&amp;lvlId=0</a></p> <p>Free</p>	<p>A bank of digital mathematics resources to support the WJEC specifications. The website is bilingual.</p> <p><i>Comments:</i> The majority of the resources are designed to support the specifications but there are resources that can be used at KS3 to help develop skills needed in order to succeed at KS4. Many of the resources have been developed for use as front of class teaching tools, but the newer resources can also be used on mobile devices making them ideal as self-study/revision tools also.</p> <p>The bank of resources is constantly being updated and added to in line with any changes made to the specifications.</p>
<p><b>WJEC Online Exam Review (website)</b></p> <p>Years 10 - 13</p>	<p>2014</p> <p><a href="http://oer.wjec.co.uk/Pages/ProjectByArgs.aspx?subId=44&amp;lvlId=0">http://oer.wjec.co.uk/Pages/ProjectByArgs.aspx?subId=44&amp;lvlId=0</a></p> <p><a href="http://aaa.cbac.co.uk/Pages/ProjectByArgs.aspx?subId=44&amp;lvlId=0">http://aaa.cbac.co.uk/Pages/ProjectByArgs.aspx?subId=44&amp;lvlId=0</a></p> <p>Free</p>	<p>A bank of digital mathematics exam review resources to support the WJEC specifications. The website is bilingual.</p> <p><i>Comments:</i> These resources have been designed to be used with students in the lead up to the examinations. Students and teachers have access to a bank of questions that caused problems for candidates in previous years' exams, which encourages discussion about potential issues. They have the opportunity to see real candidates' answers and mark them against the mark scheme before seeing actual marks awarded and reviewing the examiner's feedback. This bank of resources is updated after every series of exams.</p>



<p><b>WJEC Question Bank</b></p> <p>Years 10 - 13</p>	<p>2015</p> <p><a href="http://wjec.co.uk">http://wjec.co.uk</a></p> <p>Free</p>	<p>A searchable database of all past questions from the maths suite of examinations. This database is bilingual.</p> <p><i>Comments:</i>  This database will allow teachers to search for particular types of questions based on topics and build their own revision papers, which can be printed out in PDF format.  The database will be updated on a yearly basis after each exam.</p> <p>The database will be available in the near future. For further information please contact <a href="mailto:resources@wjec.co.uk">resources@wjec.co.uk</a></p>
<p><b>WJEC Secure Website</b></p> <p>Years 10 - 13</p>	<p>2014</p> <p><a href="http://www.wjecservices.co.uk">www.wjecservices.co.uk</a></p>	<p>WJEC's secure website for all registered centres.</p> <p><i>Comments:</i>  This website provides access to all of the past papers and mark schemes, Item level data arranged by school and by candidate and a range of CPD materials and circulars.</p> <p>All teachers at registered centres should have a password for the secure website. If you don't have yours then please check with your exam officer.</p>