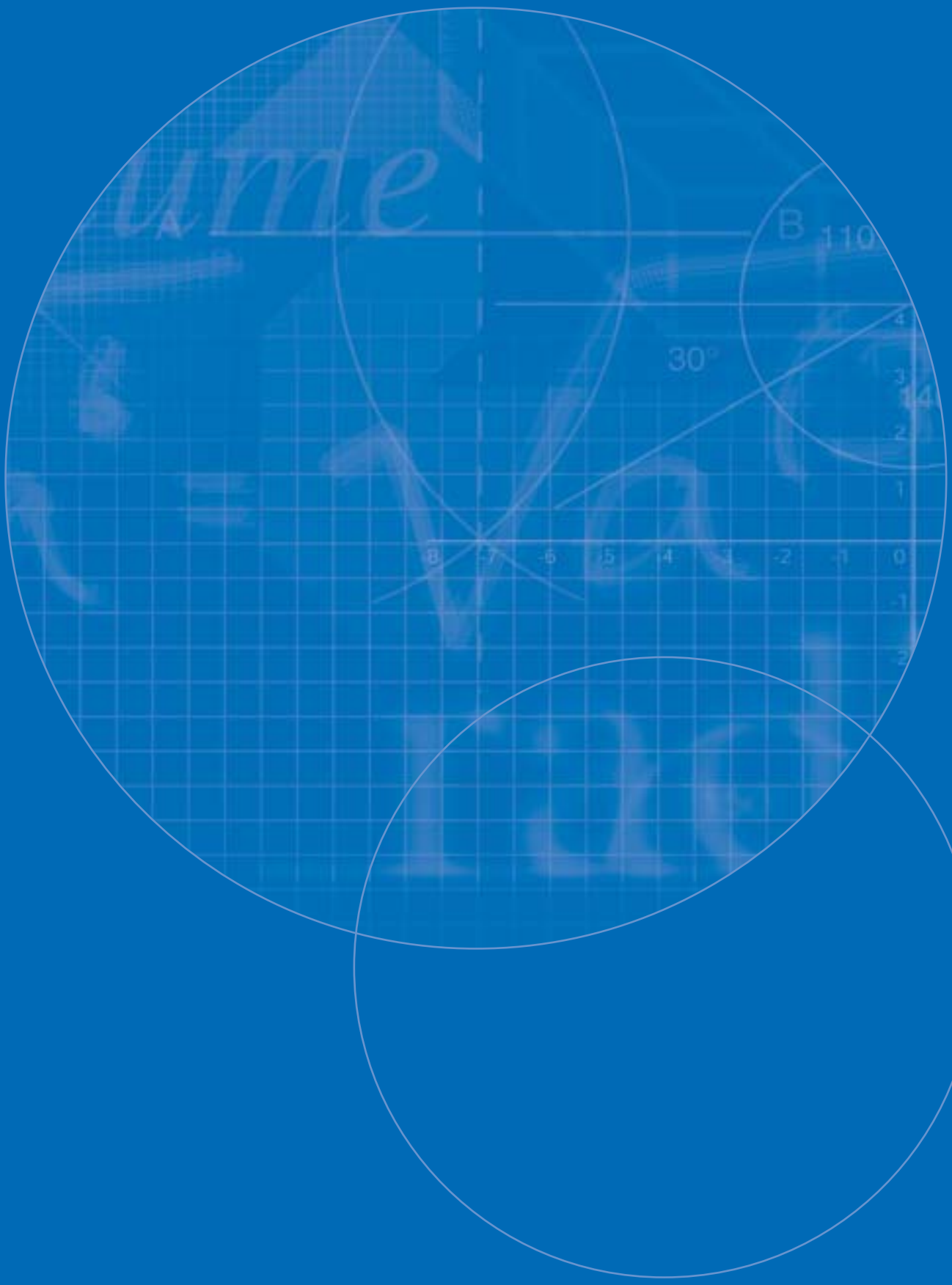

Secondary Mathematics

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ICT Advice

Using **web-based resources** in Secondary Mathematics

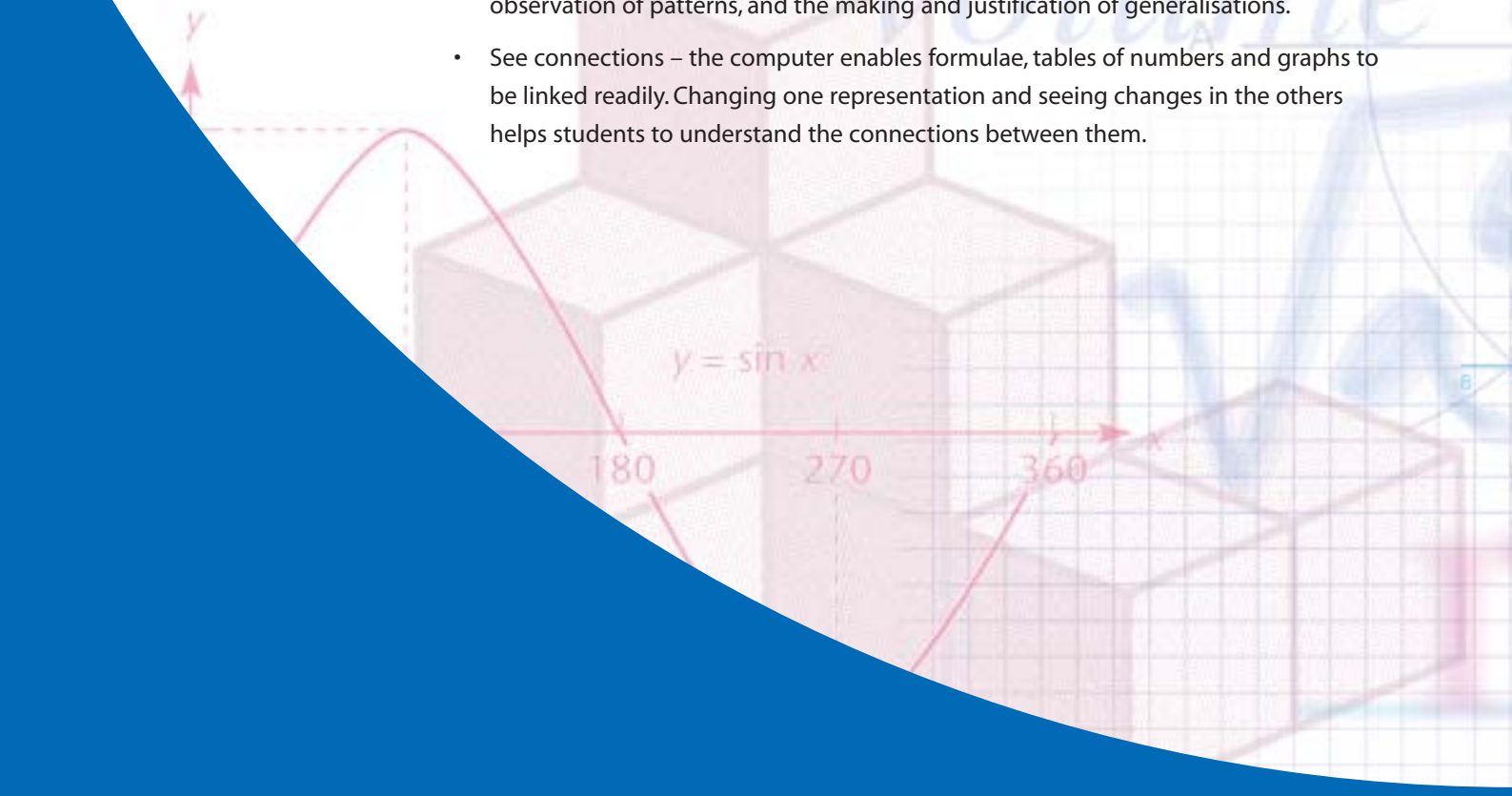
Using web-based resources in Secondary Mathematics

Many good resources for mathematics can be accessed using the internet. Some of these resources can be downloaded and adapted by the teacher to meet specific learning objectives while others can be used 'as is'. The examples in this booklet describe a number of lessons in which ICT is used effectively to support the learning and teaching of mathematics at Key Stages 3 and 4.

Students do not acquire mathematics skills and strategies by magic. They need to be taught how to work things out in their heads, how to check whether their answers are reasonable and how to think ahead when solving mathematical problems. They need opportunities to discuss their ideas with their teacher and their peers, to test things out and to listen to how other students arrived at their solutions. This interaction is vital for developing mathematical thinking, and this is where the skills of the teacher – in questioning and probing students' understanding – are so important.

ICT is particularly useful for helping students to:

- Learn from feedback – ICT provides fast and reliable feedback which is non-judgemental and impartial. This encourages students to make conjectures and to test and modify ideas.
- Observe patterns – the speed of computers and calculators enables students to produce many examples when exploring mathematical problems. This supports the observation of patterns, and the making and justification of generalisations.
- See connections – the computer enables formulae, tables of numbers and graphs to be linked readily. Changing one representation and seeing changes in the others helps students to understand the connections between them.



http://www.ictadvice.org.uk/webbasedresources

- Work with dynamic images – students can use computers to manipulate diagrams dynamically. This encourages them mentally to visualise the geometry as they generate ideas.
- Explore data – ICT enables students to work with real data represented in a variety of ways. This supports interpretation and analysis.
- 'Teach' the computer – when students design an algorithm (a set of instructions to make a computer achieve a particular result), they are forced to express their commands unambiguously and in the correct order. This encourages explicit thinking.

The role of the teacher, or a teaching assistant, is paramount in raising standards. They can use ICT to model mathematical ideas and strategies; to demonstrate, explain and question; to stimulate discussion; to invite predictions and interpretations of what is displayed; and to ask individual pupils to give an instruction or a response. ICT can also be used effectively in plenary sessions to 'model' what pupils have been engaged in – allowing them to explain what they have learned and how they have worked out their answers.

Using ICT to help students learn and deepen their understanding in these ways does not need large amounts of specialised software. As the examples illustrate, schools need a range of targeted applications that can be used by different year groups as part of the mathematics lesson.

All web addresses have been checked and were correct at time of printing.

Maths File KS3

This site accompanied the BBC television series of the same name. The programmes showed mathematics in 'out-and-about' settings. The website provides a collection of 12 games across the range of mathematics. Every game is supported by background on the mathematical ideas.

(Note: the games require Macromedia Shockwave.)

URL: **http://www.bbc.co.uk/education/mathsfile/index.shtml**

Relevant to the following:

Framework for teaching mathematics: Year 7, Algebra, 122-5 …solve simple linear equations with integer coefficients (unknown on one side only)…

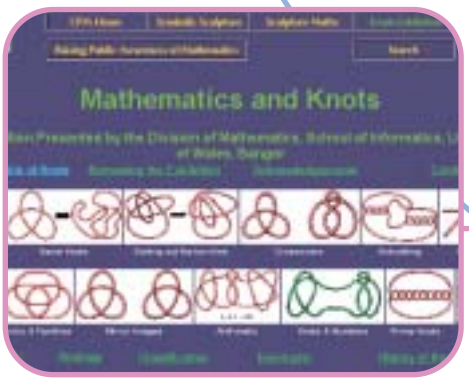
A Year 7 teacher working on linear equations with her class used the game Equation Match as an oral/mental starter activity.

The teacher divided the class into small groups and asked each group in turn to choose one of the equations. Then all of the students had to write the matching equation onto personal whiteboards and hold them up. The most popular choice was tested. When the whole class was successful, the teacher moved on to the next level. Each group was asked to demonstrate, on the interactive whiteboard, how they had solved the equation they selected.

From these activities, the teacher was able to identify specific issues that students were less sure of. The teacher used the site's printable worksheets on 'matching' for homework.

As the class became more practised and competent at solving equations, Levels 2 and 3 were used subsequently as lesson starters.

Secondary Mathematics



Mathematics and Knots KS4

The main site, the Centre for the Popularisation of Mathematics, University of Wales, contains a range of different examples of visual mathematics. There is mathematical art and sculpture plus a detailed section on fractals. For higher achieving students at Key Stage 4, the Mathematics and Knots exhibition provides a rich resource and enables them to explore a piece of accessible pure mathematics.

URL: **http://www.cpm.sees.bangor.ac.uk/**

Relevant to the following:

National Curriculum paragraph: Ma2 Number and algebra, 1l … derive proofs using short chains of deductive reasoning

A teacher of a high-achieving Year 10 group used this site to give students an opportunity to investigate an area of research mathematics. Knot theory is a relatively new area of mathematics and it has the advantage of being easy to get started with.

The site explains the development of the theory of knots in a way that allows students to start their own investigations. The number of 'crossings' in the string can be related to the possibility that a knot simply falls apart and is the same as an 'unknot'. The number of 'crossing changes' needed to turn a knot into an 'unknot' shows how knotted it is. Using these measures students were able to develop provable statements about knots.

Students were able to develop their work into coursework. This coursework gave high credit because the ideas of knot theory were manageable, but supported high-level mathematical thinking and explanation.

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Descartes 2D Maths KS4

The Spanish Ministry of Education has commissioned this large site to provide interactive teaching materials for school mathematics. The resources are grouped by subject and by level and can be explored in different ways.

All of the teaching materials have been translated into English although some of the support materials (the search engine, for example) may help users to develop their language skills!

(Note: most of the interactive resources require a Java-enabled browser.)

URL: **http://descartes.cnice.mecd.es/ingles/index.html**

Relevant to the following:

National Curriculum paragraph: Ma3 Shape, space and measures, 2g …understand, use and recall, trigonometrical relationships in right-angled triangles…

Students in Year 10 were working on trigonometry. Their teacher started the lesson with a short activity that practised identifying the trigonometric ratios in a unit circle.

For the main part of the lesson students worked in groups of three to investigate the properties of the trig ratios. (The Descartes site provides interactive activities that allow students to explore the variation in each of the ratios. There is a guided activity to structure the outcomes.)

For the plenary session, the teacher used the interactive whiteboard to run the activities from the Descartes website. A representative from each group came to the board and demonstrated a property of one of the ratios.

With the whiteboard, and the site's interactive resources, the teacher was able to present a graphical summary of what had been covered.

Royal Air Force: RAF Target KS3

The website contains a set of interactive exercises dealing with solving problems using mathematical skills. Users play the role of different RAF personnel and engage in various 'out-and-about' missions. The area for teachers contains curriculum maps detailing the context in which the activities can be used.

(Note: the activities require Macromedia Flash.)

URL: **http://www.raftarget.com/**

Relevant to the following:

Framework for teaching mathematics: Year 8, Using and applying mathematics to solve problems, 2-25 solve more demanding problems and investigate in a range of contexts: number, algebra, shape, space and measures and handling data…

A Year 8 teacher wanted to help students develop their problem-solving skills. Students worked in pairs in a computer room. They were set a variety of practical problems in the context of the website's 'search and rescue' mission.

On-screen tools are available to support the work: a calculator with a text entry area for jotting notes, a hint to get users started and a help section to support the mathematical ideas. The help is context sensitive so before help becomes available, students are encouraged to make a first try using the given hint. Once accessed, the help section also acts as a glossary.

The Year 8 students took turns to either enter their ideas into the web pages, or work in an exercise book to jot down details of the problems that had been solved in readiness for a report back to the class.

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The MacTutor History of Mathematics archive KS3 & 4

This is the definitive site for information about mathematicians and the history of mathematics. Members of the School of Mathematics and Statistics at the University of St Andrews maintain the site.

Its drop-down menus allow easy access to a wide range of mathematical topics, including an index of female mathematicians. The website seems to contain the background to every mathematical project and coursework topic imaginable.

URL: **http://www-history.mcs.st-and.ac.uk/history/**

Relevant to the following:

Key Stage 3

Framework for teaching mathematics: Year 7, Using and applying mathematics to solve problems, 26-7 …represent problems mathematically, making correct use of symbols, words…

Key Stage 4 (higher)

National Curriculum paragraph: Ma2 Number and algebra, 1i examine critically, improve, then justify their choice of mathematical presentation; present a concise, reasoned argument

As part of a departmental policy to encourage written mathematics, students were asked to write short passages about the history of, and the characters involved in, the mathematics they were learning. The principle resource used was the MacTutor archive.

Teachers made a point of starting each new topic with reference to the key mathematical characters involved. Students made notes of names and keywords and searched the archive.

The articles in the archive are generally quite long, but the introductions are readable at any level. Students were discouraged from printing, or copying and pasting. Instead, they were asked to write their own summary and given strict limits of 100 words for a topic and 50 words for a mini-biography. A writing frame was provided to structure the writing of students in Year 7 or 8.

MathsNet KS3

Bryan Dye has developed this site over a number of years. It offers a very wide range of learning activities covering the whole mathematics curriculum at Key Stages 3 and 4, and at AS-level/ A-level. All activities are interactive and make good settings for exploring mathematical ideas.

The materials for exploring transformations at Key Stage 3 provide activities to support students in the development of their thinking. To find these activities, follow the link to 'geometry' from the home page, then choose 'interactive transformations'.

(Note: many of the activities need a Java-enabled browser.)

URL: **http://www.mathsnet.net/**

Relevant to the following:

Framework for teaching mathematics: Year 9, Shape, Space and Measures, 202-7 transform 2-D shapes by combinations of translations, rotations and reflections, on paper and using ICT… identify reflection symmetry in 3-D shapes

A Year 9 teacher used the MathsNet 'transformations' activities [**http://www.mathsnet.net/transformations/index.html**] to support students in producing group projects. Over a two-week period, students managed the structure of the lesson. Each group took a turn in running the oral/mental activity by using the interactive whiteboard with an activity chosen from the MathsNet materials.

In the main part of the lesson, each group developed their understanding of transformations by using and exploring the MathsNet dynamic transformations activities. These are structured as an ordered sequence for each transformation with a final set on combinations. The teacher set differentiated targets for each group, giving them one lesson on each transformation and a final lesson for writing up their report.

At the end of each lesson, the teacher used specific activities to give a dynamic summary of the properties of each transformation at increasing levels of difficulty.

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Count On KS3

The Count On website has a whole range of resources and materials, from games and puzzles to a mathematics newsletter (The Sum) and a virtual maths museum. The most popular resources are in the games collection. (Click on the games icon on the home page, then choose the game from the list.)

URL: **http://www.counton.org/**

Relevant to the following:

Framework for teaching mathematics: Year 7, Calculations, 82-5 understand addition, subtraction, multiplication and division as they apply to whole numbers and decimals…

A Year 8 teacher started a series of lessons over a two-week period using the 'Who wants to be a Mathenaire?' game. (The lessons were in the number strand since the majority of questions in the game are on number.) The game is an ideal support tool for a class oral/mental starter activity.

The first question required the whole class to put a list in order, so complete agreement was needed! After this, questions were asked in turn to pairs of students. Lifeline activities – 'ask the audience' or 'phone a friend' – were addressed to the remainder of the class.

Students were given a shorter homework if they won at least £500,000 since they had proved their knowledge as a class. Any questions that were answered wrongly were added to the homework, so that everyone ended up with a complete set of answers.

The game has sets of questions at five levels of difficulty, therefore towards the end of the two-week period the class found the activity increasingly difficulty.

A mathematics department was developing its practice by providing extension work to improve the coursework of students at GCSE level.

A Year 8 teacher used the NRICH site to give students the chance to explore a range of mathematical problems. An important feature of the site is that students can post their solutions and their thinking to a bulletin board within the site. Allowing students to choose (with guidance) the problems to be worked on made them keen to share their ideas and read what others had done.

Working in very small groups (pairs or well-structured threes), students wrote up the solution to their chosen problem. They used the graphics and the interactive diagrams from the site as support materials. Each group was given a five-minute slot in which to present their findings during the final lesson of the two-week period.

The NRICH Project KS3

The NRICH Project, based at Cambridge University, publishes free mathematics enrichment resources for pupils of all ages.

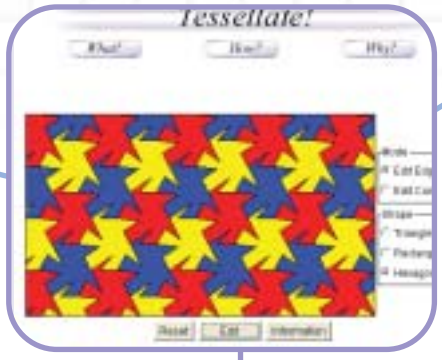
NRICH is a long-established source of mathematical problems to solve. Students post solutions to the problems posed and are able to read the contributions of others from around the world.

The site is republished every month with new content, however, there is a large database of past problems that can be searched in different ways. Problems can be chosen from many specific curriculum areas but especially shape and space, or they can be searched by topic.

URL: **http://www.nrich.maths.org/index.html**

Relevant to the following:

Framework for teaching mathematics: Year 8, Using and applying mathematics to solve problems, 26-7 identify the necessary information to solve a problem; represent problems and interpret solutions in algebraic, geometric or graphical form…



Project Interactivate KS3

The Shodor Educational Foundation website contains materials that cover a whole range of mathematical areas. The Foundation's particular focus is exploring science and mathematics using computational science, modelling and technology. Most of the activities are written in Java, so a Java-enabled web browser is needed to access and use them.

One of the activities, called Tesselate!, allows users to tessellate a plane starting from three basic shapes which can then be edited. Users can see angle and side information about the edited shape.

URL: **http://www.shodor.org/interactivate/**

Relevant to the following:

Framework for teaching mathematics: Year 7, Shape, space and measures, 184-9 begin to identify and use angle, side and symmetry properties of triangles and quadrilaterals…

A teacher of Year 7 students used the Tessellate! activity for a full lesson to investigate the properties of shapes. The software proved ideal for use with an interactive whiteboard.

The teacher used an oral/mental starter session to demonstrate how the software worked. A basic triangle, rectangle or hexagon can be selected and manipulated. The result can be tessellated and colour used to show the separate shapes. The 'Information' button gives access to data about the number of sides and the angles in each shape.

During the starter activities, students practised with the angles in the three basic shapes. Students worked in pairs to develop tessellations that were more complicated. They did this by editing the basic shapes by dragging their vertices.

Starting with the simpler tessellations, students built up ideas of a relationship between the sides and the angles in tessellating shapes. In the plenary session, students were able to demonstrate their theories on the whiteboard.

GCSE Bitesize KS4

The BBC's GCSE Bitesize website offers a collection of short, text-based material to support a wide collection of GCSE topics. Each section contains an online test that is checked on screen. The site is arranged to encourage a focus on exam preparation and includes the 'SOS teacher' service whereby students are able to ask questions of teachers about mathematics topics. The questions (and the teachers' answers) generate a valuable additional resource, particularly as they can be searched.

URL: **http://www.bbc.co.uk/schools/gcsebitesize/maths/**

Relevant to the following:

National Curriculum strands: all

Throughout Year 11, a teacher used the BBC GCSE Bitesize website to develop students' ability to create their own revision notes. At the beginning of the year, the teacher booked the computer room to allow students to explore and engage with the site. Students were then given a new revision exercise book. A general working practice was agreed whereby students would take notes in lessons using only 'keywords' and noting formulae.

Having studied the format of the revision notes on Bitesize, students chose a topic and created a new revision note in their workbook. They included worked examples, and used calculators as appropriate. The teacher marked the revision notes and any student whose understanding of their chosen topic was doubtful, was asked to write up a full explanation. Students were allowed to search the website's SOS facility or to ask a question of the service to help them complete these tasks.

After this initial session, students were expected to access the site and produce, for each new topic dealt with, their own notes according to the agreed working practice. Access was facilitated by use of the maths department's own computers and those of the school's library.

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Mathematics Fun, Fact, Fiction, Fantasy KS3 & 4

This one-page website, maintained by Jeff Berkley, leads visitors into some intriguing bits of mathematics. The site contains brief overviews of a number of topics, with a few more substantial write-ups, and links to well-chosen articles and sites. The principle focus is on number-based problems, and any one of the topics could provide several months (or in some cases, lifetimes) of study.

URL: **http://www.lifesmith.com/mathfun.html**

Relevant to the following:

National Curriculum strands: various topics across Ma2 Number and algebra

A teacher wanted to set up a maths club for upper Key Stage 3 and 4 students to work on mathematical ideas beyond the normal curriculum. The world of professional mathematics contains a number of intriguing relationships that are quite understandable, but are very difficult to prove. Fermat's last theorem is an excellent example.

In one session students looked at the statement of Fermat's last theorem and used calculators to try to find whole number triples which satisfied $x^n + y^n = z^n$ where n is greater than 2. They then moved on to using a spreadsheet to try to find solutions. This set the scene for exploring the resources, linked to from Jeff Berkley's site, which discuss the proof that there cannot be any solutions. Happily, these resources include references to one of the famous women in mathematics, Sophie Germaine.

Now students were ready to use their spreadsheets to investigate solutions of $x^n + y^n = z^n$ where n is equal to 2. In other words, Pythagorean triples.

Using these kinds of online resource, the teacher was able to create and support a group of students who were interested in exploring the world of number theory from a historical and, more especially, a mathematical viewpoint.

The Black Chamber KS3

Simon Singh's popular book, The Code Book, can be used and understood by students in schools. The author has created a website that gives the background to the book, and provides activities and resources to support those interested in exploring and breaking codes. The site links to Simon Singh's main site, which has a comprehensive section to support his exploration of the proof of Fermat's Last Theorem.

URL: **http://www.simonsingh.net/The_Black_Chamber/home.html**

Relevant to the following:

Framework for teaching mathematics: Year 9, Handling data, 272-5 communicate interpretations and results of a statistical enquiry using selected tables, graphs and diagrams in support, using ICT as appropriate…

A Year 9 teacher wanted to give students the opportunity to investigate an area of mathematics. The period immediately after the statutory assessment tests (SATs) proved an ideal time for generating exciting project work in an area less directly specified in the syllabus.

Students worked in small groups and chose one code to investigate. The teacher ensured that two groups were studying each code. They used the interactive activities on the Black Chamber website to develop their understanding of the code and to get to a level where they could pass messages to the other group studying that particular code.

Each group prepared a report explaining how the code they were studying worked, together with step-by-step instructions on how to de-code a message. They also prepared a (suitably vetted) example message in code. The teacher prepared a class book by collating the submissions of each group. Decoding the messages of the other groups became the final homework.

Having worked through the materials in this way, the teacher was able to engage the whole class when looking at how to break codes using frequency analysis, which led naturally into a syllabus focus in data handling.

Maths Zone KS3

Maths Zone, from Channel 4 Learning, is an interactive role-playing adventure game. Two characters, Ben and Mai, have been kidnapped and to escape they need to use their maths skills. Behind the role play is a series of maths problems linked to the National Curriculum for Key Stage 3 (click the 'About the maths' link for more detailed information).

(Note: the game requires Macromedia Flash.)

URL: **http://www.channel4.com/learning/microsites/M/mathszone/**

Relevant to the following:

National Curriculum strands: Ma2, Number and Algebra; Ma3, Shape, Space and Measures

A Year 7 teacher wanted to give students the opportunity to sustain a mathematical task. The Maths Zone provided a set of mathematical problems for students to solve in a role-playing adventure setting.

The teacher started by using the projector and whiteboard to introduce the activity. Once the characters and the setting had been introduced, the whole class solved the first puzzle. This involved finding a number efficiently using greater than and less than questions. This led naturally into an oral/mental activity in which the teacher thought of a number and pairs of students took turns to ask a question or guess the number.

Students then worked in pairs at a computer to complete the quest. One of the pair entered the information on the website while the other kept a note of the solutions to the problems. The students swapped roles regularly to ensure equal access. In a plenary session, students shared their solutions to the four problems.

Mathematical Games, Madras KS3

Madras College, St Andrews, Fife, maintains an extensive website including an archive of mathematical Olympiad papers and commentary. The Mathematical Games section is part of the mathematics department's web pages.

URL: **http://www.madras.fife.sch.uk/maths/games/**

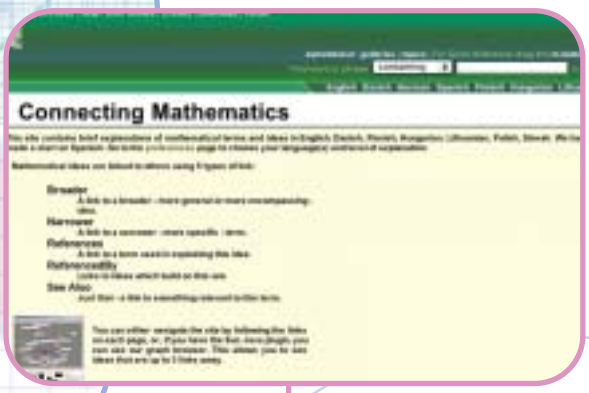
Relevant to the following:

Framework for teaching mathematics: Year 8, Using and applying mathematics to solve problems, 28-9 solve more complex tasks by breaking them down into smaller steps or tasks…

A Year 8 teacher had been using different mathematical games as lesson starters. Interest had been generated in developing better strategies in games such as Nim and Sprouts. The teacher used the Mathematical Games site as a way to engage students in the analysis of strategy and get students started on game theory.

The students' first objective was to be able to win at Nim. The site has a link to a computer-generated game of Nim. Playing against the computer quickly developed the students' skills. The notes on the Nim game's page gave useful pointers and the students began to develop their own ways of describing a successful strategy.

Members of the class were invited to demonstrate the game to another Year 8 class and were challenged by members of that class. The original class had the skills to win every game. During this session, the first class went on to work on improving their strategies for variants of Nim and Sprouts, while the second class began to learn the strategies needed to avoid being beaten.



Maths Thesaurus KS4

A simple concept done well by Cambridge University. Users can start from a text-based 'clickable' alphabet giving access to a comprehensive thesaurus of mathematical terms. The definitions are clear and straightforward and each one gives access to further possible terms.

There is advice on creating a toolbar button for direct access, which could set up the possibility of good research practice for students' online mathematics work. The thesaurus is available in a range of European languages.

(Note: most of the graphical views require a Java-enabled browser.)

URL: **http://thesaurus.maths.org/**

Relevant to the following:

National Curriculum paragraph: Ma2 Number and algebra, 1e discuss their work and explain their reasoning using an increasing range of mathematical language and notation

A mathematics department decided to develop students' skills in written mathematics throughout Key Stage 4. They asked the ICT technician to add the Maths Thesaurus button to each browser toolbar so that maths words could be looked up when students were online.

The policy was mirrored in classrooms by making printed mathematical dictionaries easily available. Students created a space in the back of their normal class exercise books to develop their own glossaries. The school made extensive use of web-based resources such as MathsNet [**http://www.mathsnet.net**] and Bitesize [**http://www.bbc.co.uk/schools/gcsebitesize/maths**].

Whenever students were using these resources, they were encouraged to look up any technical mathematical words.

They were expected to write a definition of their own for any new word and add an example of its use. Class presentations at the end of each half term provided a forum for sharing what students had found.