TACCLE 2.EU

E-LEARNING

FOR TEACHERS OF STEM

A STEP-BY-STEP GUIDE TO IMPROVING TEACHING AND LEARNING IN YOUR CLASSROOM

Lifelong Learning Programme

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INTRODUCTION

This book is targeted specifically at secondary school STEM teachers. We believe it is one of the first that addresses the specific needs of those teachers wanting some practical ideas on how to introduce and use information and communication technologies in the 11-16 classroom. It is not a text book, academic reader or a book which addresses the ICT skills curriculum. It is designed to help you get started on using e-learning methods and techniques in your subject area to make your lessons more fun, more creative and easier to prepare. Nor are we going to cover techy-science-equipment like data loggers, digital microscopes, digital cameras and videos as most maths and science teachers are already pretty good at using those. The focus is on using freely available web 2.0 tools rather than dedicated maths or science programmes. We also focus on using social media to create and share pupil generated content rather than simply using the web for research. We have also a short section on using mobile devices.

This is just another way of saying we just wanted to share some subject-related, practical teaching ideas we have used - things you can actually do with your class tomorrow morning!

How the book is organised

Following discussions with STEM teachers, we have split the book into subjects. However, although the examples might relate to one particular topic, many of the ideas are transferable across the STEM curriculum so we hope you will browse through all the sections. We are also a bit constrained by the fact that the book is translated into lots of language versions and different countries have different curricula so we have tended to restrict the examples that are common to all countries.

Again, in consultation with teachers, this book contains less in the way of step-by-step guidance in favour of a greater number of ideas, applications and activity descriptions. However, there are at least two quite detailed ideas for each subject for those who feel less confident, together with several shorter ideas for you to try out! Before we launch into the individual subjects, there is a short section called 'How Science Works' that is equally applicable to all STEM subjects. Similarly, towards the end of the book, under the heading Overarching Projects, we have included some multi-disciplinary ideas to show how it can all be linked together - but the idea is for you to dip in, take what you like and adapt it for your own purposes. Finally, there is a generic section on 'How to Record and Present Results' which looks at some creative and fun ways you can use as an alternative to the traditional *'Now write up your experiment....'* (Makes marking more enjoyable as well!)

Each page is split in two, on the left you will find the information, activities and and guidelines and on the right we have placed the URL's. The right hand side also acts as a scribble pad for you to make notes. Quite apart from the fact that including long weblinks in the text makes it unreadable, websites come and go, apps that are trending have been replaced by new ones before the year is out and great on-line tools sometimes disappear. At least this means you can scribble out a broken link and replace it with a new one or add your own stuff.

Previous Expertise

Having said that this is NOT a book for ICT teachers or experts, we are making some basic assumptions.

- That you can switch on a computer and access the internet
- That you have some basic experience of using computers in the classroom (e.g using Word or PowerPoint)
- That you are committed to improving your practice
- That you are good teachers and experts in your subject!
- That you have an open mind are confident enough to try out some new ideas to make your lessons more engaging, more creative and more fun.

If you can tick all these boxes, then read on – this book is for you.

Other Tacle Resources

This book is a one of a series: the others are e-learning for Primary, e-learning for Humanities & Languages, e-Learning for Creative & Performing Arts and e-learning for Core Skills 14-18.

The launchpad for this new series was the popularity of the first Tacle e-learning handbook for teachers published in 2009. The original book covered the basics of e-learning practice, including how to use a basic toolkit of social software tools together with ideas for using them in the classroom, teacher-friendly explanations of some important issues underpinning e-learning (such as metadata, copyright, web 2.0 and web 3.0) and some basic skills teachers need to create learning resources. It also has a comprehensive glossary of terms and abbreviations related to e-learning. Print copies of the original handbook are still available in limited numbers in English, French, Dutch, Italian, Portuguese, and Spanish or they can be downloaded as pdf files[1]. If you live outside of these language communities there are also local translations in Arabic, Swazi and a few others.

The launch of the original Tacle handbook was followed by a series of teacher training courses all over Europe. It was feedback from these courses that sowed the first seeds of the follow-up books. In particular, because the courses (and the original handbook) were targeted at ALL secondary school teachers, the examples were generic and subject teachers found it difficult to redeploy them in their own discipline *("Podcasting is great fun but you couldn't use it in Maths!")* There were also a number of primary teachers who were enthusiastic about the ideas but clamouring for a book addressing the needs of younger learners. You may find it worth checking out some of these too as many of the primary STEM ideas can be adapted for junior secondary.

Tacle2 Website

Finally, don't forget... the Tacle 2 website[2] is an on line resource for teachers packed with instant ideas for e-learning in the classroom. It contains complete lesson plans for teachers who are just starting to experiment with e-learning together with shorter posts on a much wider range of ideas for the more experienced. We look forward to seeing your contributions! At the very least, please send us some examples of work that your class has produced as images, text, video or audio so that we can use it to inspire others to have a go.

So, whether you prefer to use the handbook, the website or both, you can rest assured that these ideas have been created, tried and tested by real flesh-and-blood, often exhausted, but none the less conscientious, teachers just like you.

SO LET'S GET STARTED...

1 *http://www.tacle.eu*

2 *http://tacle2.eu*

HOW SCIENCE WORKS

This chapter contains 8 ideas and uses these tools, sites and resources: social networks, Myspace, interactive Flash diagrams, Amap debating tool, Glogster, Pinterest, Diigo, Wordle, Christmas Lectures and RSS.

What do we Mean by HSW?

'How science works' (HSW) or 'scientific methods' is often covered in a few pages at the end of a text book. This is the bit about getting your students to ask questions and explore alternative ideas in order to develop strategies to solve problems.

There is an ongoing debate about how much emphasis should be placed on learning the facts as opposed to understanding the scientific process. Whether you view your students as future scientists, future citizens in a science-based community or a mixture of both may determine which camp you lie in. Whatever your view, there is no escaping that science is inherently a practical subject so we are not about to suggest you up-sticks and move to a virtual lab! Computer simulations have their place but there's nothing quite like experiencing the real tactile, smelly, fizzy, gloopy thing. In this section you will find some general ideas on ways to enhance your STEM lessons using ICT, as fun ways to introduce science, as lesson starters or as ways of filling in the gaps after you have completed your scheme of work or syllabus.

Who has Un-friended Einstein?

Ask your students to create a social networking profile for a scientist on MySpace explaining their discoveries. Find a list of scientists[3] and see our Einstein page[4] for inspiration. Get each person in the class to add a Facebook profile for a famous scientist - who would their 'friends' be? What would their favourite books or music be? What sort of conversations or arguments would they have with each other? (it's more fun if you assume that they they can communicate over time as well!)

Find present day scientists on Linked-In[5] or academia.edu[6] or MyExperiment[7]. What research are they doing right now? Create a class blog where students can record what they have learned.

Stories for Starters

The website "Understanding Science - How science really works"[8] has lots of great resources including an interactive flowchart of the scientific process. If you click on the resources button there are inspiring stories about asteroids and dinosaurs, cold fusion and DNA to get your students thinking. It makes a great starting point for debates.

3 *www.famousscientists.org/list/*

4 *http://myspace.com/taccle2einstein*

5 *www.linkedin.com*

6 *http://academia.edu/*

7 *www.myexperiment.org*

8 *http://undsci.berkeley.edu/article/scienceflowchart*

Can I Have an Argument!

Talking of debates, check out aMap[9] to start an argument. Students follow the on-screen instructions in order to join an existing argument or start a new argument. They'll have to provide an email address, name and location but you can use the same email for multiple users. They are prompted to add reasons and supporting evidence for their argument. When they have finished they get an embeddable mind map which others can reply to by creating their own "argument map". See the Tacle2 blog[10] for an example.

Bad Science

There is a whole lot of mileage for exploring *'Bad Science'* as a way of developing critical thinking. Here are a few ideas.

Aluminium Foil Hat

There is an interesting piece of research you may want to share with your class on the effectiveness of aluminium foil helmets[11]. The original study was done way back in 2005 so after reading the information on the website and any other published research you could challenge your class to conduct their own, modern investigations.

Once they have designed their helmet they could test whether wearing the helmet has an effect on mobile phone or wifi signals or if they get a better quality Skype call. Maybe a Facebook status written wearing the hat will get less 'likes' than one written without it! They could use Glogster[12] to report their findings. (Of course the hat has no real influence on the experiments but it is a fun way to teach about variables, controls and how to conduct research.)

Chemical-Free Substances

The Royal Society of Chemistry is offering £1,000,000 to anyone who can show them a 100% chemical-free substance. Obviously, they are on to a safe bet here but you could challenge your class to try and find one - it should be easy as there are hundreds of products advertised as being "chemical free"! Use Pinterest[13] or Diigo[14] to collect examples of bad advertising.

Wordle-Burble

Ask students to look at a load of marketing websites (cosmetics is a good place to start - or patent medicines or sports supplements or food) and ask them to make a list of the 'scientific' words used. (Think 'protein enriched' and 'free radicals' in face cream or 'active probiotics' in food products or 'anti-oxidants' in almost anything). Each time they get a repeat of a word, they should write it on their list again (or copy and paste it straight into Wordle). Enter the list on Wordle[15] or TagCrowd[16] - these are both free on line tools that let you make word clouds. The more times a word appears in the text, the bigger the word appears in the word cloud. You can adjust colour, layout typeface etc. Tagsonomy is another one that, unlike Wordle, allows you to create clouds in recognisable shapes e.g. a tree. As a follow up, you could get pupils to take each word from the word cloud and search for a scientific definition and post these on a wiki.

9 *http://bit.ly/1jKRO2G*

10 *http://tacle2.eu/core-skills/start-an-argument-2*

11 *http://web.archive.org/web/20100708230258/http://people.csail.mit.edu/rahimi/helmet/*

12 *http://edu.glogster.com*

13 *http://pinterest.com*

14 *www.diigo.com*

15 *www.wordle.net*

16 *http://tagcrowd.com*

Christmas Lectures[17]

Ask your class to watch some of the Royal Institution Christmas Lectures. You can find them on YouTube and the work can be set as homework or done in class. Split them into groups and get them to make their own Christmas Lecture (or Easter Lecture or End-of-Term Lecture). Big up the occasion! The groups will need to consider how they will structure their lecture, what props and visual aids they will need, who is going to deliver the lecture, who will look after the technical side, how will they film it and record it, how will it be edited, where are they going to publish it - this will be just for starters!

The subject is really up to you and will depend on what you are covering during the year, you can even leave it up to the students. Set a time limit on the performance or video - 15 minutes is ample. Encourage them to take an everyday topic and to keep the language simple - assume an un-technical audience. (It's less boring if the groups have different topics!). With older children you may want to ask them to create a lecture for younger classes. If you are stuck for topics, the Readers Questions in the back of the New Scientist are good (e.g 'What is dust made of?', 'Why is yawning contagious?') or go to the Highlights Kids[18] site for more ideas.

(By the way, the Royal Institution website is a fabulous resource and there is a special section for children).

Live Science

News feeds or RSS feeds (Really Simple Syndication) allow you to see when websites have added new content. You can get the latest updates from all your favourite websites as soon as they are published without having to visit the websites you have taken a feed from. In order to read an RSS feed you will need an RSS feed reader. There are several types - those you can download (just Google 'feed readers') or those you access through your browser or search engine.

Get everyone in the class to install or subscribe to a feed reader and give each pupil or group of pupils different websites to monitor - or, with older students, let them choose their own. They have to report back to the class when there is interesting new information on a topic. Kids love it when they can tell you something new about your own subject that you don't know!

17 *www.rigb.org*

18 *www.highlightskids.com*

CHEMISTRY

This chapter contains 14 ideas and uses these tools, sites and resources: QR codes, Jigsaw Planet, interactive whiteboard games,Twitter, YouTube, Podcasting, Slideshare, Padlet, digital storytelling timelines, karaoke, Prezi, Pinterest, stop motion animation, Google Maps, Newseum and Newsmap.

ELEMENTS AND COMPOUNDS

Periodic Table of QR Codes

Brady Haran from Periodic Videos has created a periodic table with QR codes in place of the elements[19]. Each QR code takes you to a video about the appropriate element. You could try doing exactly the same thing but with different groups of students creating, for example, a Pinterest board for a group of elements. Also check out the interactive table[20] as a really useful revision aid.

Periodic Jigsaw

Download a clear image of the periodic table and upload it onto Jigsaw Planet[21]. This is a brilliant bit of free software that allows you to create on line jigsaws using your own images. You can choose the shape of the pieces, how many pieces you want in the jigsaw and how the pieces are jumbled up.
(Er....we took almost 15 minutes to complete the one we made but the kids are usually quicker.)

Periodic Table Games

Ever found yourself with five minutes to fill at the end of a chemistry lesson? You can find a quick and easy interactive game[22] on the periodic table which can be played on an interactive whiteboard. You could also ask students to do this as homework and ask for a screenshot of their results.

Other games you could try are element hangman[23], element word scramble[24] and element maths.[25]

What the..?

We love using Twitter especially for homework, lesson starters and lesson feedback. We asked learners to describe a material in 140 characters on a microblogging site such as Twitter to see if others can guess what the material is without mentioning the name or Chemical symbol. You could do the same for different processes and offer a prize to the first person that guesses is correctly!!

19 *http://periodicvideos.blogspot.co.uk/2011/07/periodic-table-of-qr-codes.html*

20 *www.ptable.com*

21 *www.jigsawplanet.com*

22 *http://14823.stem.org.uk/index.html*

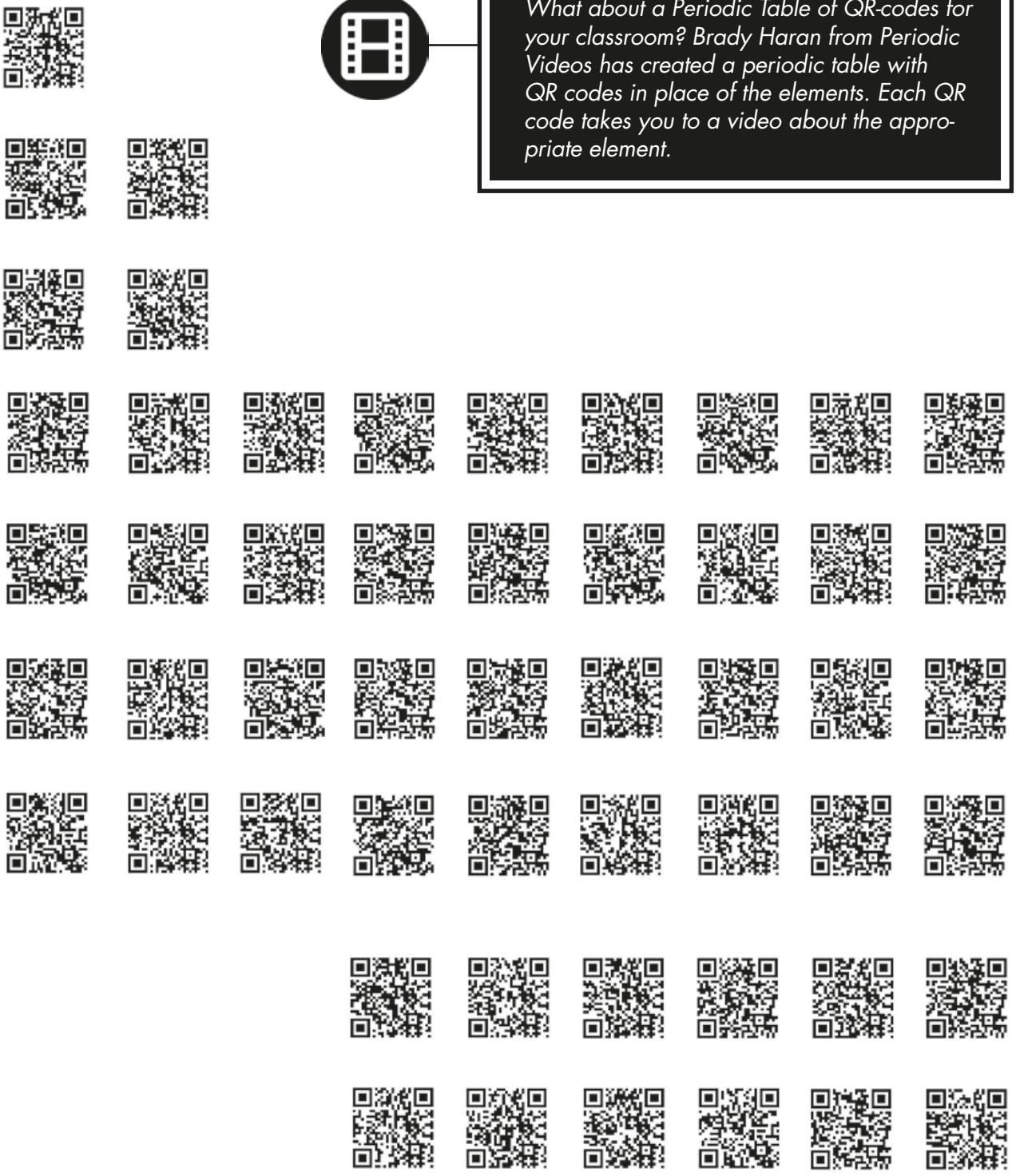
23 *http://education.jlab.org/elementhangman/*

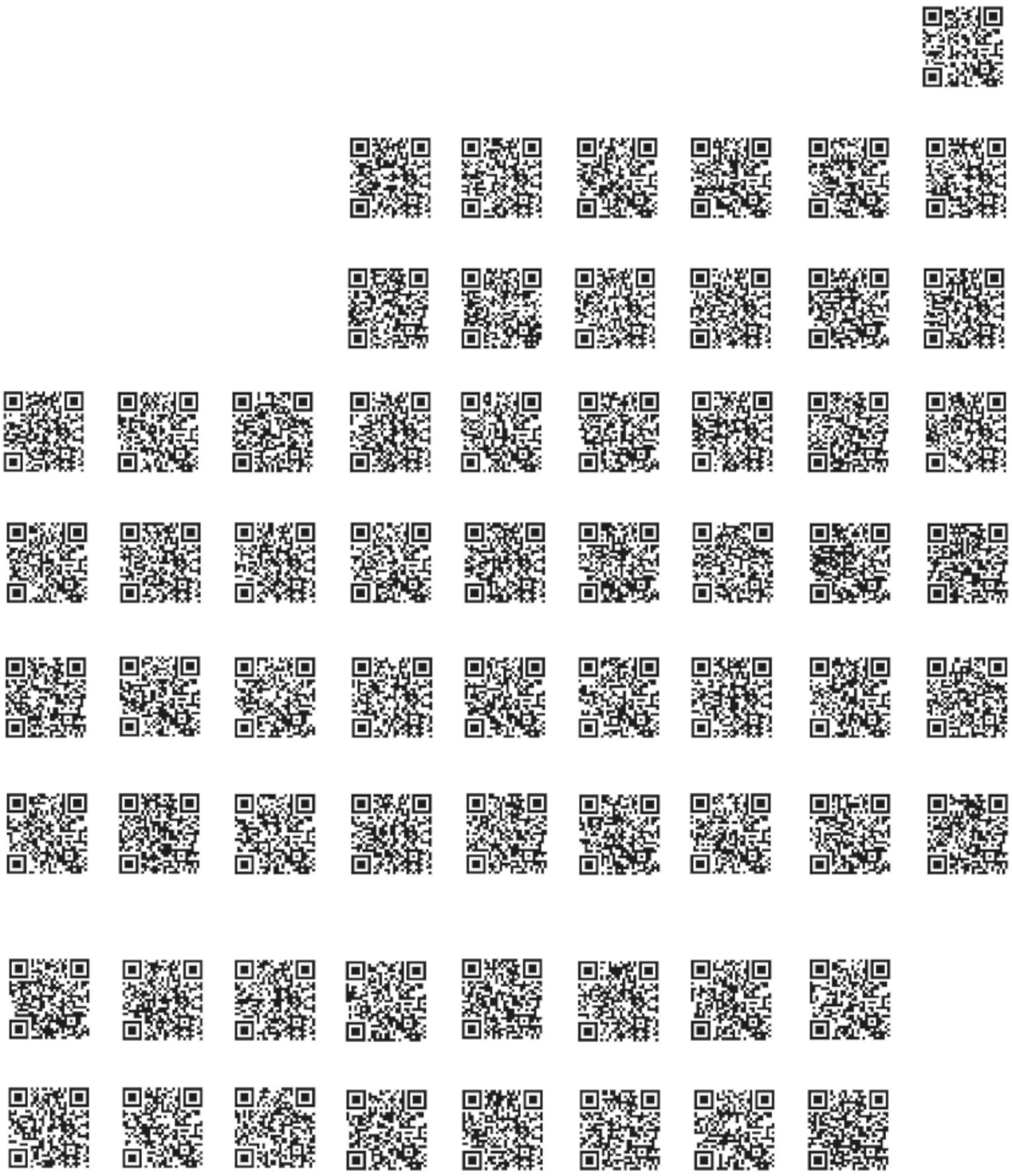
24 *http://education.jlab.org/elementwordscramble/*

25 *http://education.jlab.org/elementmath/*

PERIODIC TABLE OF QR CODES

What about a Periodic Table of QR-codes for your classroom? Brady Haran from Periodic Videos has created a periodic table with QR codes in place of the elements. Each QR code takes you to a video about the appropriate element.





Set up accounts on Twitter for each child in advance using a nickname. e.g. TooCool and also a hashtag for the activity e.g. #YEJguessme (Where the initials represent the name of the school).

Don't make the hashtag too long as it counts in the number of characters you are allowed but make it very specific or you might have other people interested in science joining in - although this could part of the fun..?

Learners could do it in groups and see who has the most right. With younger children this could mean giving them some materials such as wood, paper, cork, plastic, rubber. With older children this could include chemical elements and compounds or reactions and processes (you try describing oxidation, deliquescence or buckminster fullerenes in 140 characters!).

If you are worried about safety you have several choices. You can delete all the accounts when the activity has finished, ask parents' permission for learners to set up their own accounts using their own (or parents') email addresses or create ONE account that you supervise and provide the login information to pupils so that they can use it to post their ideas. With this last option, learners' comments will all appear under the same name so, maybe, as part of their comment they can add a code number that you've given them so they can be easily identified e.g. 007.

Science Songs

Mark Rosengarten has recorded a lot of chemistry tutorials and songs. One of our favourites is "It's a family thing"[26] a song about a list of organic molecules. It's great to use at the end of the lesson so that you can end the lesson on a high. You can also give students the link to use the song as a revision aid. Watch out for humming during exams!

The other classic song (which may only be familiar to those of us of a certain age) is Tom Lehrer's 'Elements Song'. Some versions have pictures of the elements[27] for added interest. Or you can find a version with words[28]. Divide the class into groups and let them have an impromptu karaoke session - can they keep up with him? A lyrics sheet may nelp! Total chaos but fun.

Divide your class into groups and ask them to write their own song about something they are learning in chemistry. Create a podcast using Audacity (or GarageBand on a Mac). If you don't feel confident about that, make a PowerPoint, upload it to Slideshare and add a voice over. Or use Helloslide[29] or Knovio[30].

We Love Homework!

Padlet is a great way to collect ideas and contributions from learners and an easy and effective way of presenting them. It can be used for gazillions of purposes e.g. collecting feedback on lessons, making predictions, describing things and a platform for learners to post general ideas and contributions. We used it as a quick, easy and fun homework task.

Click on 'build a wall' on the Padlet[31] homepage. Choose a themed background and complete the title, subtitle and all relevant fields - it is very easy. You can write the aim of the homework in the title and subtitle fields to help students focus their replies. For homework, everyone in the class is asked to contribute one thing they know about a given subject or topic. All they need is the wall URL and a quick tutorial on how to submit a post. Remind them that they must put their name in the box at the top of the post.

26 *http://youtu.be/mAjrnZ-znkY*

27 *http://youtu.be/6b2Uy1TDAl4*

28 *http://youtu.be/bfrv8Y9746g*

29 *http://helloslide.appappeal.com*

30 *www.knovio.com*

31 *http://padlet.com*

Back in school, read the wall as a class and discuss the contributions. This is a great activity for generating a debate as some posts will be considered obvious, trite or just plain wrong. Look at the example[32] for inspiration.

PROCESSES AND REACTIONS

Time for Chemistry

From the combustion of carbon to the synthesis of a vitamin, every chemical reaction has a story. Have a look at the American Chemical Society website to start you off. It has a chemistry landmarks programme with a multimedia timeline[33]. However, the landmarks go right up to the present day but the timeline stops short in 1983! Get your students to look at the timeline so that they can see the sort of material that is attached to each image before they create their own multimedia timeline to fill in the last thirty years. If you click on the landmarks tab, it will give you basic factual information (dates and discoveries) that students can use as a starter.
You could ask students to use a particular sort of presentation tool (see p xxxx) but it should ideally be one which can cope with a variety of media e.g prezi or Powerpoint or a class blog or a wiki. You need to ask each child to use the same software because then you have a unified collection and a proper timeline.

A variation on this theme is to look at the chemistry of your local area over a time period. For example, we live in an area which changed from sheep farming (e.g dyes for wool) to iron and steel production (e.g Bessemer process) to a coal mining area (e.g dangers of methane, coal products) to petrochem (e.g fractionation) to electronics (e.g use of silicon). Researching the 'chemical story' could include details of key processes and people, adding images, taking photographs (in our case old mines and blast furnaces) and so on.

Students could also pin the text, images, video links they have found onto Google Earth if they are investigating their own town or region.

Black Gold

As a quicker alternative to the last idea, use Facebook or a similar social network timeline to tell the story of how coal is made and used. You could add an extra dimension by getting the class to set up pseudonyms and play the part of a miner (e.g worried about the 'fire damp') or a mining engineer (interested in the depth of the shaft, the rock strata, the problems of surveying underground), the coal-owner (concerned with cutting costs, with transportation etc.) - you get the picture!

Rock On!

Make a Prezi[34] to tell the life cycle of limestone. Or coal. Or anything else you fancy. Prezi is a wonderful alternative to creating yet another PowerPoint... and not a bullet point in sight! Check it out on p.47

pHodcasts

Podcast a pH scale. Divide the class into small groups and give them one or

32 *http://padlet.com/wall/science-wood*

33 *http://acswebcontent.acs.org/education/chemical_landmarks/timeline/timeline2/timeline2.html*

34 *www.prezi.com*

more pH values to investigate. Each group creates a podcast using Audacity or Garageband and starts each one by saying "Hi, I'm pH 4 and I am...". Pupils complete the rest of the podcast as they like. For example, "I'm pH 4 and I am the drunken one. I'm the pH of beer. Hic! " Obviously you will need to tell them that the pH values do not have to be whole numbers. You may also want to encourage them to discuss their work with each other and make some links - so pH 1-3 may be the pH for stomach acids (after a protein rich meal) and could link up with pH 9 which is, in this case, Alka Seltzer!

Or if you are not confident about podcasting, collect pictures of substances across the pH scale and create a whole class on line Pinterest board or make a Powerpoint or Prezi (see p 47). Upload it to Slideshare then embed it into your class blog or website.

Claymation Molecules

Have a go at making stop motion movies of reactions, for example with pictures of molecule models they've made in class. You can use software like MonkeyJam[35] to do this or watch a how-to-do-it video from the makers of the best stop 2D motion ever, Common Craft[36].

ROCKS, MINERALS AND GEOLOGY

River Project

Locate the source of a river and follow it to the mouth,or confluence, where it meets a sea or lake. Use the altitude information on Google to calculate the difference in altitude between the origin and the mouth. Mark all geographical spots of interest (canyons, other confluences, dams, weirs, cascades and waterfalls). Use the grid references (GPS co-ordinates) and the altitude information on GE to reference these points of interest on the map. Zoom in along the banks and make notes of the various field types along the length of the river – do the various field types (e.g. grassland, agricultural, forests etc.) have an influence on the river (e.g. siltation, changes in course, eutrophication) or vice versa? Make notes and point out the various stages of the rock cycle.

What's News?

Search relevant hashtags on Twitter to find out about a recent natural disaster. Use Newseum[37] and Newsmap[38] to collect the headlines from newspapers all over the world about a particular issue (such as a disaster) and map their locations. Talk about the science behind the event. There are some very good interactive simulations and animations on topics such as plate tectonics at the university of Colorado PhET[39] site.

A Tiny Blue and Green Marble!

Produce a collection of digital photographs of natural features. Use Google maps satellite view to explore areas of desert, volcanic activity, limestone cliffs, glaciers etc. Zoom in and look at patterns of vegetation.

35 *http://monkeyjam.org/*

36 *http://youtu.be/oCl1zoxs3Zo*

37 *www.newseum.org/todays-frontpages/*

38 *http://newsmap.jp*

39 *http://phet.colorado.edu/en/simulation/plate-tectonics*

PHYSICS

This chapter has 21 ideas using these tools, sites and resources: Audacity, SimSound, Padlet, QR codes, Pinterest, Interactive LHC, YouTube, Moovly, exploratorium interactive tool, interactive Flash games, gmap-pedometer, Google Maps, Flikr, Pinterest, crayon physics, videoing experiments, Viseno, Mindmeister, interactive whiteboard games, Comic Life, Piston, citizen science, Google Sky, Twitter, Google Mars and Celestia.

WAVES

Form a band

Get pupils to make a range of untuned instruments using junk. These could involve plastic bottle shakers filled with peas, sand or other small objects, elastic bands around boxes to make guitars, glass bottles filled with different water levels, rhythm sticks, drums, castanets and so on.

After they have fun just making a noise (let them get it out of their systems!), ask pupils to think about the sound their instrument makes and if it is possible to create different sounds by shaking, hitting, scratching or plucking the instrument instead.

In groups, can they play a few notes of a simple tune including different pitches? (Three Blind Mice, Twinkle Twinkle Little Star and Frère Jacques are all good ones).

Record on Audacity[40]. When they have finished, play each recording anonymously and ask the class to study the audio trace and guess which instrument created it. Point out the frequency and the amplitude. Which instrument do they think created which noise? Was there a difference between hitting, shaking and plucking for instance? (Depending on the age of your students, you may want to introduce the notion of attack and decay rates.) You could try letting them hear it and then move to playing it on mute. Can they recognise the tune from the audio trace having seen each of them?

SimSound Game

This is a natural follow-on from the above activity for older pupils. SimSound[41] is an engaging multimedia game advertised for 11-16 year olds that uses music recordings to introduce a range of concepts about waves. However, we think it works better with ages 13+

There are four Sim Sound challenges:
- Fix the guitar riff – students learn about pitch and frequency and remove a pitch change in the guitar riff.
- Fix the vocal – students learn about volume and amplitude.
- Adding special effects – students learn about analogue and digital signals and use the software to produce sound effects.

40 *http://audacity.sourceforge.net/download/*

41 *www.iop.org/education/teacher/resources/sim/page_41572.html*

- Make an MP3 download – students learn about digital compression.

You have to download the game from the website and you also need to download Audacity and the LAME MP3 encoder. You can find the downloads on the website of the Institute of Physics[42].

Invisible Waves

Use Pinterest[43] or Padlet[44] to collect information about components of the electromagnetic spectrum.
Draw a line on a long roll of paper on the classroom wall and mark in the wavelengths together with descriptions (e.g. 'ultra violet', infra-red', 'short wave radio', 'visible spectrum', x-rays etc.). Divide the class into groups and give each group one of the bands. Get them to find websites (images, presentations on Slideshare, YouTube etc) and link the url to a QR code[45]. Print and cut out the QR codes and stick them on the timeline. Ask pupils to download a QR code reader app (free) and let them bring in their mobile phones in order to read the other groups' codes.

Find the Higgs Boson

Use the online Large Hedron Collider simulator[46] to recreate the conditions when the universe was one hundredth of a billionth of a second old. Follow the onscreen instructions - they have to adjust each control and then click on the slider to read the on-screen information. Once you have programmed the optimal settings, you will need to memorise the patterns to look out for. The simulator then shows a series of more complex patterns. Can they identify a mini black hole or even a Higgs particle? You can print out copies of the events and you could photograph the best ones and tweet them to CERN[47]

Other resources to enhance this lesson include ready made presentations about how the LHC works[48]

Give Me Two and a Half Minutes

Challenge your class to explain a topic such as constructive and destructive interference patterns using cartoons, pictures and words. There's a great example which condenses theoretical physics into two and a half minutes[49]. One option is to set a time limit and insist that only basic props are used so that the emphasis is on creating a good explanation rather than spending all lesson getting the technology to work. Video the explanations using mobile phones or other devices. Another option is to use the animation software Moovly[50] (there's a free trial version). Use the built in tutorial to familiarise yourself with the tools. They are very simple and most pupils will discover how to make it work by trial and error. We suggest they start by writing a short script and recording it using the microphone tool in Moovly before adding the cartoons. Finally they adjust the timings so that things appear when they want them. Once they have finished, Moovly offers easy options for sharing animation on youtube or by email. There's an example on the Taccle blog[51]

Another idea is to use everyday objects to explain something more complex. These children have made a video[52] using a wooden train set and some marbles to explain how email works (or how about the Geiger Muller[53] groove?) Challenge your class to make their own two and a half minute film and submit it to the Institute of Physics competition[54]

42 *www.iop.org*

43 *www.pinterest.com*

44 *www.padlet.com*

45 *www.qrstuff.com*

46 *www.lhc.ac.uk/The+Particle+Detectives/15273.aspx*

47 *https://twitter.com/CERN/*

48 *www.lhc.ac.uk/The+Particle+Detectives/21st+Century+Time+Machine/13662.aspx*

49 *http://youtu.be/D6lFGJd-wRyo*

50 *http://editor.moovly.com/en/*

51 *http://taccle2.eu/stem/movies-with-moovly*

52 *http://scicast.org.uk/films/2011/06/email-1.html*

53 *http://scicast.org.uk/films/2009/01/the-geiger-muller-groove.html*

54 *http://scicast.org.uk/competition/rules.html*

Zig Zag Water Waves[55]

This is a good outdoors experiment. Set up a speaker on a bench. Run a rubber hose down past the speaker so that the hose touches the speaker and the other end is connected to a water tap. Leave about 1 or 2 inches of the hose hanging past the bottom of the speaker. Secure the hose to the speaker with gaffer tape. The goal is to make sure the hose is touching the actual speaker so that when the speaker produces sound (vibrates) it will vibrate the hose.

Install some free tone generating software on your computer[56]. Run an audio cable from your computer to the speaker. Set to 24hz and hit play.

Set up your digital video camera and switch it to 24 fps (frames per second). The higher the shutter speed the better the results - but also keep in the mind that the higher your shutter speed, the more light you need, which is why outside on a sunny day is good.

Turn on the water and look through the camera to watch the magic begin. If you want the water to look like it's moving backward set the frequency to 23hz. If you want to look like it's moving forward in slow motion set it to 25hz.

FORCES

Lead Balloon

Teaching learners about gravity can be weighed down by too much gravitas! It doesn't have to be grave! Lighten up by reviewing what learners already know about gravity. You could have them investigate a biography of Newton and his work in previous lessons.

Learners are going to investigate how much things weigh on different planets. (You could have learners investigate their own weight on different planets but we tend to avoid this as it can be a sensitive issue!). Divide the class into pairs or groups. Provide each with a selection of objects e.g. an apple, an iPod, a can of soft drink. It's more effective to choose familiar/everyday objects that learners can relate to – this enlivens the ongoing discussions and discoveries! Depending on the age of the class and how creative you feel, you could weave all this into a story about them being astronauts or space travellers.

Ask learners to weigh each object and make a note of it. When they have done this, direct them to the Exploratorium[57] website and ask them to work systematically through their list of objects, inputting the 'Earth weight' in the 'Enter your weight here' box. They must record the corresponding weight for each object on each planet, moon, sun etc.

From this point onwards, the field of possibility really opens up! You could investigate why objects have different weights on other worlds or what the limitation are on visiting other worlds. Is an object's mass affected? On which world would your weight in gold be most valuable? On which worlds would an air-filled balloon weigh the same as a lead balloon? If you have set the scene with a story about space travellers, then your astronauts could dock at each space station (or table!) to complete a task. If they get the right answer in an allotted time (before their oxygen cylinders are empty??) they get rewarded with extra tanks / rations etc.).

55 *http://youtu.be/uENITui5_jU*

56 *http://download.cnet.com/Test-Tone-Generator/3000-2169_4-10070156.html*

57 *www.exploratorium.edu/ronh/weight/index.html*

Pupils can then use their notes to write a formal report on their findings. This can be published on a blog or written on Google Docs or you could use any of the presentation ideas on page 46. Allow pupils to read each other's reports and in the case of Google Docs, allow them to ask questions or make suggestions on the document using the comment function. Before moving on, ask learners to review and re-submit their report.

Although we have used this software to discover why objects have different weights on different planets, it may also be used as an introduction to Newton's Laws.

Life is a Roller Coaster

NASA have created an e-book[58] for teachers which explains the physics of theme parks and gives real life examples along with lesson ideas. (By the way, it takes a long time to load and you need up-to-date version of Adobe) There is an interactive game[59] where you can design a roller coaster by selecting multiple-choice options for the height of each hill and style of loop-the-loop. When you have finished you get feedback on the safety and fun-factor of your ride. There is also a quiz on bumper-car collisions and information on other types of rides. Choose the Flash version to see your design animated. Mind you don't crash!

The School Run

What's the best way to get to school? Compare the routes and methods your students use and learn some physics in the process. Whether you walk, run, cycle, take the bus or drive to school you could enter your route into a mapping site such as gmap-pedometer[60] or RunKeeper[61] to study the details of the route. RunKeeper even has an app that will map your route for you using GPS tracking on a mobile phone. You could ask your students to map their route to school and to use the data in class to calculate speed, distance, time, work, power etc…and decide what is the 'best' way to travel. Extend this by looking in-depth at the physics of car motors or how a bicycle works. You could collect pictures of mechanical components on Pinterest[62] or Flickr[63] and add explanations of how the parts work as part of the description.

Crayon Physics

Crayon Physics is a 2D physics puzzle / sandbox game in which you get to experience what it would be like if your drawings were magically transformed into real physical objects. Pupils can solve puzzles combining artistic vision and creative use of physics to explore the principles of inertia, levers, inclined planes etc. There are a few apps available and also a demo desktop version of the game. Let your class explore the game[64] to get a feel for some cause and effect relationships in physics.

Upcycled Gears

Get your students to collect jar lids and round boxes. Provide corrugated cardboard and get them to cut strips of the card to fit around the outside of the lids and boxes and glue in place to make different size cog wheels. Fix the cogwheels to a soft board using tacks hammered through the centre of each cogwheel to make gear trains. Now produce a stop motion style video[65] where you film each cog-

58 *http://er.jsc.nasa.gov/seh/amuse_park_physics.pdf*

59 *www.learner.org/interactives/parkphysics/*

60 *www.gmap-pedometer.com*

61 *http://runkeeper.com*

62 *www.pinterest.com/search/pins/?q=bike%20parts*

63 *www.flickr.com/search/?q=car+engines*

64 *www.crayonphysics.com/download_demo.php*

65 *www.sciencekids.co.nz/videos/physics/gears.html*

wheel for a few seconds before pausing the camera and adding an extra gear. Check out the direction of rotation of each gear in the train. Explore the difference between large gears and small gears and find the gear ratios by counting the numbers of cogs. What do gears do?[66]

ENERGY

Pimp My Room!

Ask your pupils to design their own room from scratch using, for example, Visneo[67]. Go to RoomSketcher. As they design their room, they must bear in mind where their light switches and sockets are going to be. Ask them to explain why they are putting their sockets and switches in particular places and make sure they give reasons for their choices. You may want them to research the relevant building regulations in their country regarding the height placement etc. of the electrical fixtures. After finishing their plans they could draw the circuit diagrams for their proposed plan or construct them using batteries, wire, crocodile clips etc

There are other equally good bits of free software out there, such as Homestyler - it is worth checking them out to find out which best suits the age and ability of your students. Even Ikea has free room design software! The downside, of course, is that you can only furnish the rooms with Ikea products!

Energy Maps

Use a mindmapping tool such as Mindmeister[68] to produce energy transfer diagrams. There are many different mindmapping tools out there but we like Mindmeister for its simplicity. It's also good for collaborative tasks.

On the homepage, choose the free account option which is hiding at the bottom left of the page beneath all of the premium subscription offers. You need to sign up for an account and activate it by following a link which will be emailed to you. Delete the demo map and choose "New Mind Map" from the top menu. Now you can add lines and boxes to create a mind map. There's a simple one we made earlier[69] showing an energy transfer diagram starting with Chemical energy stored in coal but you can use any process you like. Now for the clever bit; in the bottom left hand corner click on the screen icon, and you can turn your diagram into a presentation by positioning boxes around the bits of your diagram that you want to show on the screen. Rather than a slide-show, you get a pleasant pan and zoom effect similar to Prezi. Click share to get a link or an embed code for your diagram.

Wireless Circuits

Change the components in this interactive circuit[70] and solve the problems. It also works well on an interactive whiteboard - wherer you never have to worry about the batteries running out.

Super Powers

Ever wondered why we can't fly? Check out the physics of super powers series on

66 *http://youtu.be/odpsm3ybPsA*

67 *www.viseno.com*

68 *www.mindmeister.com*

69 *www.mindmeister.com/338385776/chemical-energy-stored-in-coal*

70 *www.sciencekids.co.nz/gamesactivities/electricitycircuits.html*

TED[71] with video explanations of what would happen if we really could fly above the clouds. There are quiz questions and a discussion thread to accompany the cartoon, which you can access following the links on the page. You could have a go at making your own comic strip to explain some super powers such as invisibility or super-speed using Comic Life or Pixton[72]. There's a whole book[73] on the benefits of using comics in education or you can check the Taccle2 blog[74] for more info.

UNIVERSE

Citizen Science

There's a great project on Planetfour[75] where you can contribute to some real-life Martian research! Follow the links and you get allocated a patch of Mars to explore. You can help the researchers by marking interesting features on the surface and, who knows, you might find something never seen before by human eyes!

Planet Four, just like all the Zooniverse[76] projects, offers students a unique opportunity to explore real scientific data, while making a contribution to cutting edge research. We would like to stress that, as each image is marked by multiple volunteers, it really does not matter if your students don't mark all the features correctly. That being said, the task itself is simple enough that we believe most people can take part and make a worthwhile contribution regardless of age.

Star Gazing

Google Sky[77] lets you explore the stars without leaving the safety of your seat. Type the name of a planet, galaxy or star in the search box to view where it appears in the sky. Clicking on the Our Solar System icon gives you thumbnails of prominent solar system objects. Clicking these will take you to the current location of that object in the sky. Clicking on Microwave or Infrared allows you to 'see' those parts of the spectrum and there's even an historical map to show the constellations drawn by Cassini back in the 18th Century.

Planet Parle

Set up a Twitter account for each of the planets. What are they saying to each other? What would they tell us about themselves? Depending on your class, this may take a bit of time setting up but is well worth it. Create an account for each planet (or other celestial body). You will need a different email address for each one so you might want to get the whole department on board. Assign each planet to a group, log them in and get them each to follow the other planets. Encourage the planets to talk to each other, @Venus could ask @Mercury when it will next pass and eclipse the sun, @Neptune could enquire about the weather on @Jupiter and @Mars could share some selfies from the Google Mars site. Keep an eye on other space tweets such as Asteroid Watch[78]. Whether or not you include Uranus in the conversation is up to you.

71 *http://ed.ted.com/lessons/if-superpowers-were-real-flight-joy-lin#watch*

72 *www.pixton.com/uk/*

73 *www.janettekennedy.com/599site/combsproject.pdf*

74 *http://taccle2.eu/stem/cartoon-science*

75 *http://planetfour.org/*

76 *http://zooniverse.org/*

77 *www.google.com/sky/*

78 *https://twitter.com/AsteroidWatch*

Talking to Astronauts

Follow the NASA twitter feeds @NASA[79] and @NASA_Astronauts[80] and you can interact / send questions directly to the astronauts. Social Media-savvy astronaut Col. Chris Hadfield has a great Tumblr blog[81] and can also be found on Twitter[82]. Check out his videos filmed in space. If you don't think you can fit everything you have to say in 140 characters you could try sending a postcard[83] to the Curiosity rover on Mars.

Fieldtrip to Mars

Take your class to explore Mars[84]. You can view images of the surface or take an interactive tour narrated by Bill Nye the Science Guy. Follow the tracks of the rovers and look at the 360 degree panoramas. Search for lost spacecraft[85] and famous landmarks such as the Face on Mars or Olympus Mons.

Celestia

Travel the galaxy with this planetarium software[86] which uses an "exponential zoom feature" to make space travel smooth, no matter what scale you use. You need to download it in order to use it. Project onto a screen, darken the room and journey into space.

79 *https://twitter.com/NASA*

80 *https://twitter.com/NASA_Astronauts*

81 *http://colchrishadfield.tumblr.com*

82 *https://twitter.com/Cmdr_Hadfield*

83 *http://mars.nasa.gov/msl/participate/postcard/*

84 *www.google.co.uk/mars*

85 *www.google.com/mars/#q=failed%20spacecraft*

86 *www.shatters.net/celestia/*

BIOLOGY

This chapter has 13 activities, including time-lapse photography, Slideshare, Powerpoint, digital microscope, photosharing, virtual labs, Tag Galaxy, Google Earth, Blabberize, webcams, video recording, Fotobabble, citizen science, blogging, social bookmarking, Diigo, Wikis, Skype, mindmapping, filming experiments, audio and a virtual lab.

LIVING THINGS

Time is an Illusion

Albert Einstein said "Time is an Illusion". Discuss this with learners and explain to them that they are going to try and 'capture' time at work.

Take one picture a day of a single apple over a period of time until the apple has rotted. A month is usually enough to provide a good example but 3 months is even better. (Place the camera on a tripod, take a picture and, if possible, leave in situ for the duration. If this isn't practical, put markers on the table or floor so that you can reposition the camera correctly after it has been removed).

Spraying with water every few days can help the process along and, also, using an apple that looks fairly fresh but is already a week old can also help (we won't tell if you don't).

When they have a complete set of pictures, upload to a computer and put them into whichever photo-handling programme your computer has installed and create a slideshow. Set to auto to change the slides every second or so. Or make a PowerPoint, upload it to Slideshare then use the embed code from Slideshare to add it to the school website or share it on their personal website or Facebook page.

Up Close and Personal

To get microscopy going with a zoom, try using a digital microscope to take pictures of lots of different types of cells (onion cells, hair, cheek cells, etc.) Upload the pictures to a photo-sharing site and tag each picture with the cell organelles present in each one.

You could also try a virtual bacterial identification lab[87] which also works on mobile devices. Work through the tutorials to extract and sequence bacterial DNA and use the information to identify the sample. This would fit nicely alongside a practical activity growing cultures on a petri dish.

Another virtual lab - virtual owl pellet dissection[88] - lets you dissect owl pellets and identify what the owl ate for supper without ever getting your hands dirty!

87 *www.hhmi.org/biointeractive/vlabs/bacterial_id/index.html*

88 *www.kidwings.com/owlpellets/flash/v4/index.htm*

Tag galaxy

Tag Galaxy[89] is a fun application that makes image searching really easy. It has great visuals based on orbiting planets of different sizes which display pictures that are stored on Flickr on the surface of the 'revolving planet'. By far the best feature is that if you type in, for example, the tag "toadstool" then you get not only a glowing planet displaying pictures of toadstools but about 7 or 8 other planets tagged 'autumn', 'forest', 'mushroom', 'fungus' etc. (To display the pictures, just click on the planet. Then click on the picture to enlarge instantly - much faster than the usual image search on Google). We have found this particularly useful with younger pupils or with less able pupils. Not only is it easier to use and totally intuitive, but the related tag-planets often stimulate pupils to consider other ideas and broaden their search.

Fly, Fly Away!

Students use Google Earth[90] to find out about bird migration. Let the pupils choose a bird. We used the Lesser-spotted eagle but each group could choose a different species.

Start by giving students a Google Earth Tutorial. Let them find some basic facts about the lesser-spotted eagle using the web. In particular they should find out information about where it breeds and its hibernation grounds, how fast it flies and what it eats. Ask them to find and mark the breeding and hibernation grounds on Google Earth. Then ask them to map a likely flight path using the line and path function. (Will birds always take the shortest route? Will they fly long distances over water?).

Ask the groups to test their proposed flight path. Categorise the landscapes the eagle crosses - zoom in to explore the changes in more detail. Examine the seasonal shifts in vegetation. Find out what the Normalized Difference Vegetation Index (NDVI) is and look at an interactive map[91] of the seasonal changes affecting their propose flight path. What are the implications of seasonal changes in vegetation for migrating birds?

Choose a way of presenting their results to the rest of the group. Explore any variations in their findings. Instead of giving them 'answers' encourage students to use ways of verifying their answers themselves. For example, ask them to check their findings against an interactive map[92] of bird migration patterns. You may find that there is a scientific study[93] of the flight pattern of the bird you have chosen that you could also use the check your answers.

Finally, if you want a really fun way of ending this project, ask students to use Blabberize[94] to create an animation of their bird talking or singing about their flight!

Ant Cam.

There are lots of animal webcam sites such as Africam[95] and Pandacam.[96] It's always worth checking out the live cams because there's often not much going on! In this case, you may need to select one from the archive. On Africam click on the Live Safari Cam tab, scroll to the bottom and select a video from the archive. There will be a good selection but a particular favourite of ours is 'Warthog Family Searching for Food'! Play your selected video for learners. If you'd rather not play the adverts (I guess the website has to make money somehow!) click the tab 'Stop Ads'.

You can set up your own camera to record your class worms, ants, woodlice or

89 *www.taggalaxy.com*

90 *www.google.co.uk/intl/en_uk/earth/*

91 *http://modis-atmos.gsfc.nasa.gov/NDVI/browse.html#NDVI*

92 *http://birdmap.5dvision.ee/index.php?lang=en*

93 *www.pomarina.ro/EN/migration-blog/86-migraia-acvile-lor-iptoare-mici*

94 *http://blabberize.com/view/id/956442*

95 *www.africam.com*

96 *www.sandiegozoo.org/pandacam/*

fish. For example, set up a tank with a variety of habitats (stones, grass, rotting wood, moss). Collect some woodlice, introduce them to the tank and film which habitat they prefer. You should release them back into the wild later.

Alternatively use flip cams or small portable video recorders such as those on mobile phones and get students to record an ant's-eye view of the world (or butterfly or slug…) Upload recordings from your webcam or videos to a sharing site.

ENVIRONMENT AND ECOSYSTEMS

Talking Photos

Collect or take some pictures of local power-plants, wind-turbines, pylons etc. Upload the pictures to fotobabble[97] which allows you to record a short audio clip to accompany your picture and lets you share the result on social networks or on your website or blog via an embed code. Record statements about the pros and cons of each initiative. Your students could talk about the environmental impact or describe how each type of energy production works.

Teenage Wildlife

Take your class birdwatching around your school and upload the results to the Garden Birdwatch[98] project site or check out their project page[99] for other ways to get involved in some citizen science. Most of these projects call for weekly observations so you could set your class a rota.

The big butterfly count[100] is a less time consuming project requiring your students to sit quietly for 15 minutes and count butterflies. This would tie in well with a lesson on identification using keys.

Whatever the weather

Take part in a real science and history project by transcribing weather observations made by ships as far back as the mid-nineteenth century. Go to the Old Weather[101] website for details. You will need to create an account and follow the onscreen tutorials to get started. Why not find a historical report for today's date or your students' birthdays[102] then get your class to make their own observations for today and compare the two. They can even have a go at predicting the weather.

You could also organise groups of students to take daily daily meteorological readings for your town or village. They will need access to a Stevenson screen and instruments such as a barometer, thermometer, hygrometer, anemometer, wind vane and rain gauge. They then upload the readings and observations to a school or community blog. They can also add them to the Met Office WOW[103] project site which co-ordinates the weather observing community in the UK by inviting anyone to submit the observations they are taking.

You might want to encourage your students to be more creative and take photos of the sky, cloud formations or other weather features that they could add to a written or videoed weather report. You could link up with another school in a different climate to compare results. There's an example made by students in San Walabonso school[104] in Niebla, Huelva (Spain).

97 *www.fotobabble.com*

98 *www.bto.org/volunteer-surveys/gbw/about*

99 *www.bto.org/volunteer-surveys/gbw/about/background/projects*

100 *www.bigbutterflycount.org*

101 *www.oldweather.org*

102 *www.metoffice.gov.uk/education/teachers/weather-data*

103 *http://wow.metoffice.gov.uk/*

104 *http://meteorologiaescolar.wordpress.com*

HUMAN BIOLOGY

Bookmarking Biology

You can save (and share) all of your useful, informative or fun websites and access them from anywhere using social bookmarking tools. Diigo[105] is a bookmarking tool with added functionality in that you can make lists, add people to a bookmark-sharing group and, best of all, you can highlight text and add sticky-notes to web pages just like in a physical book.

You could use it for an exercise in understanding scientific texts. Set a topic for students to research. Share with them a list of bookmarks you have already created or add them to a sharing group so that they can add the ones they find to your list (this will encourage them to look for different sources rather than all using the same ones). Using Diigo, students can add sticky-notes to summarise the text. They will also be able to see each other's notes. When they select a web page to save they will also be prompted to add a description. Great practice in reading and summarising text. They can also add keyword tags and comment on each others' bookmarks.

There is more information on Bookmarking on the Taccle2 websiteblog[106].

Feed Your Mind

Learners use the web to research nutritional value, quality, composition and storage of foods that are usually present in a healthy, balanced diet by relating the demand for calories to physical and mental activity. You may also wish to invite experts to speak to the group via Skype, find someone on Future Sparks[107] or Skype in the Classroom[108]. Publish the results in a class wiki and create your own on line encyclopedia of health. To do this, point your browser to pbworks.com[109] and click where it says you can "get started with a free version". Say that you want a K-12 Education account and choose the **free** option. Choose a name for you site and fill in the details. A wiki is a collaborative website so everyone in your class (up to 100 usernames) can contribute.

For individual work students could sign up to the social network Spark People[110] which enables them to set personal health and fitness goals. They could use the site to keep a blog of their activities and progress or use a personal blog as a diary. Some students may wish to publicise their achievements, others will wish to keep them private. Ask your students to design a five minute workout or a short dance routine, they can then video it and upload it to the blog or wiki along with a description of the activity.

We would always emphasise the phrase 'healthy and balanced diet' rather than focussing on being 'overweight' or 'underweight'. If you are discussing height/weight ratios we would also emphasise that it is VERY general and sensitivity is paramount when teaching activities such as these.

105 *www.diigo.com*

106 *http://taccle2.eu/tools/social-bookmarking*

107 *http://futuresparks.org.au/teachers/skype-an-expert.aspx*

108 *https://education.skype.com*

109 *www.pbworks.com*

110 *www.sparkpeople.com*

The Great Science Movie

Make a list of the main topics for the term and divide the class into groups. Each group has to make a short movie with an experiment in it to explain a concept or topic. At the end of the term all the short clips are edited into one movie as a revision aid.

Give every group a topic at the beginning of term. Every time a topic is covered during lessons, the group assigned to that topic starts working on their video. The group can work on their clip during lab lessons (and/or as homework). The following is a suggested work programme for the groups.

- brainstorm session.
- make a storyboard for their clip. It has to be short so everything should be well prepared and thought through. Explain that they are allowed to make it fun (dressing up for example) but that the concept or topic needs to be clearly explained.
- clips should contain: an experiment (related to real life) with everyday life materials, theoretical explanation/background, a link to a website that gives more explanation or an applet and, if possible, a mobile app.
- hand in the storyboard for correction before they go ahead and start shooting.
- film and edit the clip.
- at the end of the term, ask for volunteers to edit all the small clips into one movie (with some nice tunes, flashy transitions etc.).

The Axon Game

Wellcome Trust[111] has collected and designed lots of interesting biomedical resources. Among them there is an interesting 'brain' game called The Axon[112] where the aim is to grow a neuron as long as possible. In the end, when you "lose" the game they tell you what kind of neuron you've grown. They then give you a link to Wikipedia with some explanation about that specific neuron. The best place to start is with the instructions. You need to click on the proteins or dots inside the circle of influence before it gets too small. (On my fourth attempt I finally managed a 11,163µm Golgi Cell).

You could ask students to play the game as part of their homework and maybe tell them to play it ten times (you need to get the hang of it). Ask them to do some research about their neuron (not only on Wikipedia): description, picture, location, function… and tell them to put their information in a mindmap (MindMeister[113] for example). The whole class can work on the same mind map so they have to make sure they've designed a logical structure. This can be used afterwards as a study tool.

Audio Autopsy

Take photos of a flower dissection and make a podcast or slidecast, adding slides to describe each stage and labelling the pictures. They could also use stop motion to do the same thing using overlays which are removed one layer at a time. You don't have to use a flower - if you don't fancy making a mess, how about a virtual salmon dissection?[114] If you are feeling creative ask your students to add a horror movie soundtrack. (You could use public domain clips from SoundBible)[115]. All the gore and all the science without the smell or clearing up to do! If you're feeling particularly gory there are some great virtual labs to try out. Our favourite is the virtual knee replacement[116], remember to wash your hands!

111 *www.wellcome.ac.uk/Education-resources/Education-and-learning/index.htm*

112 *http://axon.wellcomeapps.com*

113 *www.mindmeister.com*

114 *http://iasdthematict-eaching.com/wp-content/uploads/2012/08/1.-Dissecting-a-Salmon.LP_.pdf*

115 *http://soundbible.com/tags-horror.html*

116 *www.toadhaven.com/virtual%20surgery%20and%20dissection.html*

MATHS

This chapter has 22 ideas (plus computer based maths) and uses the following tools and technologies: barcodes, Pinterest, Glogster, Wikispaces, Dipity, TimeRime, Tiki-Toki, Twitter, Google docs, Prezi, Thing Link, Mazaika, Pantherlife, My Life in Numbers, Sketchometry, Creaza, Moovly, Animoto, Magisto, Ngram Viewer, Public Data Explorer, Nationmaster, Walkjogrun, Google Earth, Flickr, Friend Wheel, Weebly, Storybird, Padlet, Reprap, robots, Tinkercad, Excel, Gliffy.

The impact of computers on the teaching of maths has been immeasurable - there are many excellent resources available on the web ranging from games which help children to practice fractions through to colourful 3D representations of advanced surface graphs. Most maths teachers will already use many of these - the days of drawing graphs of quadratic equations on the blackboard have long gone.

However, there is a more fundamental revolution going on in that represents a paradigm shift in the way in which we conceive of the mathematics curriculum in the computer age. The driving force behind this is Conrad Wolfram - one of the founders of the computational search engine Wolfram Alpha[117], who, together with an increasing large community of teachers, researchers, industrialists (and the occasional politician) are redefining the way that mathematics is taught[118].

COMPUTER BASED MATHS

His arguments are simple. Maths are increasingly important in industry, science, research, economics and in daily life. Employers are complaining about the lack of maths graduates and demanding a workforce which is mathematically competent at a basic level. Governments, meanwhile, are despairing about the failure of their education systems to rise to the challenge.

Traditionally, maths teaching has been about learning how to calculate from a given set of information. Governments, in their endeavours to improve standards of maths, have focussed on ways to improve pupils ability to calculate. Simultaneously, there has been a drive to improve numeracy - a subset of calculating.

However, Computer Based Mathematics is proposing a radical rethink. Maths in the 'real world' of finance or engineering or environmental science or almost every area of life you can think of, depends on four basic steps.

1. Recognising the problem in the 'real world' and posing the right questions.
2. Formulating the 'real world' question in mathematical terms
3. Calculating the 'answer'
4. Translating and representing the outcomes of the computation back into the 'real world' and verifying them.

Historically, about 80% of the time spent in maths education is focussed on the third stage. However, computers were designed to do this and is something that they can do better, faster and more accurately than humans. Now that computers are ubiquitous, the logic is inescapable. Refocus the maths curriculum on stages 1,

117 *www.wolframalpha.com*

118 *www.wolfram.com/broadcast/video.php?channel=104&page=2&video=769*

2 and 4 and let computers deal with stage 3. This is the basic premise of Computer Based Maths - liberate the teaching of maths from learning how to calculate.

Conrad Wolfram suggests that each day, 106 lifetimes are spent in schools across the world on hand calculation. Worse, most of these are often extremely boring and tedious lifetimes. If this time could be freed up by using computers to do the calculating, pupils can work on harder questions, more 'real life' questions, try more concepts and play with a multitude of new ideas. It is also a much more authentic way of integrating mathematics across the curriculum.

Forecasting the future

Consider the following example. You set your class the task of working out what your town or village is going to look like in twenty years time (or 10 or 30 or any other number!). Will it have grown? By how much? What will the population be? What will be the demographic of the population (by age, gender, ethnicity etc) be? What land area will it cover? What is the land-use likely to be? What sort of jobs will people do? What sort of buildings will be constructed - will there need to be more or less schools/hospitals/factories? What might the transport infrastructure look like - and so on. You get the point.

Most all the information you need to model possible futures exists already and through the rapidly increasing OLD (Open and Linked Data) sources, is accessible to your pupils. And if there is missing data, then exploring the potential unknowns and constructing the 'what-if' scenarios is an integral part of the mathematical modelling. When that is all done, how are they going to communicate their conclusions? how are they going to communicate their conclusions to other students? To the local Chamber of Commerce ? To a local government department? Is this just about text and graphs or is it about representing growth on e.g. Google Earth or constructing 3D representations of new builds?

The hand calculations necessary to complete this assignment could take years. Using computers to do the tedious work means you can complete it as a term's project. This is much more relevant, engaging and fun than all those years of calculating how many mythical men it took to dig holes or drawing endless diagrams of your yacht sailing in an improbable 40mph wind to teach trig!

Arguments against Computer Based Maths

There are many arguments against this approach; some are interesting, some are predictable, some defensible and some are not. However, this book is really not about defending CBM. As maths teachers, we are 100% committed to the approach - rarely is there an opportunity to move the maths curriculum forward in a way which both increases conceptual understanding AND makes it more practical, hands on and located in the real world. For those of you that want to hear different points of view, there are many online debates[119]. For those that are interested in learning more, join us at computerbasedmath.org

You do not need particular software to embrace the idea of CBM - it is really a state of mind! However, Wolfram Alpha have produced an awesome, powerful and very easy to use set of tools that makes it all so very easy. Just search Mathematica 9 and have a look for yourselves. We try to avoid recommending commercial software if there is a no-cost equivalent but if you like the ideas and are serious about introducing CBM, then check it out.

Ultimately, you may be hidebound by school policies or by government driven national curricula - but there are still things you can do as a class teacher to em-

119 *www.computerbasedmath.org/forum/*

brace some of the basic principles of CBM. (And talking about governments - Estonia has just become the first to introduce CBM in all schools across the country!)

Right - now we have got that out of the way and shared our own personal opinions, what follows are some ideas which show how you can use computers - and, in particular, social media - in your classroom. Many of them are designed to show that mathematics, irrespective of whether you are moving towards CBM or following a more traditional curriculum, are all around us and exist in the 'real world' rather than as squiggles on a sheet of paper.

120 *www.pinterest.com*

121 *www.glogster.com*

NUMBER, MEASURE AND MONEY

The Maths of Barcodes

Create a Pinterest[120] board or a Glog[121] and pin or stick text, images or multimedia that answer some or all of the following questions. All the answers are easily available using a Google search or searching with Wolfram Alpha

- How many digits does a bar code have on an item you might buy in a supermarket?
- Where were the first bar codes used and why?
- What is the difference between a 1D bar-code and a 2D bar-code?
- Universal Product Codes (UPC) that can be scanned on consumer goods that have been around since 1974. What was the first package to carry one?
- The current bar coding system on 'point of sale' consumer goods is called EAN13. Find out what each block of numbers represents.
- Look at a bar code in detail. Use a magnifying glass if necessary. Where are the long lines and where are the short lines?

(By the way - some of the answers may be hotly disputed but the debate is part of the fun!)

Cracking the code:
what Control Numbers are for and how they work

The control number in an EAN bar code is the last digit. It just tells you whether the bar-code on the tin of beans you have just bought was scanned properly. Some times the control number is the same size as the other digits. Sometimes it is a little smaller or moved to the right. The control number is calculated from all the other digits. Each of the other 12 digits is multiplied alternately by 1 or 3, with the last number being weighted by a 3. (i.e weight from the right) The weighted numbers are summed and subtracted from the nearest multiple of 10 that is equal or higher. Get groups working on representing this as a series of mathematical statements, first in words then using symbols.

Example: for code 4006381333931 the check code is:

first 12 digits of code	4	0	0	6	3	8	1	3	3	3	9	3
weights												
multiplied by weight												
sum												

The nearest multiple of 10 that is equal to or higher than the sum is 90.
90 - 89 = 1. This will be the last digit of the barcode.

The reason for saying that the *last* number must be a 3 is that some barcode systems (other than EAN13) have more or fewer digits. In these cases you count the digits backwards from the right to determine whether to begin with a x3 or x1. (So it follows that a code with an even number of digits starts with a x1 weighting but an odd number of digits starts with a x3 weighting.)

POSITION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
WEIGHT	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3
CODE											7	3	5	1	3	5	3
SUMS											21	3	15	1	9	5	9

The sum from this barcode is then 63. The nearest multiple of 10 is 70.
63 mod 10 = 3
10 - 3 = 7
(or 70 minus 63 = 7)
So 7 is the checksum
So the complete EAN 8 code is then: 73513537

You could ask children to collect examples of e.g. EAN8 barcodes and say why they think certain products have a bar code with fewer numbers (It is a system primarily designed for small products like chewing gum or cigarettes where the packaging simply does not have room for a longer number!)

Barcode Sums

Ask each child to bring in an item with a barcode. Ask them to calculate the control number and use the actual last digit of the barcode printed on their item to check if their answer was right. Ask them to make a record of the control number. Then ask them to hide the control number e.g. by blacking it out with a pen. Then they can swap their barcoded item with a friend and see if they can work out the hidden control number. You can also do this in groups where everyone records their control number before blacking it out and then all the items are put in the middle and everyone has to complete the sum.

Another variation that we quite like is that the teacher takes in several pairs of items e.g. 2 identical tins of beans, 2 tins of sardines, 2 packets of sweets etc. Black out the control number for one of each pair and distribute these on each table. (You need at least one item per table). Let them work out the control numbers and write it on a piece of paper. Put the other items of the pair in a row on the teacher's desk with the control number visible. As soon as they have finished, they can run up and check their answer against the same item on the teacher's desk. Make sure that one of the items is a tube of Smarties which can be used as a 'reward'! (recording their answer on a piece of paper ensures they are not cheating!)

You can either do this as a speed competition to see which group can do it fastest or, to give them more practice, as soon as they get an answer, they give their item to the next group and start again.

How do control numbers identify scanning mistakes?
Ask them for any suggestions as to how they think control numbers can check for errors. Then give them a problem to solve e.g.

- *Supposing there was an error such as an '8' being read as a '3' – what would happen? Check this out with a real life example.*
- *Supposing 12 got read as 21 – what would happen?*
- *So what are the black lines above the numbers?*

Explain that the numbers are represented by the long black lines above them. The lines are the same length except for the longer pair at either end and in the middle, which just tell the scanner when to start and stop 'reading' the bar code. Each digit from 0-9 is represented by a series of lines of different thicknesses.

There are 95 lines in a standard bar code. Ask why they think all these lines are needed? The answer is because each number has to be converted into binary.
If you have worked with binary numbers, you could ask each group to write the numbers 0-9 in binary then add up all the 0's and 1's.

To finish, watch a video[122] on how barcodes are read.

On Line Maths Glossary

In order to encourage learners to use maths terms consistently, appropriately and accurately, creating a glossary on a wiki can be really helpful - just researching terms and definitions means they will have to use the terminology! Discussing the quality and appropriateness of entries will also improve their understanding and use of terminology in general.

You can organise this activity in many different ways:

- Each group of learners has a letter/letters of the alphabet and they are responsible for all terms beginning with that letter.
- Give specific terms to learners (great way to differentiate) e.g. "Emily, I'd like you to write a definition for Algebra. Pierre, can you find a definition for Addition?"
- Learners choose terms and definitions they find difficult to remember. These then become their 'Target Terms'.

  a - algebra, abacus, arc
  b - binary, base ten, brackets, binomial
  c - chord, co-efficient, co-ordinates etc

If you get stuck there is a very good kids mathematics dictionary[123] on line. (Hint: don't give anyone 'j' unless you REALLY want to challenge them!)

When the class bank of terminology and definitions is ready, introduce them to wikispaces[124]. It's easy to register and is free as long as you opt for the basic version. If you'd like to show them an example or 'One I created earlier' feel free to use ours[125].

The tour given on registration is fool-proof, learners will find their way around in minutes. Encourage learners to upload images and video files as well as text especially for particularly tricky definitions.

Alternatively, if you prepare a list of target terminology you can tailor the lesson to your own requirements so you may decide your class will create a glossary of terms relating to a specific area of learning e.g. angles.

122 *http://youtu.be/e6aR1k-ympo*

123 *www.amathsdictionary-forkids.com/dictionary.html*

124 *www.wikispaces.com*

125 *http://e-glossary.wikispaces.com/*

If you do not want Wikis to be open to comment by everyone on the web, leave the permissions settings unchanged. If you want other people, or the learners themselves to access the glossary (e.g. for homework purposes) you may want to change the 'permissions' settings. To do this click on 'Manage Wiki' in the right hand menu, then click on 'Permissions'. You'll need to apply for verification, this will only cost you $1. This only needs to be paid once, and when you've been verified all your future Wikis will be open to having their permissions changed. If you do change the permissions settings, check in regularly to review any comments that may have been left.

Ideas for Timelines

Use Dipity [126] TimeRime[127] or Tiki-Toki[128] to build multimedia timelines which integrate text, images and videos. Some ideas are;

- The historical evolution of the ideas (models) regarding atomic structure.
- The historical evolution of the concept of a cell.
- The main geological and biological events of different geological eras.

Making timelines are particularly good for understanding relative time periods.

10 Days of Maths Tweets

In a period of, say, ten days, ask each student to tweet one question relating to maths. (#10daysofmathtweets). The content of the tweet should be a picture (taken somewhere in the student's neighbourhood) with a question. For example, there could be a photograph showing an incorrect reduction on an item on sale *"30% off - original price £60 - sale price £40"* (depressingly common!) and the question "What is wrong?"

Or the photograph could show a doorway with an arched window above it and the question could be "How much glass (in m2) was needed?" Or a picture of a 1L soft drink bottle and a pint glass with the question "How many glasses will this fill?" etc.

Students have to answer all the questions and email them to you by a specified time. After this time has elapsed, the student who asked the question can tweet the answer. You can also add to this idea by asking each student to upload an explanation of their answer onto Google Docs thereby creating a database that others can use, for example, as an exam revision aid.

If you need a warm-up or some inspiration for your students: video "the Born Numeracy"[129]
or watch Tom Lehrer singing "That's Mathematics!"[130]

Maths Scavenger Hunt

Split the class into groups and send them out with a digital camera to "collect" pictures on a preset list of themes
e.g
- an example in the built environment of an acute and an obtuse angle.
- a helix.
- a Fibonacci series.
- an ellipse - or any other conic section you like. (yes, with a camera you can reward 'cheating' if someone photographs a round object at an angle!!)

126 *www.dipity.com*

127 *www.timerime.com*

128 *www.tiki-toki.com*

129 *www.googolpower.com/content/free-learning-resources/videos/mental-math-strategies*

130 *www.youtube.com/watch?v=2VZbWJIndlQ*

131 *http://htwins.net/scale2/*

Obviously, you adjust the items to be scavenged according to the age and experience of the group or the topics you are covering.

Maths in Nature

A variation on the above theme is to give the groups a video camera and take them on a nature walk looking for mathematical patterns. Then allow them to add photographs of fruit and vegetables. Get them to do a voice-over or add titles to explain e.g. the fractal patterns of branches in trees or the bilateral or radial symmetry in different fruits or how often the same 5-pointed 'star' pattern appears.

How Big?!

Look at the fascinating Scale of the Universe[131] interactive presentation for inspiration then have your class use Prezi[132] to create their own digital collection of photos from e.g. 10^{10} to 10^{-10}. To replicate the effect, start with the largest object and then zoom in each time you paste a picture of a smaller object. Dont miss the powers of ten video[133] from the 70's on the Scale of the Universe website.

A Matter of Magnitude

Compare the effects of a digital and optical zoom on different digital cameras - use to explore ratios and exponentials. Find out about the 'resolution' of digital images. What does this mean? Is there any point in having high resolution images if you are only going to look at them on a computer screen? How does this relate to the number of pixels? What does the term dpi mean? Why do we need high dpi for printing pictures but not for viewing on a screen? Learners can collect their findings on ThingLink , which allows you to take an image and add hyperlinks to different parts of it.

Use a free mosaic program such as Mazaika[134] to create a picture composed of lots of smaller pictures. Measure the distance that different people can 'resolve' the picture.

Collect some old pairs of spectacles. Find out about short sightedness and long sightedness. Sort the spectacles into two piles according to whether they are magnifying (long sighted) or diminishing (short sighted) lenses. Let pupils wear the spectacles and look at the mosaic pictures. Does the distance at which they can resolve the picture change. Try holding the lens in front of a digital camera lens and take a picture. Can they work out what a long sighted / short sighted person 'sees'?

You could also have a look at Pointillism and check out the size of the 'dots'. How far away from the picture would you stand? Is there a difference between people who are normal/short/long sighted? What are the differences and similarities between the Pointillist techniques and pixels on a computer screen?

Maths History

Ever had students who wondered why we always use the x as the unknown? Here's the answer on video[135]. It's just a nice lesson starter or something to end a lesson with.

Maybe this is the chance to go and look for some other maths history? We found a great website[136] with lots of things to do. It also has a daily tweet about a mathematician of the day.

132 *http://prezi.com*

133 *http://scaleofuniverse.com*

134 *hwww.mazaika.com*

135 *http://archive.org/details/TerryMoore_2012*

136 *www-history.mcs.st-and.ac.uk*

Another nice idea concerning maths history is to put a quiz question on your school website once a week and see if your students can find the answer, you could make it into a competition. Theare are lots op applications to make quizes[137]. See some examples we prepared on Pantherlife[138] and on ktb.net[139].

My Life in Numbers

My Life in Numbers[140] displays real-time calculations using interesting statistics, fun facts and fascinating numbers. The website measures all sorts of events in many different ways. For example the amount of Google searches since the beginning of the day or since the beginning of 2013 or the amount of breaths an average person has taken since Christmas. Also some fun stuff e.g. David Beckham's earnings since the end of 2012 - prepare to be horrified.

Start off by displaying the website on a screen and just let students comment. Then ask them to write down a number and then write down the number in the same category one minute later: how much did it go up? how much did it increase in %? Can you estimate what the number will be in one hour? Look at the number one hour later. How good was your estimation? How wrong (in %) were you? Follow a category for one week at regular intervals and make a graph with the numbers. This can be a starter for linear and exponential growth and an opportunity to practice reading large numbers. It is also an opportunity to practice calculations (if you think this is important) with very large or very small numbers.

You can also create your own personal events like how much your hair has grown since you got out of bed (use 'customise'/'my body' tabs). Then, depending on the age and experience of the student, get them to choose another aspect of their lives and write a set of procedures to calculate this. e.g the amount of time they spend sleeping / watching television in a year or the average per minute. Use a computer to work it out.

ALGEBRA AND GRAPHS

Sketchometry

This is a brilliant new free tool by the Maths department of the University of Bayreuth. It enables users to create geometrical forms using gestures. If you have a tablet, you can use your fingers to create perfect circles, parallels, tangents etc. Check out the videos[141] and their website[142].

Presenting... Pythagoras' Theorem

The following scenario is one that will be familiar to many teachers.

"There is a big party in our town and our school has to decorate the streets. We want to hang bunting from the ground to the top of the clock tower. We know that the distance from the point at which we want to anchor the cord on the ground to the base of the tower is 20 metres and the height of the tower is 15 metres. Before we are allowed to purchase the bunting we have to convince the School treasurer of the length of bunting required."

137 *www.edudemic.com/45-tools-create-quizzes-polls-class-room/*

138 *https://pantherfile.uwm.edu/adbell/www/Forms/histquiz.html*

139 *www.ktb.net/~cct/geom/trivia1.html*

140 *www.mylifeinnumbers.co.uk/My_Life_In_Numbers.html*

141 *www.sketchometry.com/help/videos/*

142 *www.sketchometry.com*

To bring this problem up to date using technology, divide the class into groups and ask them to make a presentation to the school treasurer using a video to show how they have calculated this using Pythagoras' Theorem. They could use models or go out into the street and use film of the real building. Or they could use an animation program like Creaza or Moovly or make a stop motion video.

To add interest, you could give two or three groups a different scenario (e.g one group could be builders setting out a rectangular building, complete with hard hats and high visibility gear if you like!) and keep one group to be the 'judges', awarding marks for 'technical merit' or 'effective presenting' or 'creative use of technology' etc.

See if your class can do a better job than the example video[143]. There are also some interactive practice questions[144] you may find useful.

You could also ask them to make a right angle triangle using nothing but themselves - assuming most pupils are about the same width, have groups of 3, 4 and 5 pupils standing with their arms around each other's waists as the 'sides' and let them shuffle around until they make a triangle. Make a video and measure the angles. Chaotic and great fun!

By the way, if you are beginners at making videos, use an instant editing program such as Animoto or Magisto. These are free online apps that allow you to make very slick videos by just uploading your clips, choosing a theme, selecting some music, adding captions and the programme does the rest. Pupils get a real buzz from seeing their work look so professional.

Graph Reading

Use Google Ngram Viewer[145] to link some common facts or history to graphs. With this website you can search for the relative frequency of any of the words within the 5.2 million books (from the last 200 years) that Google has access to. You just put in the words (for example radio, television, internet) and watch the graph appear.

Another Google website that is great to do exercises like this with is the Google Public Data[146] Explorer. You can put in two variables (X and Y axis) and it generates the graph. Maybe you can efface one of the axis titles and let students comment. Also interesting questions like "Is adult literacy a good indicator of life expectancy?" can be discussed.

Yet another interesting website for graphs and numbers is NationMaster[147]. With this website you can compare two (or more) countries on several variables. This is great for collecting data or maybe trying to make some predictions on chosen variables and countries. There is also the possibility to see a map with the results and it also calculates correlations.

Mathematical Mobiles: Equations can be sweet!

Explaining to learners that graphs can represent both flat and 3D objects is a perennial problem. This is a personal favourite - in theory I'm sure I could have done it in the pre-computer era but it's so much more fun with the graphic capabilities of current software. Firstly you need to download an app which will display surface graphs. There seems to be far more choice and better apps available for mobile devices, which is why we are recommending using a tablet - or anything you can connect to a projector or interactive whiteboard. We are not going to recommend one because there are so many and it will depend on whether you are using ios, Android, Windows etc. Just go to your usual app store and look for one with lots

143 *http://youtu.be/8R8b4NelWN4*

144 *www.ixl.com/math/grade-8/pythagorean-theorem-find-the-length-of-the-hypotenuse*

145 *http://books.google.com/ngrams*

146 *www.google.com/publicdata/directory?hl=en_US&dl=en_US#!*

147 *www.nationmaster.com/index.php*

of stars in the recommender system and which is free (or cheap!). For what it's worth, we use Graphly[148].

Type in the equation for an ellipse. Then show that by making the values of x and y the same, it becomes a circle. Add the same value of z and demonstrate the surface graph of a sphere. Then briefly show that by changing the values, the sphere becomes an ellipsoid. Magic!

Give the students some clay or Plasticene - let them mould it into the shape of the ellipsoid. Set up a challenge - as you increase or decrease the values of the variables, can they squish and stretch their clay to make a new ellipsoid which approximately represents the surface graph? Can they describe the changes without using any mathematical terms? Is it thicker /flatter / thinner / fatter /rounder/longer etc?. Check it out on the app and see how good they were at predicting the changes. (You can also do this without Plasticene and just get the class to predict the changes verbally - but not so much fun!) Make sure you use values of variables that generate laminate shapes as well as enclosed spaces so that they can see the difference.

Depending on the age and ability of the class, you can do the same exercise for a cylinder, a ring, sine and cosine curves etc.

We had great fun equating the shapes to sweets, which generated questions such as 'what is the surface graph for an M&M / Malteser / Polo Mint / Smartie / Revels / Minstrels etc.?' and we used real sweets as rewards for identifying the sweetie equation! (NB the actual values of the variables don't matter - it's the right relationship between them that gets them a prize!)

Then get them to reverse the process and make an ellipsoid and guess what the values of the variables might be compared say, with others in their group. Then do the same for any other quadric surfaces they are studying. Let them photograph their 'models' and make a Pinterest[149] board. Write the equation underneath the photographs.

Then move on to just displaying any (e.g conic) equation and let them make the shape before showing them the computer generated version. Or set up a group competition - one group makes models, another group writes the equation and vice versa. Use the app to check the 'answers'. Or create an image of several models with their name and equation underneath and load it up onto Jigsaw Planet[150]. Challenge each other to complete the jigsaw.

Finish off by adding pictures to your Pinterest board showing constructions in the real world that are based on the graphs they have studied (e.g hyperbolic paraboloids often used for sports stadium roofs, sine curves for corrugated roofs, vacuum cleaner tubes etc). Write what they are below the picture together with the general equation.

Playing with clay all sounds a bit juvenile but teenagers actually love it and being able to (literally) 'feel' equations is a fabulous way of introducing calculus and also providing an answer for the perennial question "But what *is* the point of calculus?"

148 *http://graphly.me*

149 *www.pinterest.com*

150 *www.jigsawplanet.com*

Treasure Hunters

Give each group a list of items to collect from around the school or local town - like a treasure hunt. See which group can complete it in the shortest time. Using Google maps or a mash-up application like walkjogrun.com they should record their route and place markers where the items were found, calculate the distance travelled and record the time taken, they could also work out average speed.

Line and Path Maths

Estimating is an essential skill in maths and science and one that is actually threatened by the continued use of calculators and digital measuring instruments. Turn the tables and use the Line and Path measurement tools on Google Earth (click on the ruler on the top bar) to estimate distances and areas.

Find a regular shaped feature on a map to start with – say a local football pitch – and ask pupils to measure it using the line and path function. From there they can go on to work out the area.

Once they have got the hang of it, you can do all sorts of things.

- Find out how far they live from the school. If they walk to school, ask them to estimate the time it takes them and calculate how fast they walk. Compare the costs and time taken to perform the same journey by bus, taxi or on a bike.
- Use GE to get approximate measurements of local geographical features.
- Add complexity by measuring an irregular shape – such as a park – and get them to work out the approximate perimeter and the approximate area by splitting the shape into other regular shapes they are able to calculate. (Tell them it is useful to do a rough sketch of the shape first to decide have they are going to divide it up.)
- Use it to look at the ratio of green space to built up areas in a given area as part of an environmental project. Or calculate the amount of woodland or arable land.
- If they are old enough to be able to triangulate the shape then they should be able to calculate the shape just using the path function on GE to get the perimeter.
- Do the same thing with upper secondary children using calculus!
- Find towns or cities covering the same area and check out whether their populations are different – suggest reasons why.
- Find out the length of the sides of a square that has an area of one hectare and one acre. Find a piece of land they are familiar with and draw a hectare and an acre side by side. Encourage them to visualize the relative sizes.
- Guess the number of hectares / acres of particular fields and check them out with the path and line function.

Tesselations and Mesh

Rather than just collecting images from the web – go on a maths walk with a digital camera and take pictures of tesselated shapes – you could combine this with a project about the local town or neighbourhood and look for brickwork patterns, tiling, paving slabs, cobblestones etc. When you get back, print them off as a wall display then load them onto Flickr [151]as a 'collection'.

151 *www.flickr.com*

Using simple image manipulation software, turn them into black and white images and see how many coloured crayons they need to use to colour the shapes in so that no shape touches another of the same colour.

Get learners to design their own tessellated patterns and add to an online gallery.[152] Or check out one of the many website devoted to tesselation activities with children.[153]

Have a look at Escher's tessellated drawings and, while we are on the subject of Escher, there is a marvelous interactive game for iOS devices[154]which takes you on a walk through all sorts of impossible perspectives. See if your class can explain WHY they are 'impossible' in 3D but not in 2D.

Find out how 3D computer models are created and what a 'mesh' is. Use a plastic net (like the ones nuts or fruit are sold in) and stretch it over a sphere, your arm, a soft toy…..take pictures of the results or draw them.

152 *www.tessellations.org/send-in-your-tessellation.shtml*

153 *www.tessellations.org.*

154 *www.cnet.com/uk/news/monument-valley-an-interactive-mc-escher-print-that-will-blow-you-away/*

155 *www.surveymonkey.com*

156 *http://friend-wheel.com*

157 *www.weebly.com*

STATS, PROBABILITY AND DATA HANDLING

One of a Crowd

Use crowd sourcing to survey almost anything. Post a question on Twitter or in the class blog and collect the responses as @replies or blog comments. Are the responses reliable, valid, skewed etc?

There are lots of free online tools for generating a more detailed survey. Have a look at surveymonkey[155] for a lazy alternative to marching around your local town in the rain, or why not try both approaches and compare the results?

There's a nice graphic tool, Friend Wheel[156] which displays every friend you are connected to via facebook and connects each of them to their connections to produce a very pretty wheel. Use the online example or scroll down and click on the "see your own" link to illustrate how your crowd sourced question reached people.

Maths with No Symbols!

Create a webpage that explains basic statistical concepts such as measures of central tendency, standard deviation, sampling, randomisation, significance levels etc. The webpage should not use any mathematical notation at all and should explain the concepts so a general audience could understand. We like Weebly[157] - it's free, very easy to use (drag and drop) and has a blogging engine. Bonus points if you make short 30 second animated YouTube clips that explain the concepts.

Sports Stats

Choose a sport that your class is interested in. In our case, that was rugby football. Find a video of a recent high profile game. Make a list of some of the statistics that analysts use e.g. possession, territory, average weight of players, lineouts won, metres gained etc - whatever is relevant to the sport you have chosen.

Divide the class in half. Each half is responsible for a different team. Divide the

halves into smaller groups. Each group will be responsible for recording particular elements. You can differentiate the class fairly easily so, for instance, a lower ability class could use the web to find the weights of the players and average them. The more able groups could record 'territory' or 'possession'. You will need stopwatches (or data loggers if you have them).

Play the video (always very popular!) and get the individual groups to collect the data. Then enter the data into Excel and produce pie charts - just like they do on TV!

There will be a massive debate because obviously the results of one team should be the reverse of the other - except they never are.

Presenting Data

Use Gliffy[158] to create flowcharts, organisational charts, network diagrams, wireframes and technical drawings. Gliffy runs directly in your browser and is easy to share.

Set the challenge of creating a school organisation chart, a flowchart for a simple decision making task such as what clothes or equipment to take to school on a particular day, a friendship diagram etc. Use it to create branching diagrams and simple phylogenetic trees. Students can check each other's work to ensure they are correct.

3D Stats

Divide students into pairs and locate one of each pair where they cannot see what the other one is doing. This could be just sitting with their backs to each other or located in different parts of the room or in another room entirely.

Each person will need a table or tray in front of them. Alternatively, because it's a bit messy, it works well outside on the yard with each pupil chalking a half metre square in front of them. Give both of them a plastic washing up liquid bottle with the bottom cut off and the top nozzle removed to make a funnel and half fill with sand. One of the pair lets the sand run out onto his/her table in a pile. They then have to tweet to their partner sufficient information so that their partner can replicate the pile. They can send as many tweets as they want and their partner can tweet back questions - e.g How far from the edges of the square/table is the pile? Is it a flat pile or a cone shaped pile? How steep is it? How spread out is it? Has the pile of sand got a round base or is it irregular? Is the highest point of the pile in the middle or offset?

Introduce the idea that each grain of sand is an item of data. Help pupils understand the idea that collections of data can be visualised in 3D not just represented as 2D graphs and charts. Talk about measures of central tendency, about normal and skewed distributions, about axes and about standard deviation and use different sand piles to illustrate the concepts.

Take pictures of the piles of sand and add them to a Pinterest board or a Glog and describe the pictures using statistical vocabulary. Alternatively, use Animoto[159] to create fabulously professional-looking videos to present their findings.

Living Graphs

Ask each pupil to establish some numeric fact about themselves (height in inches/cm works well). Clear a space on the floor and put some masking tape down with

158 *www.gliffy.com*

159 *www.animoto.com*

values written on it (like the axis of a plot). Get them to line up next to their value. One student climbs up on a desk/ladder (do it yourself if health and safety is an issue for you) and uses a digital camera to take a picture of the living histogram.

To enhance this basic idea, get the students to video the whole process. It works even better outside with a ladder or in the gym with one of the more athletic students (or staff members!) climbing up the wall bars. Get them to count off from each end and put down a tape where they meet in the middle (the median), then do the same for each half and put down tape for the quartiles. Then get the students in the interquartile range to wrap another tape around their waists (i.e. around the whole line of them) and then carefully lower that to the floor. Let the students outside the interquartile cut a new piece of tape to length and add the whiskers. Finally get them to step away to see the boxplot remaining on the floor. If there are enough students you could have them do this separately for boys and girls and compare the boxplots. Edit the video and insert captions showing the mathematical expression for each step. (Use easy video editing software such as Animoto or Magisto if students are not experienced with editing in IMovie or Movie Maker - see above)

Alternatively, make a simple stop motion presentation. Take still pictures with a digital camera of every stage. Get the pupils to select those that illustrate the mathematical process clearly. Add them to a powerpoint presentation, put in the captions. Practice using a program which allows you to use mathematical notation to do this. (Try the free version of MathMagic[160] or the insert equation function in Google Docs[161]) Upload it to slideshare and add a voice over. Play the finished presentation as a slideshow with automatic transition between each slide - adjust the speed until you get the right effect.

Make it harder by using hair colour instead of height. Is there a normal distribution or a skewed distribution?

160 *www.mathmagic.com*

161 *www.openeducation.net/2011/02/01/free-software-for-writing-mathematical-equations-in-a-word-document/*

Teching up the kitchen sink

"Imagine you could draw musical instruments on normal paper with any pencil (cheap circuit thumb-tacked on) and then play them with your fingers. The Drawdio[162] circuit-craft lets you turn your everyday objects - paintbrushes, macaroni, trees, yourself, even the kitchen sink - into musical instruments:"

You can either buy your Drawdio ready made or make it yourself from a kit - a great project for students but watch out as some of the components are a little bit fragile. Once they've had an opportunity to experiment with it, ask them to create a Glog, Moovly video or an infographics poster instructing others on how to set it up and use it.

You should also check out MakeyMakey[163] - the best bit of kit EVER! It is a credit card size PCB that lets you turn almost anything into a keyboard by hooking up the holes on the makey makey board to anything which conducts electricity just using bulldog clips. Makey makey then connects to your computer with a usb connector. Basically, the Makey Makey board can control the bottom 8 keys on your keyboard plus the arrow keys. This means you can play most simple games (e.g pacman) by making your controller from playdoh, grapes or even drawn on paper with a soft graphite pencil. It's also good for musical instrument apps - means you can make pianos out of bananas or by stepping on foil circles or jumping barefoot in plastic bowls of water.

Both ridiculously fun for all ages!

Bridges for Animals

Set students a scenario. It can be real or imagined. We like the following transcript taken from a news report on the radio:

"As towns, cities and the infrastructure associated with this growth spread across our countryside, the threat to wildlife increases. This is not only the loss of habitat but also because populations become isolated from each other by busy roads, railway networks and other developments. In recent years, there has been an increase in the creation of 'wildlife corridors' such as toad tunnels, hedgerow highways and bridges for animals!

You could also give them articles from your local press, like this news article[164] about bridges for dormice in Wales.

Their task would be to pitch their idea to the local council for a bridge across a busy road designed specifically and for the sole use of wildlife. The bridge must be strong enough and the model they create must have a width of 15 cm, a length of 50 cm, a height of 15 cm.[165] There are no pillars under the bridge allowed - so no pontoons! The only materials they will be given are old newspapers and one tube of glue.[166]

162 *http://youtu.be/PV_w38ldZaE*

163 *www.makeymakey.com*

164 *www.bbc.co.uk/news/uk-wales-south-east-wales-11082007*

165 *www.eduweb.com/portfolio/bridgetoclassroom/engineeringfor.html*

166 *http://bridgecontest.usma.edu/*

Tell learners should plan and make a video (10 mins max!) to present their bridge. They should also compile a digital portfolio to store all the relevant information regarding their proposal. They only have four hours, working in groups of 4, to complete the task so they must delegate task early on. [167]Encourage learners to find and use simulation software, case studies, graphical representations, website with more information about the subject as well as sites such as Padlet to collect ideas and Wikispaces to keep digital logbooks.

Flying Forces

This software gives learners a general overview of what is entailed in the design of aircraft. Learners will be need to apply aspects of design, technology and physics to be successful.

Split learners into pairs. Give each pair a piece of A4 paper. Tell them that they have a maximum of 10 minutes to build a paper aeroplane. Explain that they can build any kind of plane in any way they choose but they are not allowed any other materials. Also, they are not allowed to test their aeroplane before they are told to do so.

Create a list of success criteria that can be used to measure the success (or not!) of the test flights then let each pair test their model in front of the class. Compare each model's flight against the success criteria.

It would be a good idea to discuss the basic forces at work on the aeroplanes e.g. drag, gravity/weight, thrust and lift. Be sure to do this in the context of each force having an opposing force and that forces can be equal or unequal.

On the interactive whiteboard, introduce the online programme[168] they'll be using. A quick tour of the wings, engine and fuselage options is advisable. Then allow earners time to design their plane.

When they are ready, tell them to test their airplane by clicking on the 'see it fly' tab. This can be great fun as the planes can career off screen, crash on the island or end up in the sea! Following their test flight, they are given a report on the strengths and weaknesses of their design and reason why it did or did not work. Allow them to amend their design and to keep on trying until their plane flies well!

This software enables learners to experiment with the key components of aviation design and enables them to 'build' their own plane and test it, which is impossible to do otherwise.

During the design process, you may want to ask them to turn the volume down their computers as having the background music on constant loop on multitudinous computers is *very* irritating (for the teacher, that is, kids don't seem to mind!)

Legobots

There is a lesson plan on the Taccle2 website using real lego 'nxt' kit to make robots. We appreciate that the cost of the kit may be prohibitively expensive but there's a virtual demonstration available[169] to use for whole-class teaching and, assuming you may want to invest in one demo kit, groups can later work in turns on the real thing. The online activity lets you program a virtual robot so that it moves towards a target and fire missiles at it. We have experimented with these kits and they are great fun. Whether or not you think the investment is worth it, is entirely personal.
There's another interesting website[170] where you can find and share ideas for

167 *www.engineering.com/GamesPuzzles/BridgeBuilder/tabid/5172/Default.aspx*

168 *www.ge.com/thegeshow/flight/#ch2*

169 *http://us.mindstorms.lego.com/en-us/Software/Default.aspx*

170 *http://community.legoeducation.us/blogs*

using lego in school. You could also have a look at Bricx Command Center, open source software which allows you to program elements in a programming environment very similar to C language programming.

Small Scale Construction

Students use a free trial of Tinkercad[171] or other CAD software to design a simple item. They then work in small groups and create real life versions of their models to scale using LEGO blocks, Plasticine or clay. They can choose to scale their design up or down depending on the design. Take photos of your completed projects and share them on a photo-sharing site such as Flickr.

If you have any money to spend, check out the 3D printers that are available. We have reviewed the bottom end ones on the Taccle2 site.[172] It is perfectly possible nowadays to get a 3D printer for about £200. If you are feeling particularly adventurous you might like to check out Reprap[173] which is an initiative to develop a FREE 3D printer capable of printing it's own components! If you go down this road, students will be able to actually print 3D copies of their designs too. On the topic of 3D printers, if you are not convinced, you should really have a look at Blockify[174], the best 3D printing idea ever!

Reverse Design

Post pictures of a technical systems (e.g. microwave, thermometer, mobile phone…) on Padlet[175] along with questions about the design criteria. For example the following questions would help to define the criteria for a corkscrew:

- • *What does it look like?*
- • *Describe the user characteristics.*
- • *What criteria does the object have to fulfil in order to prove that it is a corkscrew?*
- • *What was the designer's original brief?*

Ask students to post their answers to the questions on the wall. Use a different wall for each object and/or question.

My Technology Book

Use a blog or an e-publishing tool such as Storybird[176] or Glogster[177] to create an online reference-book. Pupils can record what is learned in class about technical principles like *gear and belt drive systems, electrical circuits, energy, textiles technology, food hygiene.* Ask pupils to enhance their notes by hyperlinking key words to videos, diagrams and definitions. An easy way of doing this is to use ThingLink[178], which allows you to add hyperlinks to images. There is an example on the Taccle2 website.[179]

They should also film any demonstrations and embed the video into the blog or e-book. This could be a collaborative class effort or each pupil could create and maintain a personal technology e-book.

171 *https://tinkercad.com/*

172 *http://taccle2.eu/news/i-want-one-of-these*

173 *http://reprap.org/wiki/RepRap*

174 *http://taccle2.eu/stem/blokify-best-3d-printer-idea-ever*

175 *www.wallwisher.com*

176 *www.storybird.com*

177 *www.glogster.com*

178 *www.thinglink.com*

179 *http://taccle2.eu/news/thing-link*

OVERARCHING PROJECTS

There are two lesson plans here for cross-curricular projects to give you an idea of how you might make this work for your school. These are also useful for gaining insight into how other teachers integrate e-learning into their lessons and how they structure their lessons plans accordingly.

Nanotechnology

OVERVIEW
In this project, students use web 2.0 tools to debate the uses of Nanotechnology. In groups, the students should decide which of the three, very different, research projects that have applied for the funding should receive it.. Only one project can get the funding.

DESCRIPTION
Each group should research three different nanotechnology projects. Provide the students with possible sources and encourage them to find their own. Some examples are: the Nanotechnology homepage of the European Commission,[180] the EIROforum[181] (a partnership between eight of Europe's largest inter-governmental scientific research organisations), the list of national research centres[182] and the EthicsWeb - a collection of websites that address moral and ethical issues[183].

For each nanotechnology project, students should upload a description to Voicethread[184] or Voxopop[185]. This could be a picture, presentation slide or paragraph of text. They should then use the audio recording feature to add comments explaining their reasons for and against each project. As with any group work, make sure everyone in the group has a role. You could give each pupil an individual topic to research and then put them into groups to discuss the pros and cons.

A variation would be use on-line debate mapping software such as Argunet[186] to evaluate the structure and quality of the groups arguments.

The Human Race

OVERVIEW
By investigating the most up-to-date scientific material about human evolution, learners are asked to use their researching, predictive and reporting skills to create a simple web-based thesis on the 'likely' future stages of human evolution.

DESCRIPTION
The teacher must decide how much initial information to provide but it is probably a good idea to discuss with pupils the basics of evolution in general terms to identify their previous knowledge, exchange information and challenge any false assumptions. There are some excellent websites which can provide a launch pad for discussion.[187]
Once learners have discussed the indispensable processes, ask them to gather images for 4 or 5 of our Hominidae ancestors. In their own words, and using software of their choice, they then place these images in sequence and write a description for each one. Each description should include a comparison with the previous ancestor and a description of the differences.

180 *http://ec.europa.eu/nanotechnology/index_en.html*

181 *www.eiroforum.org*

182 *www.nanowerk.com/nanotechnology/research/laboratories_alist.php?letter=N*

183 *www.ethicsweb.ca/nanotechnology/*

184 *https://voicethread.com*

185 *www.voxopop.com*

186 *www.argunet.org*

187 *www.sociologyguide.com/introduction-to-sociology/human-evolution.php*

Having done this, learners could then make a list of any patterns following their visual study e.g. increasingly upright posture, taller, less hair, smaller jaw etc.

Based on their findings, learners are then asked to predict how humans may evolve in future. In 10,000 year increments, ask them to create artistic impressions along with written descriptions of the next 2 or 3 stages in human evolution. Younger learners (or any learners if you want to have fun) could experiment with Build Your Wild Self.[188] It is whacky but very entertaining. It can also be useful if you want to discuss issues such as genetic engineering, the effects of environment on evolution or how humans may in future evolve on other worlds.

Unless your school has access to fairly sophisticated drawing software, ask learners to draw their illustration on paper before scanning them and uploading them to their online thesis. If you specifically want learners to present their thesis in a web page, check out Pagetutor[189] for a step-by-step guide to creating your own web page. An easier option would be to direct learners to Wikispaces[190] as we did with our primary school colleagues.[191]

To finish, ask learners to present their findings and theories. Ensure they give reasons for their theories. Treat it like a PhD viva!

188 *www.buildyourwildself.com*

189 *www.pagetutor.com/html_tutor/index.html*

190 *www.wikispaces.com/content/student*

191 *www.taccle2e-encyclopaedia.wikispaces.com*

RECORDING, PRESENTING AND SHARING RESULTS

We have collected some ideas which could be used in any lesson, they are summarised here but you can find full lesson plans on the Taccle2 blog.[192]

➤ *Storybird* [193]
This is a wonderful tool to create picture books for and with your students. All you need is to set up an account, which is free. You will act as administrator and be able to add students, invite them to collaborate or set assignments for them. Their work can be published, so parents and friends can appreciate them too. The best thing is the beautiful artwork by artists from all over the world which students are free to use in their own Storybird books. Students can also upload and use their own artwork.

➤ *Science Comics* [194]
We all know how much children like doing hands-on science and finding out for themselves how things work. Sadly, we also know that writing up their experiments according to very rigid criteria is guaranteed to dampen their natural curiosity and turn science into a chore. Our primary team came up with a novel way of recording science investigations by making a comic strip which is as much fun as doing the actual experiment. It works just as well for junior secondary school and, if anything, works even better because older students are able to get to grips with more functions and, therefore, create increasingly effective pieces of work.

We like Comic Life - a great bit of software that is really a must-have in any teacher's toolbox. We don't ordinarily advocate spending money on software but Comic Life is the exception – a teacher version is $19 for Mac or Windows, $4.99 for the iPad.

Pixton[195] is a very good free resource that can be used for the same purpose (get a personal account as you have to pay for the educator version!)

➤ *Vodcasting*
An alternative to the practical write up is to make a vodcast. Get your class to collect photos and videos during the different phases of the practical work. Use Movie Maker from Microsoft, iMovie from Apple or other available video editing software to combine these into a short Vodcast which can be uploaded to YouTube or Vimeo and embedded in your class blog. Check out a videoed experiment from Romania called Egg in a Bottle.[196]

➤ *Glogster*
Whenever you want learners to present information to others, why not get them to 'Glog' it using Glogster![197] This software is perfect for creating interactive posters, fact files, project boards or 'how to…' instruction sheets. It also serves as a good entry-level activity to blogging. Once you get the hang of it, you'll begin to see how endlessly adaptable it is.

➤ *Powerpoints*
Yes, we know you can all make a PowerPoint presentation but do your students get enough practice in making them too? Do you and your students use Slideshare[198] . Slideshare allows you to store presentations and make them available to others.

192 *http://taccle2.eu*

193 *http://storybird.com*

194 *http://comiclife.com*

195 *www.pixton.com*

196 *www.youtube.com/watch?v=IHEOVW1qn90&feature=related*

197 *http://edu.glogster.com/*

198 *www.slideshare.net*

The advantages are:

- it allows students to search other people's presentations as part of their research into both the content and presentation of a subject.
- many authors allow downloading and adaption of their presentations. Depending on the context and the attribution, you must decide if this is plagiarism, cheating, good research or intelligent use of web 2.0!
- Slideshare gives you a very easy way of adding a voice-over to your slides. The instructions on how to do it are on the site and your computer's built in mic will be fine as long as the room is fairly quiet.
- you can set up an account for your whole class to store their presentations which gives you a class library around particular topics.
- you can choose to make them private or public and kids get a huge thrill if they can see that someone else has 'viewed' their presentation and - even better - commented on it. Using the comment box is also a great way of the teacher giving feedback if you have set creating a presentation as homework.
- in order to upload a presentation onto e.g. a blog, you will need to 'embed' it in a post, which you cannot do directly. Slideshare automatically generates an 'embed code' for each presentation it holds. This is just a bit of html coding which you copy from Slideshare and paste on your website to link your site with the right page on the Slideshare site. Marvellous.

> *Prezi*

We love Prezi[199] and students love it too. Check it out and look at the demonstration. Imagine a huge canvas on which you can create your presentation and then fly from one part to another, zoom in on a video or image and click to view text or images you have added. Much more fun than PowerPoint.

> *Voki*

Voki can be used to create speaking avatars. The process of avatar creation can motivate students to participate in school activities and introduce technology in a fun way. Each student or group of students can use Voki[200] to present the conclusions of their individual or group research work.

To do that, students can:

· Create customised avatars.
· Add audio to each Voki avatar.
· Post the Voki to any blog, website or on line profile.

> *Pinterest*

Pinterest[201] is a social software tool for making collections of pictures from other websites - just like a giant digital pinboard. You can set up multiple boards each focussing on a particular topic and can choose to share these with others or keep them private.

199 *http://prezi.com*

200 *www.voki.com*

201 *www.pinterest.com*

MOBILE DEVICES

We promised in the Primary book that we would include a section in the STEM book about using mobile technologies. However, events seem to have overtaken us. For a start, most all of the activities that are described in this book can be done using a phone or tablet and a few can ONLY be done on a mobile device so we are not sure whether this warrants a separate section. There are so many websites and scoop.it feeds (including the one on the Taccle2 site) that focus on mobile technologies that it seems pretty redundant.

All we want to say is that we are total converts. Imagine if, instead of having to confiscate students' phones, you could use them to your advantage...Sound good? Well, with a bit of careful planning you could suddenly have the most well equipped, state of the art lab or classroom imaginable. Sure, the very thought of setting Ceri Morgan in Year 8 loose with a camera phone gives us nightmares, but we're talking about a controlled teaching environment here. We wouldn't set him loose with a pipette either but that does not mean we don't allow him to do experiments. Some schools are investing in class sets of tablets or iPads thus removing the issues around the 'haves' and the 'have nots'. If your school cannot afford to do that, it's a great shame to relegate all those cameras, video recorders, sound recorders, stop watches, QR code readers, digital compasses, gprs devices etc. to pockets and bags. There's a useful list of the pros and cons to consider[202] but, since this book is about ideas and inspiration, here are a few practical things[203] you could do tomorrow with a mobile device:

- Listen to science radio or download some science podcasts[204].
- Use the voice recorders to store short facts for revision, combine the audio files to make a podcast.
- Take photos or videos of a practical demonstration or of their own experiments as an alternative to writing up their methodology.
- Use polleverywhere[205] so students can text their answers or ideas to the white-board.
- Put QR codes on walls, doors, notice boards etc with links to more info, interesting videos, differentiated materials or instructions. Allow students to scan the codes with their phone or tablet (they will need to download a QR code reader).
- Tweet about their field trip as it is happening.
- Go on a nature / maths / science walk, take photographs and pin them to a Google map as you go.
- experiment with the 'flipped classroom'[206].

202 *www.pontydysgu.org/2009/11/25-practical-ideas-for-using-mobile-phones-in-the-classroom/*

203 *http://xyofeinstein.files.wordpress.com/2011/10/33_interesting_ways_to_use_mobile_phones_in_th.pdf*

204 *http://science360.gov/radio/*

205 *www.polleverywhere.com*

206 *http://net.educause.edu/ir/library/pdf/eli7081.pdf*

CONCLUSION

Together with the Taccle2 website and the Taccle2 training, this handbook is intended as a practical resource for STEM teachers in secondary schools. It has been based on feedback from real teachers telling us what they wanted - loads of ideas and minimal theory! We hope we have responded, at least in part, by providing suggestions, some instant activities and a stimulus to get your own creative juices flowing.

It was never intended to be a handbook about the pedagogy of e-learning and it is certainly not recommended to be used as a curriculum model. Even if this had been our intention it would be nigh on impossible to match the content with the curricula of every country in Europe. There are many excellent books that cover these issues. We particularly like Megan Poore's 'Using Social Media in the Classroom'[207] for a useful and easy introduction. This is a personal preference as it is very readable and provides a good follow on for any of you who want to take the next step.

If we were really honest, we don't actually believe that using e-learning in the classroom needs a special 'theory' of its own. There are innumerable theories about learning and teaching and many seem perfectly adequate and able to embrace e-learning without a problem. Nevertheless, we should recognise that ICT does offer opportunities that are not possible using traditional tools. This doesn't necessarily mean totally revolutionising what or how you teach - we hope this handbook has shown you that fairly simple adjustments can often have enormous impact on teaching and learning. We also believe that these 'adjustments' can increase the popularity of STEM amongst the students in your school - and that is part of an agenda shared by every country in Europe.

Moreover, any students wanting a career in any of the STEM subjects will need, and be expected to have, excellent ICT skills and although you may not be a specialist ICT teacher, you have a key role to play in developing pupils' skills and attitudes towards using technology for learning.

Teaching in the internet age means we must teach tomorrow's skills today. As Tim Berners-Lee said, *"The Web as I envisaged it, we have not seen it yet. The future is still so much bigger than the past."* Your pupils are part of that future. However, It is not just about developing skills but also about changing the way we think. It's the point that we, as teachers, stop saying, 'Hand it in!' and start saying 'Publish it!' instead.

Arthur C Clarke claimed *"Any sufficiently advanced technology is indistinguishable from magic."* We know where he is coming from because deep down we think it is too. However, the real magic rests in the hearts and minds of teachers using digital tools to introduce students to new individuals, new ideas and new opportunities. There are hundreds of thousands of new educational technologies out there but if teachers themselves are not able to bring them into the classroom and make them work, then they fail.

The teaching profession needs brave and innovative practitioners. To be up there with the best of them we need to understand the world our students live in and be willing to immerse ourselves in that world. We need to embrace the new digital reality. If we can't relate - if we don't get it - we won't be able to make schools relevant to the current and future needs of the digital generation. Less poetically, as Nigel Willets pointed out *"When faced with a steam-rolling technology, you either become part of the technology or part of the road!"*

You know and we know that STEM can be scintillating… there has never been a better time for us to prove it!

207 *www.uk.sagepub.com/books/Book236869*

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Koen DePryck teaches in the field of innovation in education at the University of Brussels and at ADEK University of Suriname. He is chairman of the consortium of Adult Education Providers in Antwerp where he is a centre director. He advises on education for the Organization of American States and publishes and lectures extensively on a broad range of educational topics.

Bruna Durazzi has a degree in economics and specialises in mathematics and statistics. She has been a teacher of mathematics since 1983 and is currently concentrating on applying ICT tools in the classroom to improve her teaching methodologies. She has had particular success in using ICT to improve teaching and learning outcomes with students with additional educational needs.

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Jeroen Hendrickx has taught Dutch to foreign adults in Antwerp for 10 years. During that time he has explored how education can benefit from technology. Since 2012 he has worked for CVO Antwerpen where he encourages and supports teachers who want to integrate technology in their (online) classrooms. Find out more on http://about.me/jeroenhendrickx

Jenny Hughes has been a mathematics teacher and teacher trainer for longer than she's prepared to admit. She is also a senior educational researcher, author and teacher trainer at Pontydysgu, an educational research and software development company based in Wales. Her interests include evaluation theory and practice, e-learning and teaching programming.

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Mario Procaccini has a degree in mechanical engineering. He has been a physics and science teacher for 30 years in higher secondary schools. He has been experimenting with different ICT tools within his classes with great enthusiasm!

Angela Rees has taught Maths and Science to 12 - 75 year olds in Wales since qualifying as a Chemistry teacher in 2005. She recently gained an MA in Special Educational Needs. Angela works for Pontydysgu creating e-learning content, researching practical applications for educational technology and training in the use of web2.0 tools.

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Anne-Marie Tytgat is an industrial engineer and pedagogical advisor for the Flemish secondary schools for technology education and for ICT-integration in education. She provides guidance and support to schools that want to develop a consistent approach to using ICT across the curriculum in order to ensure improved learner engagement.

Katleen Vanden Driessche teaches mathematics at CVO Antwerpen (second chance education) and works as a SEN teacher in a private practice. She has a special interest in the use of e-learning to support students with AEN in numeracy, mathematics and science.

Co-Ordinator:

Jens Vermeersch has an MA in history and an MA in communication sciences. He is an experienced manager of European projects in charge of the internationalisation department of GO! the official education of the Flemish Government in the Dutch speaking part of Belgium.

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Teachers are under increasing pressure to use Information and Communication Technologies to improve teaching and learning. But the gap between many teachers' appetite, competence and skills and the ever-increasing advances in technologies is becoming almost too wide to bridge.

TACCLE2: e-Learning for Teachers of STEM is a project funded by the EU under its Lifelong Learning Programme. We, the authors, are real teachers just like you and we've got the battle-scars to prove it! Our aim is to help other teachers enhance their current practice by providing support and guidance as they begin bridging the gaps that have, until now, prevented them from taking advantage of the educational opportunities that information and communication technologies have to offer.

This handbook contains around 100 e-learning ideas covering all aspects of maths, science, technology and engineering. As well as lesson instructions and quick and easy ideas, where appropriate you will also find activity support and advice on how to help you avoid any potential pitfalls. To accompany each activity, you'll find links to sites we've used, links to ready-made examples that we've found or created, links to online tutorials and links to other helpful websites!

There's no pressure, no hard-sell and certainly no lecturing. From the beginning we've been determined to create a resource for teachers written by teachers, the result of which is in your hands right now. So give it a go and let us know what you think at www.tacle2.eu. You'll also find 100s of extra ideas that could help you be an even better teacher than you already are!

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