Mathematical thinking across the curriculum for all staff
Success in mathematics and mathematical thinking is a national issue which affects young people in Bolton. It is clear that the causes of the UK’s under-achievement in mathematically based subjects compared with other countries are a complex interaction of many different factors. The impact of these factors on many of our children and their ability to succeed in mathematics is however very apparent.

Numerically we are a nation that believes that mathematics and numeracy are difficult. This gives pupils reasons not to engage and not to be persistent thereby helping to cause failure. We are trying to help address this problem through this publication.

This booklet is based on the view that mathematics (numeracy) is too important to a pupil’s future quality of life and life chances to be ignored. Despite the national problems, we have to start somewhere. One of the major areas of impact on a child’s life is the time spent in school; not just in mathematics lessons but in school as a whole. Therefore this booklet is written for everyone in school: teachers and all of the school’s supporting staff. The classroom based activities have been mainly supplied by staff at Mount St Joseph’s Business and Enterprise College. It is full of ideas to use in lessons. For the purposes of clarity of interpretation we take the modern view that treats the words ‘mathematics’ and ‘numeracy’ as almost synonymous. We have emphasised the word ‘thinking’ in the title to help people move away from the idea of mathematics as ‘number work’ to seeing mathematics as a much richer discipline.

For change to happen, the culture of the school’s approach to mathematics is vital. If the school has a coherent and well understood approach which all staff adhere to (even when they have doubts) then change can and will happen. The drive for change has to come from everyone: each and every one of us.

As effective work in mathematical thinking across the curriculum is dependent upon establishing and maintaining a positive culture towards mathematics, this will clearly involve strategic thinking about how this can be achieved. Alongside the strategic work being undertaken by senior leaders, the mathematics department and everyone else in the school should be working on strategies to improve pupils’ attitudes to mathematics. In the same way that they already help develop pupils’ attitudes towards literacy.

The issues are complex. However, small well planned incremental steps in a coherent direction can add up to significant progress, if everyone participates. This booklet is designed to help you understand why mathematics is as important as literacy and suggests steps which can be taken to improve pupils’ perceptions and their ability to be numerate.

We are very grateful to National Numeracy, an independent charity, who have allowed us to use the materials from their publications and from their website in preparing this document. They have significantly more material than we are able to include in the booklet and we would recommend their site to you. It can be found at: http://www.nationalnumeracy.org.uk/home/index.html

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Bolton Maths Project Board would like to thank the following teachers from Mount St Joseph’s Business and Enterprise College for their highly valued contributions to the development of this document:

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Mathematical thinking across the curriculum  
Bolton Council
Introduction

This booklet works on the principle that being numerate is a matter of choice. Attitude is important. The first part of this booklet addresses the issues related to attitude. The second part is about how mathematicians and other adults in school can promote good mathematical thinking in their lessons. For some subjects it is easy to see how an understanding of mathematical procedures is integral to the subject being taught. The sciences and business studies are classic examples. For other subjects like English or Religious Education numeracy is often more about mathematical thought processes rather than about number and procedures. Not every subject is listed in this booklet. Discussion with your mathematics department is the best way forward.

Section 1 Attitudes to mathematics

1. Why is mathematics / numeracy important?

Whilst learning the skills of basic numeracy, pupils rely on their learning in the topic of mathematics which is full of challenges. Those who learn mathematics easily enjoy:

- the clarity that is caused by application of rigour, exactness and precision to processes.
- effective working memories which adapt as the complexities of the subject deepen.
- an ability to learn and apply rules systematically.
- being creative in devising and testing new ideas within known parameters.
- compressing ideas quickly. A typical example of compressing ideas is when multiplication tables no longer are dependent on adding numbers together but the patterns are so familiar that they become a recall process.
- the ability to read both symbolic text and very ‘bare’ condensed text accurately.
- interpreting and processing abstract ideas in ways which often rely on compressed knowledge.
- using memory systems that are effective in retrieving information from a wide range of memory banks.
- spatial, visual, verbal and reasoning skills.
- logic.

Discuss:

Compare the skills needed to learn maths with skills needed in other subjects. Where are they similar and can be reinforced through the curriculum?
What does the latest information say about why numeracy is important?

### Distribution of adult skills in numeracy i.e. age 16 +

... England’s performance in numeracy was significantly below the OECD average. There were 15 countries that significantly outperformed England and five countries that England significantly outperformed. The highest performing countries in this skill included: Japan, Finland, Flanders (Belgium), the Netherlands and Sweden.

... In England, 17 per cent of adults had low proficiency in literacy, 24 per cent had low proficiency in numeracy and 18 per cent had low proficiency in problem solving. ... a statistically significant higher proportion for numeracy (compared to OECD averages).

... England had a relatively large difference between the score points of the lowest scoring adults and the highest scoring adults compared with many other countries.

... Men scored significantly higher than women, which was the case in every country which participated in the study. England’s gender difference was higher than the OECD average.

... The patterns for educational attainment, employment status, country of birth and mother tongue were similar to those for literacy, but in terms of ethnicity, those people of Black/Black British origin were more likely to have scores clustered at the lower levels of achievement.

... Surprisingly, speaking English as an Additional Language was also not associated with low literacy and problem solving, although it was associated with low numeracy.

... There is a clear relationship between salary and literacy, numeracy and problem solving skills, except for those adults on the very lowest salaries. This group is likely to contain younger adults, those in education and work and those working part-time.

Extracts from Adult Literacy, Numeracy and Problem Solving Skills in England

(BIS Research Paper Number 139) 2013


1. Adults with poor numeracy
   a. are twice as likely to be unemployed compared to those who are competent
   b. are twice as likely to have had a child in their teens
   c. are 2.5 times more likely to have a longstanding illness or disability.

2. Every year 30 000 children leave primary school with the mathematical skills of a 7 year old. By age 16 this figure translates into nearly 59 000 children not gaining Grade A*-C in mathematics each year.

3. Pupils who struggle with numeracy at school are twice as likely to be excluded.

4. Over two thirds of prisoners at the start of custodial sentences have numeracy levels at or below Level 1.

**Discuss:**

Does this evidence justify pupils continuing to learn mathematics up to age 18? What are the tensions?
2. What does it mean to be innumerate?

This is a snapshot view of the implications of being innumerate. Look at the table below and think about the implications for adult lives if we allow so many pupils to be innumerate.

<table>
<thead>
<tr>
<th>Ability Level</th>
<th>Equivalence</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below Entry Level 1</td>
<td>Ages 5-7</td>
<td>Adults may not be able to write short messages or select floor numbers on lifts</td>
</tr>
<tr>
<td>Entry Level 1</td>
<td>Ages 7-9</td>
<td>Adults may not be able to describe a child’s symptoms to a doctor or use a cash point to withdraw cash</td>
</tr>
<tr>
<td>Entry Level 2</td>
<td>Ages 9-11</td>
<td>Adults may not be able to understand price labels on pre-packaged food or pay household bills</td>
</tr>
<tr>
<td>Entry Level 3</td>
<td>GCSE grade D-G</td>
<td>Adults may not be able to read a bus timetable or check pay and deductions on a wage slip</td>
</tr>
<tr>
<td>Level 1</td>
<td>GCSE grade A*-C</td>
<td>Adults may not be able to compare products for best buy or work out a household budget</td>
</tr>
<tr>
<td>Level 2</td>
<td>Defined as numerate. But in 2012, 42% of pupils in England failed to achieve a GCSE A*-C grade in mathematics. “Many of those who scrape a grade C are still incapable of truly understanding how to calculate percentages and fractions or interpret data.” Vorderman report 2011</td>
<td></td>
</tr>
</tbody>
</table>

It is worth bearing in mind that, under the current government thinking, to have a GCSE in mathematics means that you are numerate, even if at times you don’t feel it.

Adapted from National Numeracy’s website

How are these two statements related?

- Numeracy is just like literacy if you don’t keep on practising, as a tool, you lose it over time.
- The emotional side of being mathematically illiterate is probably the most corrosive aspect. There is considerable research to show that self-esteem is damaged and that pupils resort to ‘not trying’ to protect themselves from failure.
3. **Why are attitudes important?**

It is unacceptable for adults, who have a negative attitude to mathematics, to damage children’s life chances by sharing that attitude. Be wary of what you say to children about mathematics.

Maths “…… requires a considerable amount of perseverance from the individual in order to succeed. A negative attitude towards mathematics could considerably reduce a person’s willingness to persist with a problem. Without the ability to persevere, mathematical development is likely to be difficult.”

Ben Ashby 2009

“Human nature does not favour futile endeavours; if a difficult task appears to have no purpose, then few will continue to follow it through.”

Ben Ashby 2009

It is our responsibility as teachers to help pupils to make the connections, in every subject we teach, which gives mathematics its sense of purpose. As teacher of other subjects you are in a privileged position as you are able to help pupils make these connections and hence limit the feelings of futility.

**Discuss these graphs with a colleague:**

They describe the factors which impact on the employment status of men and women at the age of 37. They are fascinating.

- What is the impact of having poor literacy?
- What is the impact of having poor numeracy?
- What is the impact on employment chances of having poor numeracy and poor literacy?
- Are these relationships causal or correlative?
4. Evidence of a deepening problem in secondary schools

There are significant numbers of children leaving the primary schools who already dislike mathematics. However, looking at the chart below you can see teachers’ perceptions of pupils’ mathematical ability become markedly worse at age 16.

[Graph showing percentage rated with little mathematical ability by their teacher at age 7, 11, and 16]

Relate these questions to the graphs above:

1. What is the trend of perceived ‘Little Mathematics Ability’ experienced by boys with ‘Poor Numeracy’ and ‘Poor Literacy’ from 7 – 11 – 16 years of age?

2. Is this the same as girls with ‘Poor Numeracy’ and ‘Poor Literacy’? What are the differences? Why might this be?

3. What has been identified as having the larger percentage rating at age 16, ‘Poor Numeracy’ or ‘Poor Literacy’? Compare the gender difference.

4. Compare the boys at age 16 with competent numeracy with girls of the same age. Why do you think this happens?

5. Why do you think that pupils at the age of 16 with competent Numeracy and Literacy have been categorised by their teacher as having ‘Little Mathematics Ability’?

6. What other trends can you see?

7. What is it about the way we teach mathematics and numeracy, and our attitudes to it in school which creates such a discrepancy at age 16?

5. Changing attitudes

Attitudes are learnt. Attitudes are a learned tendency to evaluate things in a certain way. They are not an absolute fixed value and they depend on many different factors. The important message is that we can change children’s attitudes to mathematics. Probably more importantly do you want to? The implications for our youngsters are important.

There are several different overlapping factors which affect attitude, some of which are mentioned here:

1. **Emotional:** How numeracy and the people who teach it/talk about it make you feel.
2. **Cognitive:** Thoughts and in particular beliefs about numeracy.
3. **Behavioural:** How we behave when numeracy is discussed.

   The relationship between behaviour and attitude is a two way process;
   
   Attitudes affect behaviour and Behaviour affects attitudes

4. **Cultural:** Culture is dependent on the characteristics of a particular group of people. In our pupils’ context their school and their family life impact on expectations. Culture is used to describe a deeper more long term context than situational influences.

5. **Situational:** This is relevant to the moment and the context you find yourself in; where you currently are and who you are with whilst discussing numeracy.

Attitudes are formed as a result of experience. They can be made as a result of direct personal experience, or they may come from observing others. This has implications for the way that we behave. Social rules and social norms will have a strong influence on children’s attitudes. From a school’s perspective this means that we as adults need to consider what we say and what we do.
6. How do Mathematics departments change pupils' attitudes to Maths?

Mathematics departments have a responsibility to make mathematics interesting to all pupils not just those who have an aptitude for ‘doing’ mathematics.

Strategies that increase pupil interest in mathematics:

- Enjoy the mathematical development of children as well as mathematics itself.
- Differentiate so that each student works at an individual level of challenge. It is boring doing mathematics exercises where little or no learning takes place and the only satisfaction is task completion.
- Find out which parts of the foundation skills are missing and rebuild them.
- Utilise the well-proven link between enjoyment, participatory learning and long term memory. Don’t tell pupils the processes – give them situations and prompts which help them develop the next logical steps for themselves.
- Model the learning process so that you model appropriate reactions to making mistakes to help pupils build resilience.
- Developing pupils’ understanding of reasoning is important.
- Publically value but do not overvalue effort. Only the pupils know how much effort they have put into thinking. Saying something is ‘excellent’ when it is not is detrimental.
- Use the pupils’ own interests and situations to link the mathematics to real world examples that they may meet now or might meet in the future. Start with the situation and follow on with the mathematics rather than start with the mathematics then link it to situations.
- Errors are to be enjoyed and explored. It is better to have an error than guessing. Exploring errors helps teachers to understand the fascinatingly different ways that pupils make sense of what they are learning.
- Convince children that intelligence can be improved through hard work and resilience in the face of difficulties.
- Show real joy when pupils overcome difficulties.
- Use computer simulations to help:
  - with the visualisation of dynamic processes
  - to model dynamic processes
  - by using mathematical techniques to solve computer games.
- One of the big advantages of computer applications is that they allow learning by trial and improvement and limit the emotional damage which can arise from getting something wrong. A disadvantage is that it can take more than a lesson to make significant progress.

Further reading:

A deeper understanding of many of these strategies and how they link to current neurological evidence about how youngsters learn mathematics can be found in: Learning to Love Math by Judy Willis, © 2010 by ASCD. The book can found at http://www.ascd.org/publications/books/108073.aspx We are grateful to ASCD for allowing us to use ideas from Learning to Love Math.
7. How do other adults change pupils’ attitudes to Mathematics?

**Observing others talking about maths and numeracy.**
Through observation identify negative comments about numeracy and spend time thinking about positive comments which could replace them. Be credible.

**Walk the talk.**
Identify the behaviours that you want the pupils to display towards mathematics and exhibit those behaviours yourself. Regularly and often.

**Social norms.**
Create a culture in your classroom /area/staff room where normal behaviour is to challenge negative comments about mathematics and replace them with reasoned positive comments. Group belief is an important factor in effecting change.

**Be consistent**
Make sure that you follow the same systems and use the same language as the maths department in your school. Avoid confusion.

**Stay on message.**
Over time make sure that you are consistent in your approach and are resistant to being persuaded otherwise. Be convincing.

**Make it fun: Challenge any negativity towards numeracy.**
National Numeracy is an organisation who ‘want to take the ‘I can’t do maths’ attitude out of the media – anytime you hear someone in the public eye saying that they ‘can’t do maths’, or making negative comments about maths get in touch with National Numeracy. They will follow it up with the person involved.

Email: enquiries@nationalnumeracy.org.uk
Website: http://www.nationalnumeracy.org.uk/home/index.html
Address: National Numeracy, Phoenix House, 32 – 33 North Street, Lewes, East Sussex, BN7 2QJ
8. What does the National Curriculum say?

**National Curriculum**

5.1 Teachers should use every relevant subject to develop pupils' mathematical fluency.

Confidence in numeracy and other mathematical skills is a precondition of success across the national curriculum.

5.2 Teachers should develop pupils' numeracy and mathematical reasoning in all subjects so that they understand and appreciate the importance of mathematics.

Pupils should be taught to

- apply arithmetic fluently to problems,
- understand and use measures,
- make estimates and sense
- check their work.

Pupils should:

- apply their geometric and algebraic understanding, and
- relate their understanding of probability to the notions of risk and uncertainty.
- understand the cycle of collecting, presenting and analysing data.

They should:

- be taught to apply their mathematics to both routine and non-routine problems, including breaking down more complex problems into a series of simpler steps.

Rearranged from the National Curriculum September 2013

It is important for each school to have a ‘calculations’ policy, which describes their agreed methods for ‘doing’ different aspects of mathematics. This is so that all staff, whatever their backgrounds, are giving children coherent messages.

9. Mathematical Vocabulary

Mathematics combines rigour with abstraction. As a subject it often explores areas of thought that are not easily put into words. When language rather than algorithms are used it is important to be aware of the areas of difficulty and to be consistent in the use of language.

There are two sections to this aspect of numeracy that are considered.

a. Language used in Mathematics which is often the cause of misinterpretation.

b. Language used in Mathematics GCSE’s and what words mean in practice.
1. Look at these two sentences. How can they cause confusion for pupils?
   - 13 take away 6
   - 13 was taken away from 6

2. When reading numbers aloud the format that is used to ensure clarity is:
   - In maths we use: One thousand, two hundred and twenty three
   - For dates we often say: Twenty twelve
   - In maths for decimals: One point six four

   Any other ways of phrasing these causes pupils problems with interpretation and is incorrect – for instance saying one point sixty four for 1.64 gives too large a significance to the value after the decimal point and creates problems with imagining sizes.

3. Sometimes simplifying the language of mathematics can cause misunderstandings. Take for example the use of the terms ‘acute’ and ‘obtuse’ angles. If they are referred to by names such as ‘sharp’ or ‘wide’ this leads pupils to think about the shape of the point rather than on the amount of turning that happens. This then makes comparisons between different angles harder. Also pupils often think that diagram A is more acute than diagram B

   Diagram A
   Diagram B

4. As in English, the terms ‘fewer’ and ‘less’ and their derivatives can cause problems.
   - ‘Fewer’ always relates to a number i.e. something that can be counted.
   - ‘Less’ always refers to a quantity e.g. less milk in a cup

5. The word ‘power’ has a specific meaning in mathematics: it tells the reader how many times a number is multiplied by itself.

6. Like many words in mathematics the word ‘scale’ is difficult as there are so many meanings in English and mathematics itself has two specific meanings
   a. Scale meaning how much to enlarge or reduce the size of an object
   b. The ‘scale’ as used on measuring devices or graphs or plans

7. Some of the difficulties are caused by pupils not having text to support them in decoding their reading. Shops and adverts are classic examples where this happens. Information is briefly written to be eye-catching rather than to aid interpretation.

   Look at: ‘25% of £5.00’ compared to ‘25% off £5.00’.

   Lack of precision in reading can cause very real differences in interpretation.

There are many more such examples we could include. To help teachers understand how language is used differently in mathematics teaching we have included a list of frequently used terms and their meanings. The list is exemplar rather than definitive.
b. The language of mathematics GCSE’s and what words mean in practice

<table>
<thead>
<tr>
<th>Term used</th>
<th>What is meant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculate</td>
<td>A numerical answer is expected which requires the use of a calculator or formal calculation methods.</td>
</tr>
<tr>
<td>Deduce</td>
<td>Use logic – one step follows on from another and reasoning is given.</td>
</tr>
<tr>
<td>Describe fully</td>
<td>Use mathematical vocabulary in the description. Ensure that the answer is unambiguous.</td>
</tr>
<tr>
<td>Do an accurate drawing</td>
<td>Use compasses to draw lengths (rather than just a ruler), protractors for measuring angles and a sharp pencil – avoid parallax errors.</td>
</tr>
<tr>
<td>Estimate</td>
<td>An estimate is not a guess. Use rounded numbers to work out an approximate number.</td>
</tr>
<tr>
<td>Expand</td>
<td>Multiply to convert the brackets into individual algebraic or numerical terms.</td>
</tr>
<tr>
<td>Expand and simplify</td>
<td>Multiply to convert the brackets and then collect terms together to form the simplest version possible.</td>
</tr>
<tr>
<td>Explain your answer. Show your working</td>
<td>Show the steps taken to reach an answer and justify the reasoning for each step.</td>
</tr>
<tr>
<td>Explain/Comment/Give a reason for your answer</td>
<td>Use words and/or mathematical symbols to justify an answer or describe the limits of the process you have used to reach your answer.</td>
</tr>
<tr>
<td>Express, in terms of</td>
<td>Use the given information to write an expression which only uses the letter(s) given.</td>
</tr>
<tr>
<td>Factors</td>
<td>Factors are numbers which can be multiplied together to get another number.</td>
</tr>
<tr>
<td>Give the answer to a sensible degree of accuracy</td>
<td>For scientists: Answers should be no more accurate than the values given in the question. If the question quotes values to 2 sf. then give an answer to either 2 sf. or 1 sf.</td>
</tr>
<tr>
<td>Hence</td>
<td>Use the previous answer to work out the next part.</td>
</tr>
<tr>
<td>Make (x) the subject</td>
<td>Rearrange a formula so that it is written ( x = \ldots ).</td>
</tr>
<tr>
<td>Measure</td>
<td>Use a ruler or a protractor to measure a length or an angle.</td>
</tr>
<tr>
<td>Product</td>
<td>The answer when two or more numbers are multiplied together.</td>
</tr>
<tr>
<td>Prove</td>
<td>An algebraic or geometric proof is required where each step is justified.</td>
</tr>
<tr>
<td>Show that</td>
<td>Use reasoning which utilises words, numbers or algebra to find an answer.</td>
</tr>
<tr>
<td>Simplify</td>
<td>Collect algebraic terms together or cancel down a fraction to find the simplest version of an answer.</td>
</tr>
<tr>
<td>Solve</td>
<td>Find the value(s) of (x) that makes the equation true.</td>
</tr>
<tr>
<td>Use the graph</td>
<td>Do not calculate the answer, read the answer from the graph. Draw marker lines on the graph to show how the answer has been found.</td>
</tr>
<tr>
<td>Work out</td>
<td>A calculation is involved in finding the answer.</td>
</tr>
</tbody>
</table>
10. Mathematical thinking and mathematical procedures

Sometimes you will include mathematical procedures in your lessons. These procedures are a key aspect of mathematics and encourage pupils to understand that numeracy is an important life skill. Working alongside these processes are mathematical ‘ways of thinking’. These ways of thinking can be employed to tackle both mathematical and non-mathematical problems. Helping pupils understand that they often use this type of thinking in many situations is an important part of valuing mathematics.

The above diagram has been copied with the generous permission of National Numeracy

The above diagram would benefit from the addition of more detail about reasoning as described here.

Further diagrams showing more detail about mathematical thinking can be found in Appendix 1
11. Using and Abusing Statistics

Every subject taught in schools will probably at some stage involve statistics. Statistics is usually the most poorly understood aspect of numeracy in the adult population. One only has to read articles in a newspaper which quote statistics in relation to teaching to understand how poorly understood statistics are by journalists.

When considering statistical information we need to think about all sorts of questions about bias, processing, what was measured etc. With the current reputation that statistics holds, there is a danger that we assume all statistics are bad. This is not true. There are many instances of well conducted statistical sampling which give data that can yield reliable information.

It is a commonly held belief that information quoted as numbers is accurate and true. In reality we need to instil in children the enquiring minds which will challenge the processes by which the numbers have been created before being inclined to believe.

There is also a tendency for us to look at data and outcomes and see more in them than is actually there. There is a difference between correlation and cause. Just because two numbers follow the same upward/downward trend does not mean that one influences the other. It means we should look for further information and raise questions to deepen understanding.

As an example of the types of questions which might be raised:

Think about the following statement: 8 out of 10 cats prefer ‘Whiskas’ cat food (1980’s advert)

Were the researchers independent?
Is the data capable of being extrapolated? Could this mean 800 000 out of 1 million cats prefer ‘Whiskas’ cat food?
Does this mean that the cats know the ‘Whiskas’ cat food is nutritionally better for them?
Were the cats moggies or pedigree?
What was their normal food?
Was the test a fair test?
Was the collection biased?
How many choices were the cats given?
Were the alternatives offered to the cats sensible?
Is the sample size big enough to give reliable data?

It is because we find numbers so compelling that there is a need to teach pupils about the misuse of statistics. The Advertising Standards Authority website has many examples of misleading statistics they have banned. http://www.asa.org.uk/ See the final page of this booklet for website sources of information.

Pupils benefit from understanding if the misuse is a deliberate attempt to confuse or genuine misunderstanding on the part of the writer.
In science, technology, geography and music mathematics forms a natural part of the syllabus. Staff in these departments should liaise with the maths department over the language and strategies used. Do not however let the maths national curriculum hold you back. If it is appropriate to teach mathematical methods of interpretation or processing to understand your syllabus then teach the pupils in the current context. Do not wait for the maths department to teach it first.

In some subjects ideas are included which demonstrate how maths can enhance the understanding of the taught subject in one lesson and for others a series of ideas are included to trigger thoughts in more than one lesson. It is worth looking at all subject areas to deepen understanding.

**Art and Design**

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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Designing and making 3D letter structures (accuracy in measuring using a ruler and joining edges of a 3D letter together using the correct angles). Activity with Year 9 students.</td>
</tr>
<tr>
<td>2.</td>
<td>Looking at artists who use shape and form as the main focal point of their work example: Rex Ray, pupils to identify and draw a variety of shapes from the artist’s work. (Year 7 pupils)</td>
</tr>
<tr>
<td>3.</td>
<td>Using a grid framework to create block lettering, accuracy in using squared paper and a ruler. (Year 8 pupils)</td>
</tr>
<tr>
<td>4.</td>
<td>Using a view finder to crop and zoom in on an area e.g. an artist’s painting or pupils’ own design work. Then using a grid to plot and measure to assist in zooming in and enlarging an image when drawing. (All year groups 7-11)</td>
</tr>
<tr>
<td>5.</td>
<td>Looking at artist Ruth Piper and her use of shape. Using a compass accurately to draw circular patterns and shapes inspired by the artist.</td>
</tr>
<tr>
<td>6.</td>
<td>Isometric drawings, using grid paper to draw 3D shapes accurately. (Year 7)</td>
</tr>
<tr>
<td>7.</td>
<td>Textile activities where students have to work with a design template/pattern to draw around and accurately cut out the design onto fabric before stitching together. (Year 11)</td>
</tr>
</tbody>
</table>
### Business Studies

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>1.</strong></td>
<td><strong>Produce a Profit &amp; Loss Account</strong></td>
</tr>
<tr>
<td></td>
<td>- Start with calculation of:</td>
</tr>
<tr>
<td></td>
<td>- Total Costs = Fixed costs + Variable Costs</td>
</tr>
<tr>
<td></td>
<td>- Revenue = Number of Sales x Price per unit</td>
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<tr>
<td></td>
<td>- Gross Profit = Revenue – Cost of Sales</td>
</tr>
<tr>
<td></td>
<td>- Net Profit = Gross Profit – Expenditure</td>
</tr>
<tr>
<td></td>
<td>- Then create a basic Profit and Loss Account.</td>
</tr>
<tr>
<td><strong>2.</strong></td>
<td><strong>Plot Break Even Point (BEP) on a graph</strong></td>
</tr>
<tr>
<td></td>
<td>- Calculate the Break Even Point:</td>
</tr>
<tr>
<td></td>
<td>- Fixed Costs / (Selling Price per unit – Variable Costs)</td>
</tr>
<tr>
<td></td>
<td>- Use Sales, Variable Costs, Fixed Costs and Total Costs to create a table for these values in a business.</td>
</tr>
<tr>
<td></td>
<td>- Then, produce a graph to show the patterns and where Revenue &amp; Costs cross at the Break Even Point.</td>
</tr>
<tr>
<td></td>
<td>- Extend by producing graphs to show what happens to BEP when costs or prices/revenue change.</td>
</tr>
<tr>
<td><strong>3.</strong></td>
<td><strong>Produce a basic budget</strong></td>
</tr>
<tr>
<td></td>
<td>- Produce a basic household budget.</td>
</tr>
<tr>
<td></td>
<td>- Produce a basic business budget.</td>
</tr>
<tr>
<td></td>
<td>- Calculate variances between budgets and actual spending/revenues.</td>
</tr>
<tr>
<td><strong>4.</strong></td>
<td><strong>Produce a Cash Flow Forecast</strong></td>
</tr>
<tr>
<td></td>
<td>- Understand Inflows, Outflows and Balance.</td>
</tr>
<tr>
<td></td>
<td>- Create a Cash Flow Forecast using monthly figures for a 12 month period manually.</td>
</tr>
<tr>
<td></td>
<td>- Produce a CFF on a spreadsheet. Use formulas.</td>
</tr>
<tr>
<td><strong>5.</strong></td>
<td><strong>Investigate how to improve a small business</strong></td>
</tr>
<tr>
<td></td>
<td>- Analyse revenues and costs for a business.</td>
</tr>
<tr>
<td></td>
<td>- Use the tools of P&amp;L Account, BEP and CFF.</td>
</tr>
<tr>
<td></td>
<td>- Suggest how changes can be made to revenues and costs; to make business improvements.</td>
</tr>
</tbody>
</table>
### Citizenship and PSHE

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Within the budgeting and money management aspects of economic well-being there is a lot of scope for numeracy. For example: budgeting for a specific purpose i.e. Christmas, holidays, a purchase such as a mobile phone etc. Supply pupils with Christmas catalogues for example and a set budget. They need to think about who they want to buy for and how they can save/earn the money to pay for the presents.</td>
</tr>
</tbody>
</table>
| 2. | Choosing the right bank account necessitates pupils looking at favourable interest rates when opening a current/savings account.  
   ‘Banking on It’ [http://www.moneysense.rbs.co.uk/schools/resources/](http://www.moneysense.rbs.co.uk/schools/resources/) Fantastic resources. |
| 3. | Preparation for working life deals with: tax and NI payable and the amounts that will be deducted from gross pay.  
   [http://community.tes.co.uk/tes_pshe/f/39/t/100631.aspx](http://community.tes.co.uk/tes_pshe/f/39/t/100631.aspx) |
| 4. | ‘You’re in Business’ is a superb resource supplied by Nat West Bank that has resources that can easily be adapted. Pupils are encouraged to work as a team to promote an opening event for a new business. They adopt business roles such as: catering manager; finance officer; project manager etc. and work as a team to create a successful bid for their business ideas.  
| 5. | ‘Barclays Life Skills’ have a wonderful set of resources and lesson plans etc. that assist pupils considering their finances when they prepare to leave school. They also offer speakers who come into schools.  
   [https://www.barclayslifeskills.com/getstarted/?campaign=9955&chnnl=PSB&mpch=ads](https://www.barclayslifeskills.com/getstarted/?campaign=9955&chnnl=PSB&mpch=ads) |

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*Photo courtesy of [Stephen McKay](https://www.flickr.com/photos/steven_mckay)*
### Computing

<p>| | |</p>
<table>
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</table>
| 1. | Spreadsheets  
   - It is important when using a spreadsheet as a model to consider the mathematical conventions on comparing and converting between fractions and decimals and liaise with the Mathematics Department in order to use the conventions as taught there. This is an opportunity to build fluency with fractions and also decimals in the form of currency. |
| 2. | Problem Solving  
   - Begin to model situations mathematically and express the results using a range of formal mathematical representations. |
| 3. | Data Handling  
   - Students should be taught to select data prior to drawing a graph. Axes, titles and/or a key need to be included. They need to understand the terms discrete, continuous and grouped data and be familiar with the appropriate measures of spread. |
| 4. | Programming  
   - Students should be taught to use formulas and substitution into these formulas to calculate the value of a variable. This could also help to make the links between input and output in the context of simple function machines. |
| 5. | Binary Code  
   - Students consider how computers use switches to control the output of programs. They begin to compare binary numbers with decimal numbers and order numbers in binary code. Place value is a very important consideration here. |
Computing (continued)

What is the difference between a C grade spreadsheet model and an A grade model?

The student has selected relevant data and developed a spreadsheet model that generates meaningful information.

The student has selected relevant data, developed a complex spreadsheet model that generates sufficient reliable and meaningful information to fully inform the decision making process.

Present the previous slide to your pupils without the highlighting and ask them to choose the key words and explain why they are important.

<table>
<thead>
<tr>
<th>Event</th>
<th>Venue Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Size (area available sq m)</td>
</tr>
<tr>
<td></td>
<td>Maximum capacity</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Venue Decisions (Pitches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charity pitch size</td>
</tr>
<tr>
<td>Number of pitches</td>
</tr>
<tr>
<td>Charge per pitch</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hire of pitches to charities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number hired</td>
</tr>
<tr>
<td>Income from pitch hire</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Venue Decisions (Ticket Prices)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of tickets available</td>
</tr>
<tr>
<td>Adult ticket price</td>
</tr>
<tr>
<td>Child ticket price</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Event Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
</tr>
<tr>
<td>Costs</td>
</tr>
<tr>
<td>Profit / Loss</td>
</tr>
</tbody>
</table>

Your Task:

To predict how much it is going to cost to run your Community Spirit event by developing your spreadsheet model.

Learning Objectives:

- Investigate the costs involved in running a summer fair.
- Develop skills with spreadsheet software.
- Assess how far I am meeting the mark scheme for this task.

Key Stage 4 Mathematics

Students should be given the opportunity to identify variables and relationships in familiar and unfamiliar situations and develop mathematical knowledge through problem solving and through evaluating the outcomes.

Now criticise your own decisions

- What makes your model reliable?
- Give one example of where you have used a sensible decision.
- Give one example of a situation where you are not so sure if it is sensible or reliable.

So how did you do?

Mathematical thinking across the curriculum

Bolton Council
Using numeracy during English lessons should not be forced onto the subject. As with other areas of the curriculum the teacher needs to be familiar with the contents of numeracy in the National Curriculum and look for ways that they can apply methods of mathematical thinking.

1. Venn diagrams are used in maths and English for comparing similarities and differences e.g. Of Mice and Men

![Venn Diagram](image)

Which adjectives describe each one and which describe both? How has Steinbeck’s choice of language been used to create different personalities?

2. Look in this booklet at the pages about the vocabulary of maths and when using the words make children aware of how they are used differently in different contexts.

3. Creation and analysis of poetry e.g. iambic pentameter; rhythm and patterns in the number of syllables words in poetry.


4. When creating non-fiction articles the evidence can be chosen from graphs, charts, tables and mathematical vocabulary which have to be interpreted. This includes being pedantic with children about including the units on any measurement.

5. Tension Graphs: Graph the changes in the amount of tension a story creates by calibrating the amount of stress when important events occur in a play/novel. This helps focus pupils on the structure of the story and to establish when the climax occurs. Annotation is important.

![Tension Graph](image)

Which classic GCSE play does this represent?

6. Create time lines showing the sequence of the actions introduced in the plot. Recognise the difference between a time line where time is evenly spaced out on the horizontal axis as in mathematics and when the axis is labelled with the scenes in a play or chapters in a book. In this case the horizontal axis marks the passage of time but it is no longer possible to interpolate events in an accurate time frame. Help pupils to understand the numbering system used for Acts and Scenes in plays.

7. In creative story writing, recognising the use of mathematical types of thinking when placing restrictions on the way the writing is formed or a character can behave during different events.

8. Create a 2 dimensional diagram or 3D model of the location of a story – annotate the diagram/model using quotes from the text as evidence for your choices.
History

Look at the sequence of slides used for two history lessons. The maths has been used in a way which enhances and deepens the understanding of the history rather than as ‘add on’. This is really good practice.

Included is:

- the magnitude of the numbers of people who died in the conflict
- the impact of the symmetry of the graves
- the interpretation of maps and graphs including the size of countries involved i.e. area and numbers of people
- The coding of the countries as the start of algebra

T: World War I

LO: To describe the main causes of the First World War

Success criteria:

- To discuss my ideas effectively and with maturity
- To scan read information
- To describe, in my own words, the main reasons for the First World War
- To organise my ideas effectively into categories

Key words:
Conflict          Rivalry
Tension

At 11 a.m. on 11 November 1918, French and German representatives signed an armistice, bringing the ‘Great War’ to an end. The war had resulted in destruction and loss of life on a scale which few people had even dreamed was possible. On average, around 6000 lives were lost every day in the war.

30 days hath September
April, June and November
Excepting February
When comes the time
Every Leap Year gives it twenty-nine

Numeracy check!

If the First World War was on 6th August 1914 and the last death was on 11th November 1918, and approximately 6000 people died per day.

How many people had died by the end of the war?

Use the Rhyme to help you.

Alliances

By 1905, in Europe, two major ‘groups of countries’ had been formed. These ‘groups’ were known as Alliances. Alliances are often formed to increase a country’s overall power, in that when needed they can call for an ally to help fight a war.

By 1905 there were two main Alliances:

- The Triple Alliance
  \[ G + A : H + I \]
- The Triple Entente (agreement)
  \[ B + F + R \]
In the late 19th Century France and Germany had been at war with one another. Germany had won. As a result of this Germany made France pay compensation (land and money) for the damage caused during that war. Germany knew that France may always seek revenge for how harshly they had treated France. In particular, the Kaiser knew France would try to regain the land Germany took from them. Revenge

By 1905 Germany was beginning to build up its naval strength by building battleships. Britain was fully aware of the challenge Germany may make. In response Britain also began to build battleships that were bigger and better than Germany’s. These battleships were called ‘Dreadnaughts’. In response Germany built even bigger battleships…what transpired was an ‘arms-race’. Both countries became ‘locked in a race’ to become the biggest and best. Power

By 1900 Britain had the largest Empire in the world. In addition to this, Britain also had the strongest navy. The Kaiser was determined to ‘have his time in the sun’ and he knew that to achieve this he would have to take colonies from Britain. He was prepared to do this.

Using the information sheets and the images, describe (in your own words) the main causes of the First World War.

Success criteria:
- To discuss my ideas effectively and with maturity
- To scan read information
- To describe, in my own words, the main reasons for the First World War
- To organise my ideas effectively into categories

Key Words
- Conflict
- Rivalry
- Tension

How do you feel about the progress you have made today?
- Have you understood the main causes?
- Have you organised your ideas effectively?
- Discuss with your learning buddy what you have learnt today.

Homework task:
Find out who was the Prime Minister of Britain when war was declared.
Also find out how the people of Britain found out we were at war.
If you can, print out evidence of your findings.
1. **Number recognition and number sequencing**  
   Give students a 100 square and a counter, which they slide from square to square as you all count out loud in the target language. Students can help each other to learn with a laminated 100 square and a whiteboard marker. One student says a number and their partner has to circle the same number on their 100 square. Count forwards and backwards in tens or hundreds from any two- or three-digit number, recognise and continue number sequences.

2. **Four rules of number**  
   Using the target language recall all number bonds, addition and subtraction, for each number to 20, students work out what they need to add to any two-digit number to make 100, or add or subtract any pair of two-digit whole numbers. They can recall times tables to 10 x 10 and use them to derive quickly the corresponding divisions or double and halve any two-digit number.

3. **Fractions**  
   Students can use a match card activity with cards such as ‘calculez le quart de quarante’, calculating the answer and selecting the correct answer cards.

4. **Shape and space**  
   Using a variety of coloured 2-D and 3-D shapes or posters showing coloured shapes students can name the shapes, describe their size, colour and properties in the target language.

5. **Data Handling**  
   Students work out if the nouns are masculine or feminine, singular or plural, using a glossary or dictionary if necessary, cut them out and stick them into the right box on a diagram. Carroll Diagrams lend themselves very well to data sorts of this kind.  
   Reading distances from a table, and practising large numbers in the target language.

6. **Measures**  
   Using conversion tables between Imperial measures and the Metric system such as miles and kilometres, pounds and kilograms. Comparison of the cost of items in Euros and Pounds Sterling, money exchange.

7. **Time**  
   Telling the time using the target language, calculating the time taken to carry out a task, reading train timetables in the context of the country being studied.

We are very grateful to Sunderland Local Authority. Many of the ideas above are taken from the MFL Sunderland website. There are more excellent ideas and resources available at:

http://www.sunderlandschools.org/mfl-sunderland

Photo courtesy of Pixabay.com
## Physical Education

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<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>1.</td>
<td>Measuring accurately. During throwing events pupils choose the</td>
<td>Measuring accurately. During throwing events pupils choose the</td>
</tr>
<tr>
<td></td>
<td>correct measuring device (tape) and measure from point A to</td>
<td>correct measuring device (tape) and measure from point A to</td>
</tr>
<tr>
<td></td>
<td>point B to compare distances.</td>
<td>point B to compare distances.</td>
</tr>
<tr>
<td>2.</td>
<td>Basketball uses a 2 point system for scoring. Other games use</td>
<td>Basketball uses a 2 point system for scoring. Other games use</td>
</tr>
<tr>
<td></td>
<td>different scoring systems. Ensuring pupils understand scoring</td>
<td>different scoring systems. Ensuring pupils understand scoring</td>
</tr>
<tr>
<td></td>
<td>systems. Learning to apply the rules for scoring is similar to</td>
<td>systems. Learning to apply the rules for scoring is similar to</td>
</tr>
<tr>
<td></td>
<td>the way mathematicians apply the rules.</td>
<td>the way mathematicians apply the rules.</td>
</tr>
<tr>
<td>3.</td>
<td>Athletics: Use of division in team events like relay races to</td>
<td>Athletics: Use of division in team events like relay races to</td>
</tr>
<tr>
<td></td>
<td>decide pace. Comparing speeds run by individuals running 400m</td>
<td>decide pace. Comparing speeds run by individuals running 400m</td>
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<tr>
<td></td>
<td>and teams of 4 running 100 m each. Understanding number in</td>
<td>and teams of 4 running 100 m each. Understanding number in</td>
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<tr>
<td></td>
<td>split second timing of events.</td>
<td>split second timing of events.</td>
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<tr>
<td></td>
<td>lines to help judge how far the javelin, discuss, shot and</td>
<td>lines to help judge how far the javelin, discuss, shot and</td>
</tr>
<tr>
<td></td>
<td>hammer are thrown. This requires pupils to interpolate to judge</td>
<td>hammer are thrown. This requires pupils to interpolate to judge</td>
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<tr>
<td></td>
<td>the distances.</td>
<td>the distances.</td>
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<tr>
<td></td>
<td>In team ball games anticipating where team mates and opponents</td>
<td>In team ball games anticipating where team mates and opponents</td>
</tr>
<tr>
<td></td>
<td>will be and estimating their positions and placing the ball</td>
<td>will be and estimating their positions and placing the ball</td>
</tr>
<tr>
<td></td>
<td>accurately.</td>
<td>accurately.</td>
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<tr>
<td>5.</td>
<td>Methods of keeping tally charts of scores in different ball</td>
<td>Methods of keeping tally charts of scores in different ball</td>
</tr>
<tr>
<td></td>
<td>games. Understanding the coding signals that umpires use in</td>
<td>games. Understanding the coding signals that umpires use in</td>
</tr>
<tr>
<td></td>
<td>different sports.</td>
<td>different sports.</td>
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<tr>
<td>6.</td>
<td>Problem solving in physical exercise planning sessions, where</td>
<td>Problem solving in physical exercise planning sessions, where</td>
</tr>
<tr>
<td></td>
<td>pupils create fixture lists so that the teams play each other</td>
<td>pupils create fixture lists so that the teams play each other</td>
</tr>
<tr>
<td></td>
<td>the correct number of times.</td>
<td>the correct number of times.</td>
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</tbody>
</table>

## Religious Education

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<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>1.</td>
<td>Patterns and symmetry form an important part of religious icons.</td>
<td>Patterns and symmetry form an important part of religious icons.</td>
</tr>
<tr>
<td></td>
<td>Ensure that you use the correct mathematical language when</td>
<td>Ensure that you use the correct mathematical language when</td>
</tr>
<tr>
<td></td>
<td>referring to the way patterns are configured.</td>
<td>referring to the way patterns are configured.</td>
</tr>
<tr>
<td>2.</td>
<td>Data gathering and representation of people's views about RE</td>
<td>Data gathering and representation of people's views about RE</td>
</tr>
<tr>
<td></td>
<td>based issues.</td>
<td>based issues.</td>
</tr>
<tr>
<td>3.</td>
<td>Understanding the numbering systems in religious texts and the</td>
<td>Understanding the numbering systems in religious texts and the</td>
</tr>
<tr>
<td></td>
<td>reasons for them.</td>
<td>reasons for them.</td>
</tr>
<tr>
<td>4.</td>
<td>The importance of number in different belief systems.</td>
<td>The importance of number in different belief systems.</td>
</tr>
<tr>
<td>5.</td>
<td>The pattern for the days of the week, the calendar and</td>
<td>The pattern for the days of the week, the calendar and</td>
</tr>
<tr>
<td></td>
<td>recurring festivals all have mathematical processes that</td>
<td>recurring festivals all have mathematical processes that</td>
</tr>
<tr>
<td></td>
<td>underpin them. They involve counting in different number</td>
<td>underpin them. They involve counting in different number</td>
</tr>
<tr>
<td></td>
<td>systems.</td>
<td>systems.</td>
</tr>
<tr>
<td>6.</td>
<td>The study of maps which track journeys or land use and/or</td>
<td>The study of maps which track journeys or land use and/or</td>
</tr>
<tr>
<td></td>
<td>possession involves the use of mathematics to identify</td>
<td>possession involves the use of mathematics to identify</td>
</tr>
<tr>
<td></td>
<td>co-ordinates and ideas of direction and scale. Discussion</td>
<td>co-ordinates and ideas of direction and scale. Discussion</td>
</tr>
<tr>
<td></td>
<td>could be about the transmission of information in previous</td>
<td>could be about the transmission of information in previous</td>
</tr>
<tr>
<td></td>
<td>epochs and the numbers of people who could be reached.</td>
<td>epochs and the numbers of people who could be reached.</td>
</tr>
<tr>
<td>7.</td>
<td>Comparing annotated time lines involved in the development of</td>
<td>Comparing annotated time lines involved in the development of</td>
</tr>
<tr>
<td></td>
<td>different religions.</td>
<td>different religions.</td>
</tr>
</tbody>
</table>
12. Numbers (and the Number System)

Numbers are all around us. To have a sense of the size of a number and where it fits into the number system we need to understand how the pattern and structure in the number system works and how numbers relate to each other.
13. **Operations and Calculations**

As well as knowing about the number system, being numerate also means understanding the ways in which numbers can be combined or acted upon. This allows us to make confident and sensible choices about which methods to use in a given context and then to calculate accurately.

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14. Handling Information

Whether cooking, browsing the web, interpreting a pay slip, giving medicine to children, watching the news, working out personal finances, or taking part in elections, everyone needs to be numerate to interpret and make sense of data and information presented in a variety of ways.

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15. **Shape, Space and Measures**

We use measurement all the time, and we measure lots of different things such as time, length, and temperature. We regularly solve problems using our knowledge of shape, space and measure, for example, working out if a new sofa will fit in the living room or laying a carpet.

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16. Sources of information about how to use statistics

Although these titles refer to science many of the examples quoted on the websites are not scientific

www.senseaboutscience.org - in particular the publication – Making Sense of Statistics. – is available for free download

www.badscience.net/ is a regularly updated website which has many articles which debunk the claims made by newspapers

Stat-Spotting A Field Guide to Identifying Dubious Data by Joel West – publication date October 2013

17. References


www.nationalnumeracy.org.uk/essentialsofnumeracy
Further copies of this booklet can be downloaded from:

http://educationexchange.bolton.lea.org.uk