Rosenshine's Principles in the Mathematics Classroom

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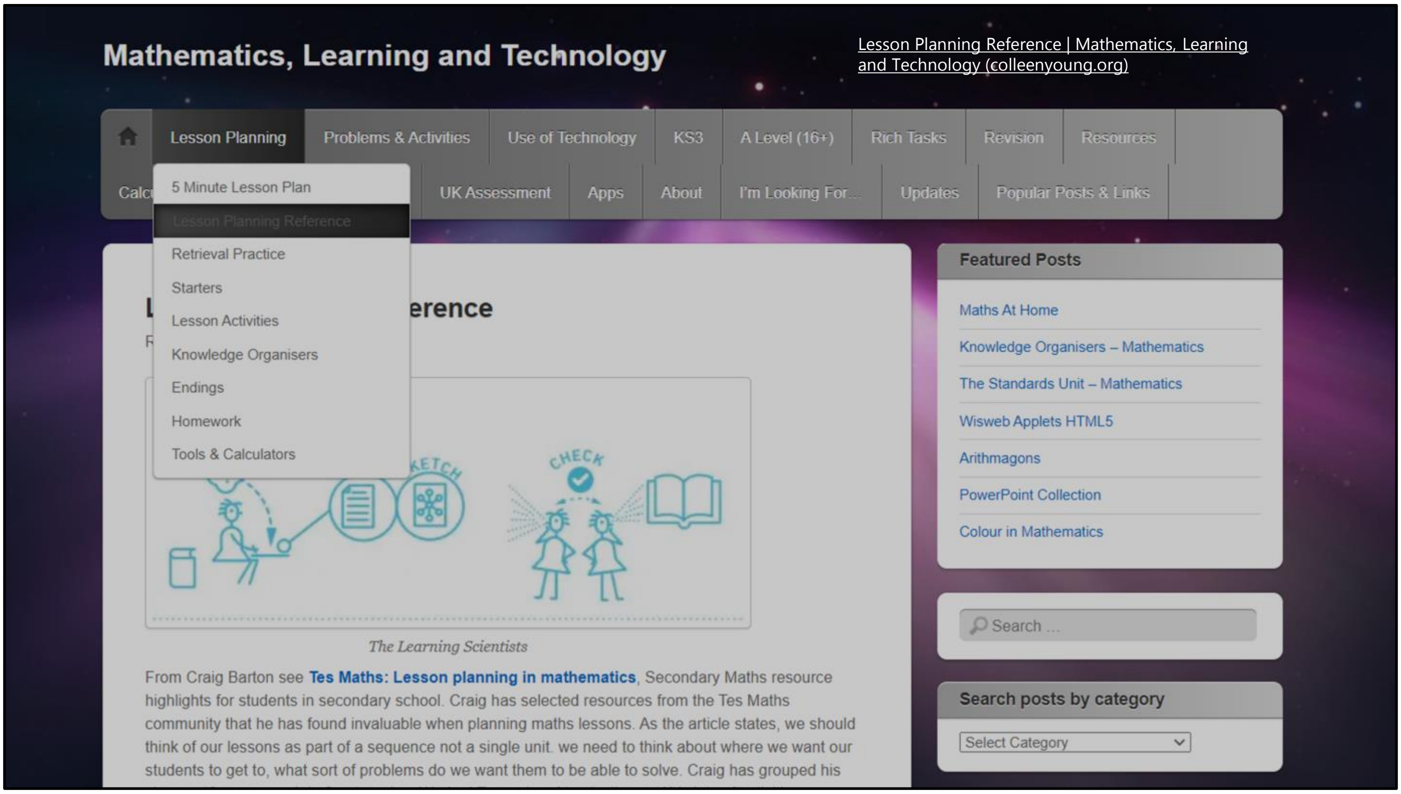
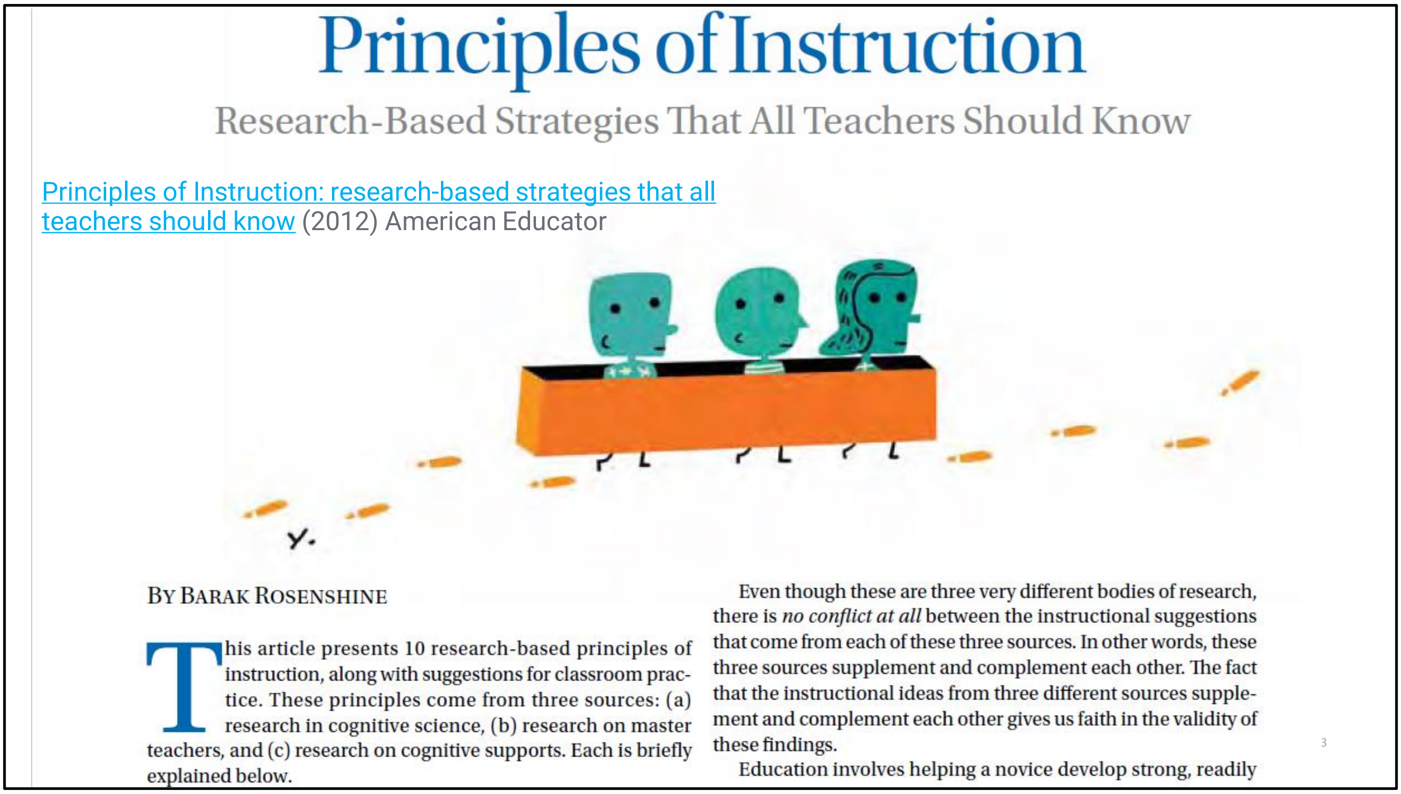


- Reference material available on my blog – colleenyoung.org under lesson planning.
- Lesson Planning Reference (page)



Principles of Instruction

Research-Based Strategies That All Teachers Should Know

Principles of Instruction: research-based strategies that all teachers should know (2012) American Educator

BY BARAK ROSENSHINE

This article presents 10 research-based principles of instruction, along with suggestions for classroom practice. These principles come from three sources: (a) research in cognitive science, (b) research on master teachers, and (c) research on cognitive supports. Each is briefly explained below.

Even though these are three very different bodies of research, there is *no conflict at all* between the instructional suggestions that come from each of these three sources. In other words, these three sources supplement and complement each other. The fact that the instructional ideas from three different sources supplement and complement each other gives us faith in the validity of these findings.

Education involves helping a novice develop strong, readily

- So, Rosenshine's Principles – I have long been a fan – before it's more recently popularity in fact. Research papers can be hard to read, but this is so accessible.
- The language is very clear – and perhaps it seems just common sense. They are sensible principles which are also importantly evidence informed. We can use them for reflection and ask ourselves just how well we address the issues here in our teaching.
- An excellent paper to read is illustrated above. This is very clearly structured article where a section is devoted to each of the principles; for each section the research findings are given and very importantly what this means for classroom teachers.
- Today we are looking at the principles and thinking how we make this work in the **Mathematics** classroom.

Triptico | Rosenshine Order Sorter – change the order to categorise these principles

17 Principles of Effective Instruction

	9 Provide models of worked-out problems.
1 Begin a lesson with a short review of previous learning.	10 Ask students to explain what they have learned.
2 Present new material in small steps with student practice after each step.	11 Check the responses of all students.
3 Limit the amount of material students receive at one time.	12 Provide systematic feedback and corrections.
4 Give clear and detailed instructions and explanations.	13 Use more time to provide explanations.
5 Ask a large number of questions and check for understanding.	14 Provide many examples.
6 Provide a high level of active practice for all students.	15 Reteach material when necessary.
7 Guide students as they begin to practice.	16 Prepare students for independent practice.
8 Think aloud and model steps.	17 Monitor students when they begin independent practice.

- If you have seen Rosenshine's Principle you are probably now thinking – there's 10 principles..!
- There are, but note in the paper I have referred to Barak Rosenshine presents this list of 17 principles emerging from his research; I find this provides useful detail.
- These principles I think fall naturally into groups.
- Take a few minutes to look at these 17 and put them into groups of principles you think fit together. You may well find you have different size groups. No right or wrong answers here, but it will get you thinking about the principles and how in fact there is a great deal of overlap between them.
- Go to this link: https://www.tripticoplus.com/media/resources/orderSorter.html?save=4592&array=%5B%5D
- Next slides show possible groups – each will be examined in

more depth as we move through the session.

Instruction

Present new material in small steps with student practice after each step

Limit the amount of material students receive at one time

Give clear and detailed instructions and explanations

Think aloud and model steps

Use more time to provide explanations

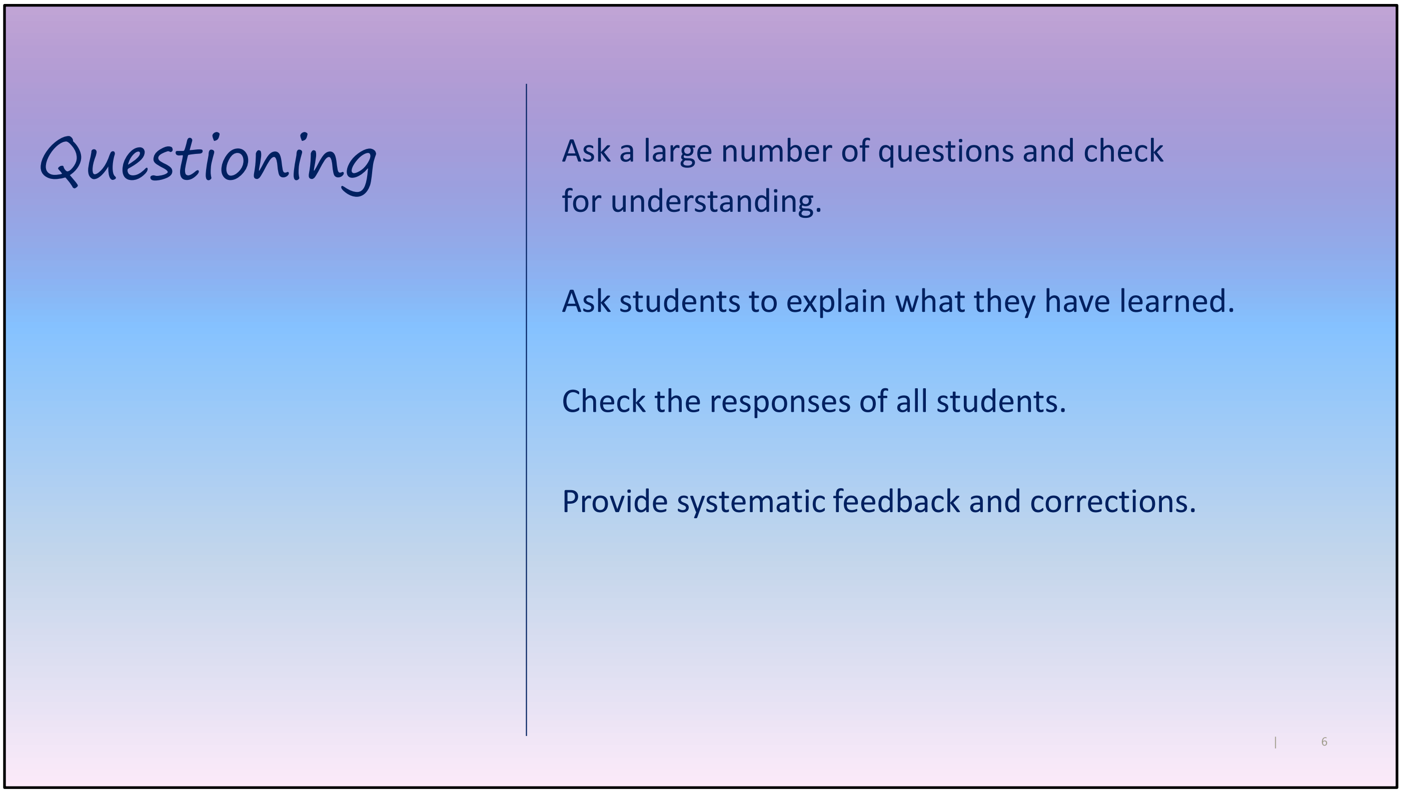
Provide many examples

Reteach material when necessary

| 5

- We'll look at each theme and consider what we do in Maths. Look at that list great description of what we do in Maths.
- We can also see the overlap between these themes – instruction includes practice – you can see I have put a couple of the principles in more than one group.
- If you have seen the work of Tom Sherrington, you can see his work looks at the principles in themes, I think a very helpful way to think about the principles. TS articles highly recommended
- Think of this as a framework for thinking about your lessons, but: the **principles do not all apply to every lesson.** Different lessons in a learning sequence will require a different focus: some might have more explanatory modelling; more questioning or more independent practice. You might have whole lessons of practice and whole lessons of teacher modelling and questioning. You might not literally do 'daily review' every day. However, over a series of lessons that relate

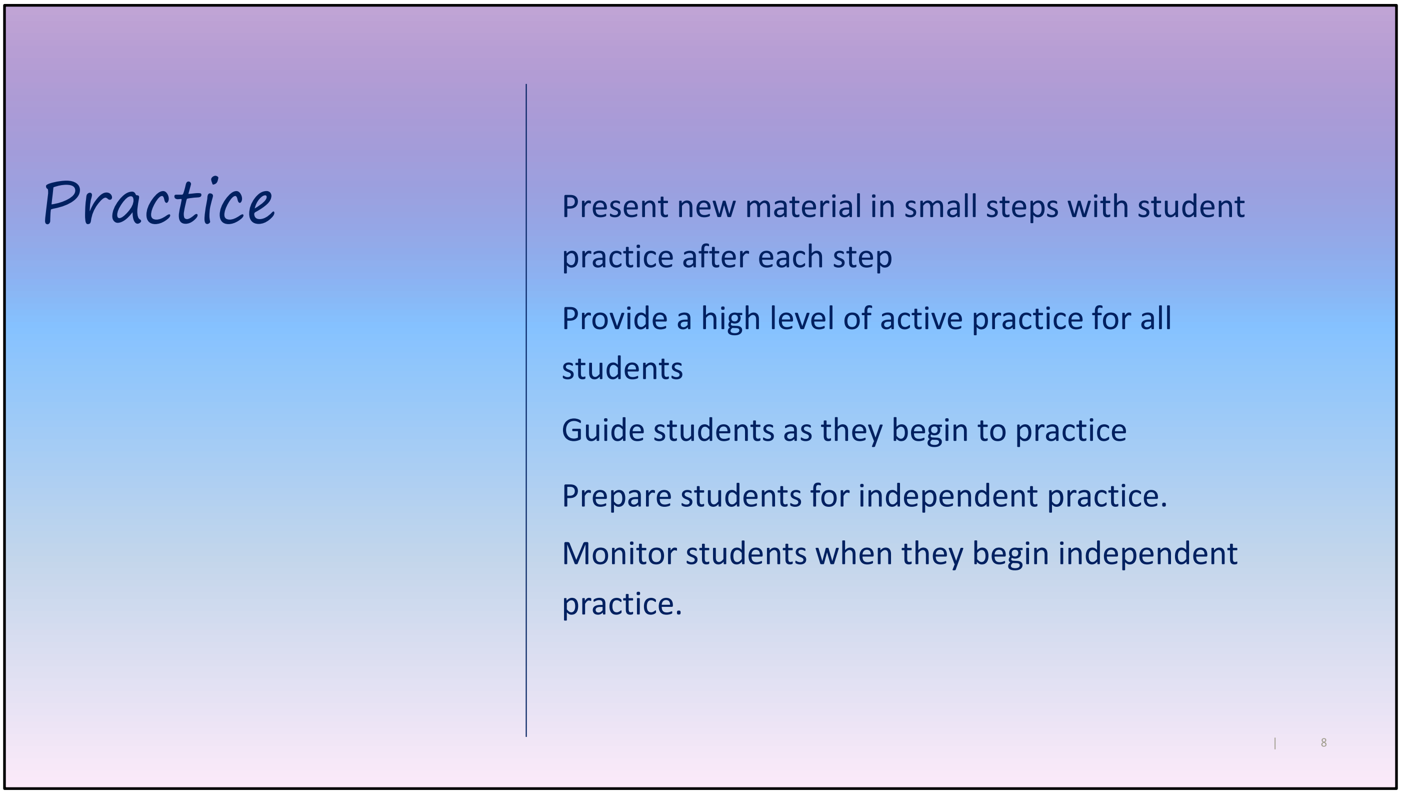
to a secure sequence, you might expect all elements of the Principles to feature in some form.



- Essential for us to check understanding, so we need to ask questions and make sure all students participate
- We need to scaffold carefully

Could do a whole session on just this…

So important – do it day in day out



- Practice essential and a large part of what we do.
- But we can’t just leave them to it, need to make sure they have had sufficient instruction and clear guidance.

A Model for **Great Teaching**

Great Teaching Toolkit
Evidence Review June 2020

04 Activating hard thinking

1. Structuring: giving students an appropriate sequence of learning tasks; signalling learning objectives, rationale, overview, key ideas and stages of progress; matching tasks to learners' needs and readiness; scaffolding and supporting to make tasks accessible to all, but gradually removed so that all students succeed at the required level

2. Explaining: presenting and communicating new ideas clearly, with concise, appropriate, engaging explanations; connecting new ideas to what has previously been learnt (and re-activating/checking that prior knowledge); using examples (and non-examples) appropriately to help learners understand and build connections; modelling/demonstrating new skills or procedures with appropriate scaffolding and challenge; using worked/part-worked examples

3. Questioning: using questions and dialogue to promote elaboration and connected, flexible thinking among learners (e.g., 'Why?', 'Compare', etc.); using questions to elicit student thinking; getting responses from all students; using high-quality assessment to evidence learning; interpreting, communicating and responding to assessment evidence appropriately

4. Interacting: responding appropriately to feedback from students about their thinking/ knowledge/ understanding; giving students actionable feedback to guide their learning

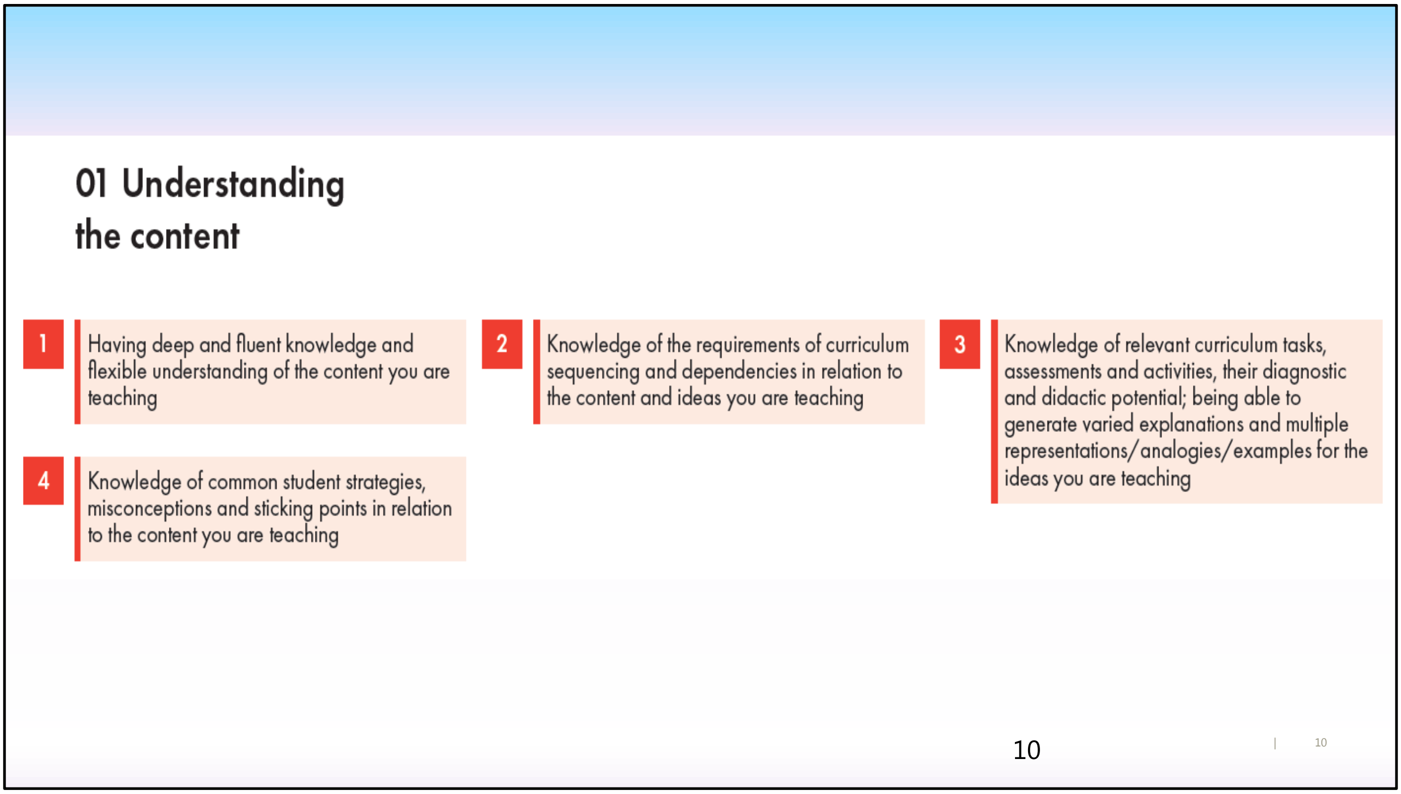
5. Embedding: giving students tasks that embed and reinforce learning; requiring them to practise until learning is fluent and secure; ensuring that once-learnt material is reviewed/revisited to prevent forgetting

6. Activating: helping students to plan, regulate and monitor their own learning; progressing appropriately from structured to more independent learning as students develop knowledge and expertise

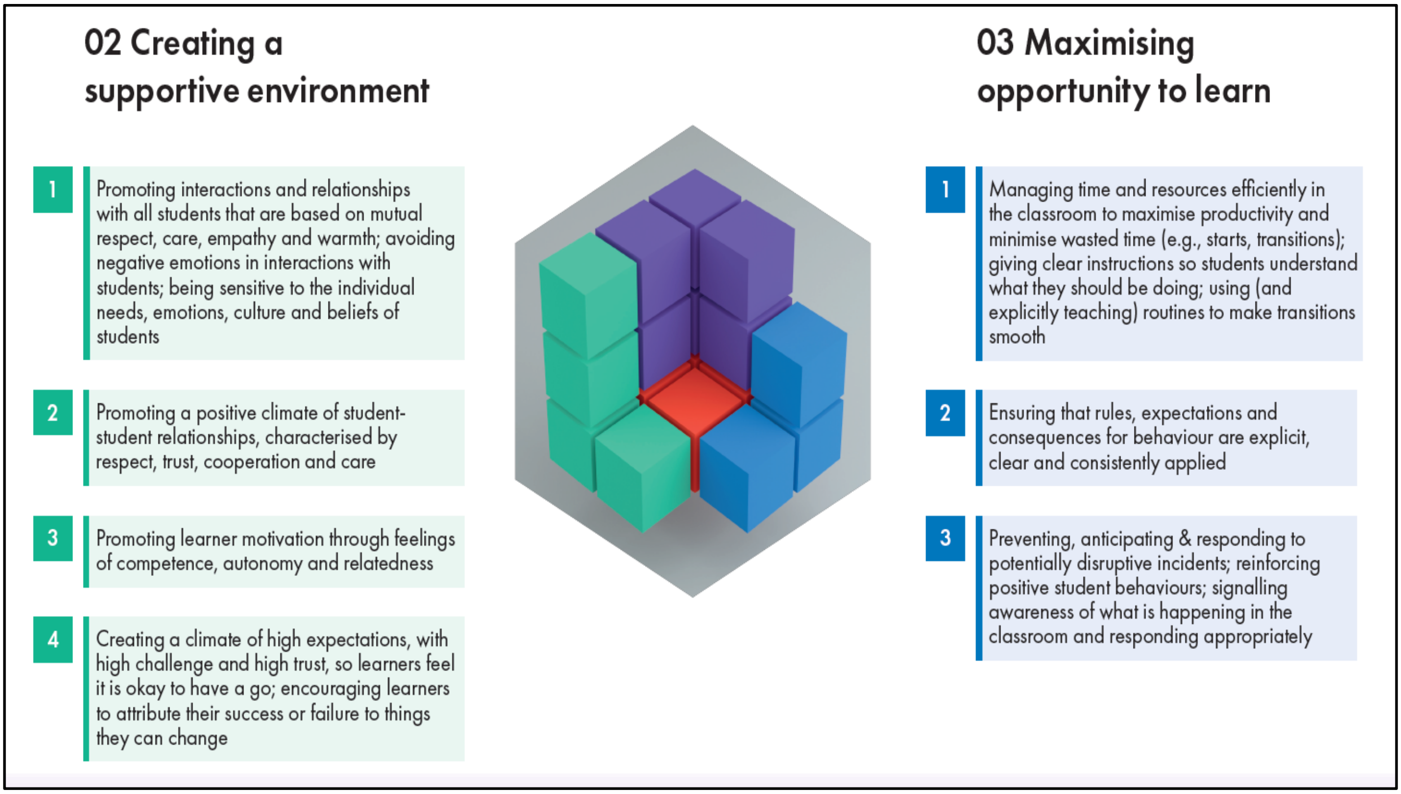
- In the Great Teaching Toolkit Evidence Review Professor Rob Coe and his team at Evidence Based Education have drawn from a wide range of research, examined hundreds of pieces of research on the links between teacher performance and student outcomes.
- What really makes a difference? What should teachers focus on?
- A model is presented in the paper with 4 dimensions, with 17 elements within those dimensions.
- An 'element' is defined as something that may be worth investing time and effort to work on to build a specific competency, skill or knowledge, or to enhance the learning environment.

Looking here at Dimension 4 – many links with Rosenshine here. In fact the review drew on much research including Rosenshine.

Look briefly at the elements



For me, dimensions 1 understanding the content and 4 activating hard thinking go hand in hand, we have to have that deep subject knowledge in order to explain it to our students.



- Just a mention of the other two dimensions of the toolkit.
- Clearly also key.

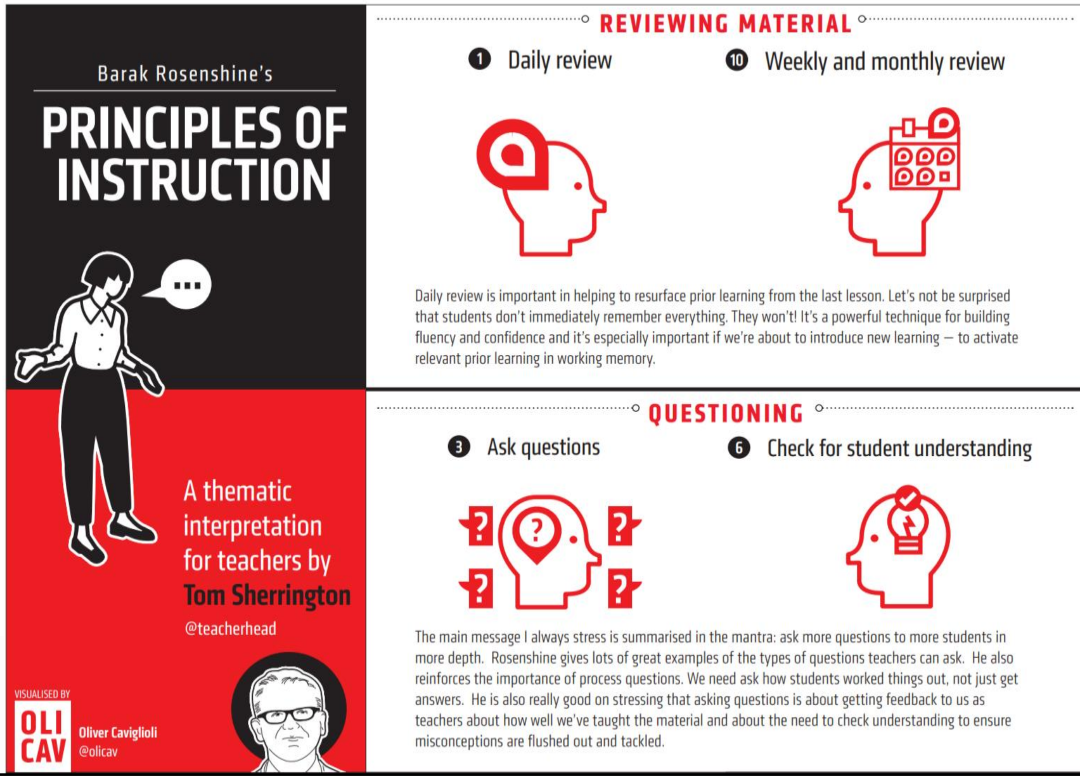
- These elements provide a useful summary.
- A supportive environment is crucial, Dylan Wiliam commented that without this you can forget all the research

- An article from the Dylan Wiliam centre in 2014:

- **when you know your students and your students trust you, you can ignore all the “rules” of feedback.**
- **Without that relationship, all the research in the world won’t matter.**

VISUAL CLARITY

https://www.olicav.com/



- The **10** principles are wonderfully presented in the very talented Oliver Caviglioli's poster. This makes a great summary.
- Do explore Oliver's website – many wonderful posters providing summaries of educational ideas – he is a master of sketchnoting.
- I sat next to him at a ResearchEd conference and saw the master at work – brilliant!

SEQUENCING CONCEPTS & MODELLING

2 Present new material using small steps

4 Provide models

8 Provide scaffolds for difficult tasks

Small steps – with practice at each stage. We need to break down our concepts and procedures (like multi-stage maths problems or writing) into small steps so that each can be practised.

Models – including the importance of the worked-example effect to reduce cognitive load. We need to give many worked examples; too often teachers give too few.

Scaffolding is needed to develop expertise – a form of mastery coaching, where cognitive supports are given – such as how to structure extended writing – but they are gradually withdrawn. The sequencing is key. Stabilisers on a bike are really powerful aids to the learning and confidence building – but eventually they need to come off.

STAGES OF PRACTICE

5 Guide student practice

7 Obtain a high success rate

9 Independent practice

Teachers need to be up close to students' initial attempts, making sure that they are building confidence and not making too many errors. This is a common weakness with 'less effective teachers.' Guided practice requires close supervision and feedback.
High success rate – in questioning and practice – is important. Rosenshine suggests the optimum is 80%. i.e. high! Not 95-100% (too easy). He even suggests 70% is too low.

Independent, monitored practice. Successful teachers make time for students to do the things they've been taught, by themselves... when they're ready. *"Students need extensive, successful, independent practice in order for skills and knowledge to become automatic"*

Instruction

Present new material in small steps with student practice after each step

Limit the amount of material students receive at one time

Give clear and detailed instructions and explanations

Think aloud and model steps

Use more time to provide explanations

Provide many examples

Reteach material when necessary

Great Teaching Toolkit Elements
1. Understanding the content 1, 2, 3, 4
4. Activating hard thinking
1: Structuring and 2: Explaining

Questioning

Ask a large number of questions and check for understanding.

Ask students to explain what they have learned.

Check the responses of all students.

Provide systematic feedback and corrections.

Great Teaching Toolkit Elements
4. Activating hard thinking
3: Questioning and 4: Interacting

Review

Daily review

Begin a lesson with a short review of previous learning

Weekly and Monthly review

Reteach material when necessary

Great Teaching Toolkit Elements
4. Activating hard thinking
5: Embedding

Practice

"In one study the more successful teachers of mathematics spent more time presenting new material and guiding practice. The most successful teachers used this extra time to provide additional explanations, give many examples, check for student understanding, and provide sufficient instruction so that the students could learn to work independently without difficulty"

Present new material in small steps with student practice after each step

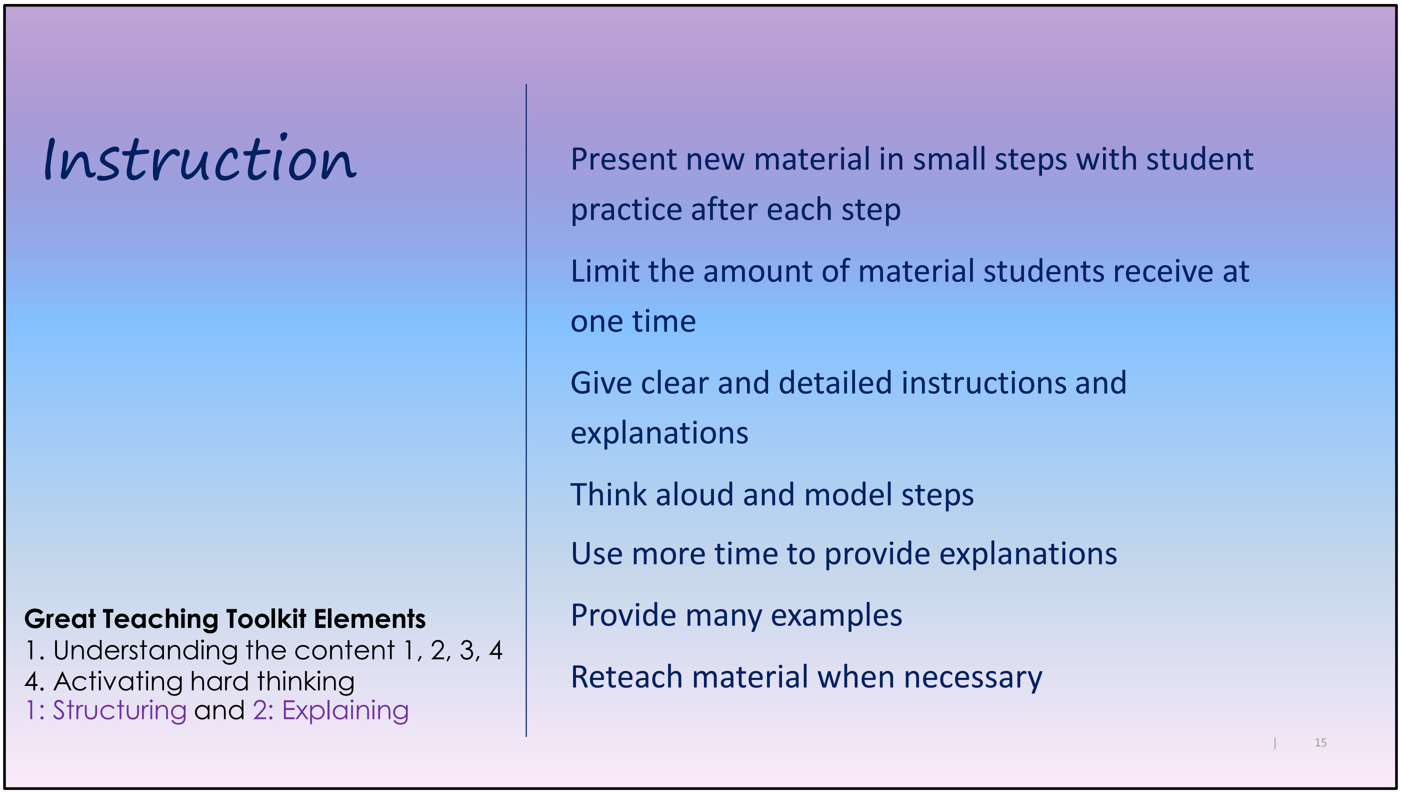
Provide a high level of active practice for all students

Guide students as they begin to practice

Prepare students for independent practice.

Monitor students when they begin independent practice.

Great Teaching Toolkit Elements
4. Activating hard thinking
5: Embedding and 6: Activating



- So let’s look at each theme and consider what we do in Maths.
- Just look at that list, it really is perfect for Maths teaching!
- We all provide many examples, do we provide enough? Could explanations be clearer? What can we use to help make our explanations clearer.
- Rosenshine on the right hand side, to reference the Great Teaching Toolkit elements all the elements of Dimension 1 are essential, clearly we need to have a deep understanding of the content. From Dimension 4 I’d say the relevant elements here are 1 Structuring and 2 explaining

1. Understanding the content

1 Having deep and fluent knowledge and flexible understanding of the content you are teaching

2 Knowledge of the requirements of curriculum sequencing and dependencies in relation to the content and ideas you are teaching

3 Knowledge of relevant curriculum tasks, assessments and activities, their diagnostic and didactic potential; being able to generate varied explanations and multiple representations /analogies/examples for the ideas you are teaching

4 Knowledge of common student strategies, misconceptions and sticking points in relation to the content you are teaching

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- Here we see Understanding the content.
- To present the material in small steps we clearly need to know about sequencies and dependencies in our content. We need to know that subject content inside out.
- Very helpful that for Maths at GCSE and A Level the subject content is the same – I use material from all the examination boards.

4. Activating hard thinking

1 Structuring: giving students an appropriate sequence of learning tasks; signalling learning objectives, rationale, overview, key ideas and stages of progress; matching tasks to learners' needs and readiness; scaffolding and supporting to make tasks accessible to all, but gradually removed so that all students succeed at the required level

2 Explaining: presenting and communicating new ideas clearly, with concise, appropriate, engaging explanations; connecting new ideas to what has previously been learnt (and re-activating/checking that prior knowledge); using examples (and non-examples) appropriately to help learners understand and build connections; modelling/ demonstrating new skills or procedures with appropriate scaffolding and challenge; using worked/part-worked examples

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- From the toolkit, you can see the detail for activating hard thinking – structuring and explaining.
- Good descriptions of what we need to do

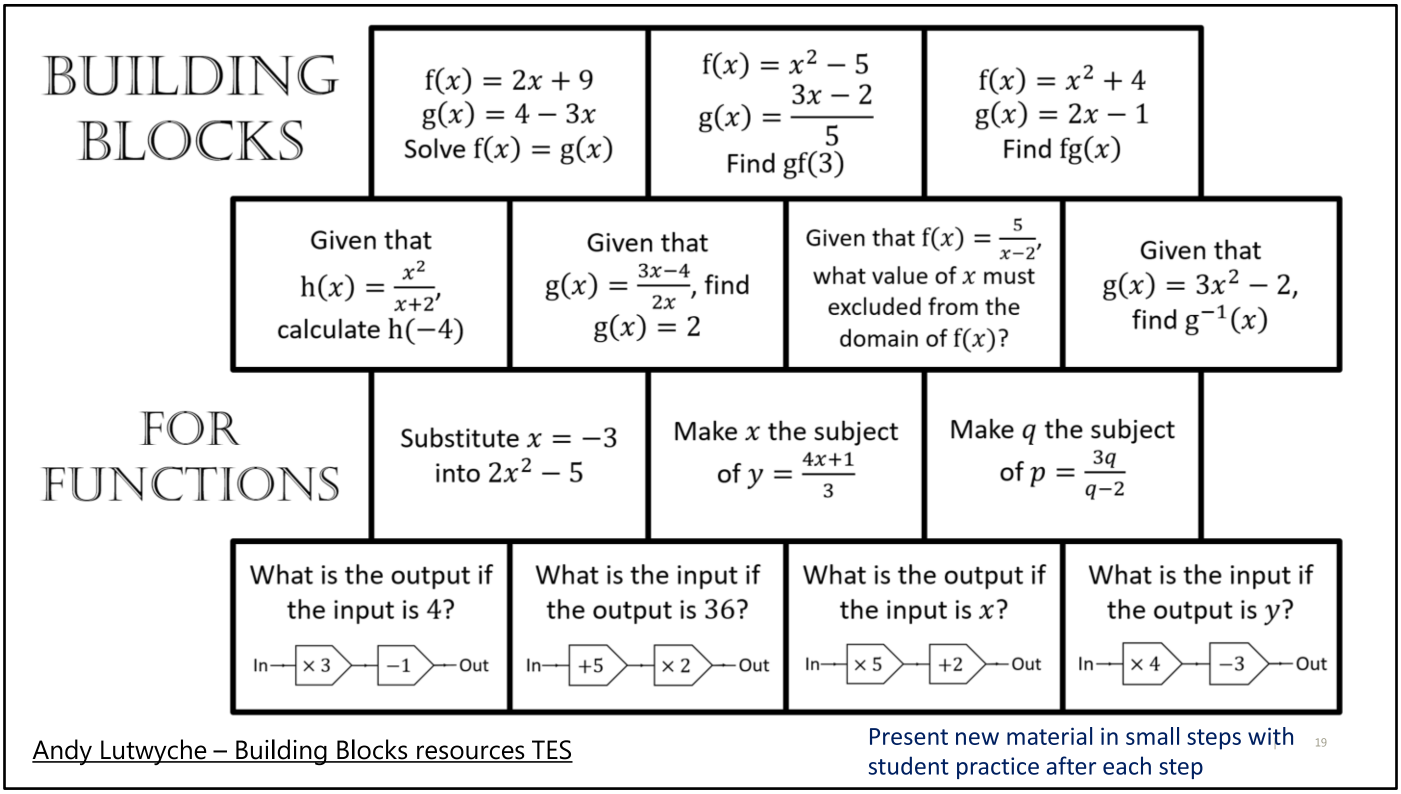
Small Steps…requires time

“In a study of mathematics instruction, for instance, the most effective mathematics teachers spent about 23 minutes of a 40-minute period in lecture, demonstration, questioning and working examples.

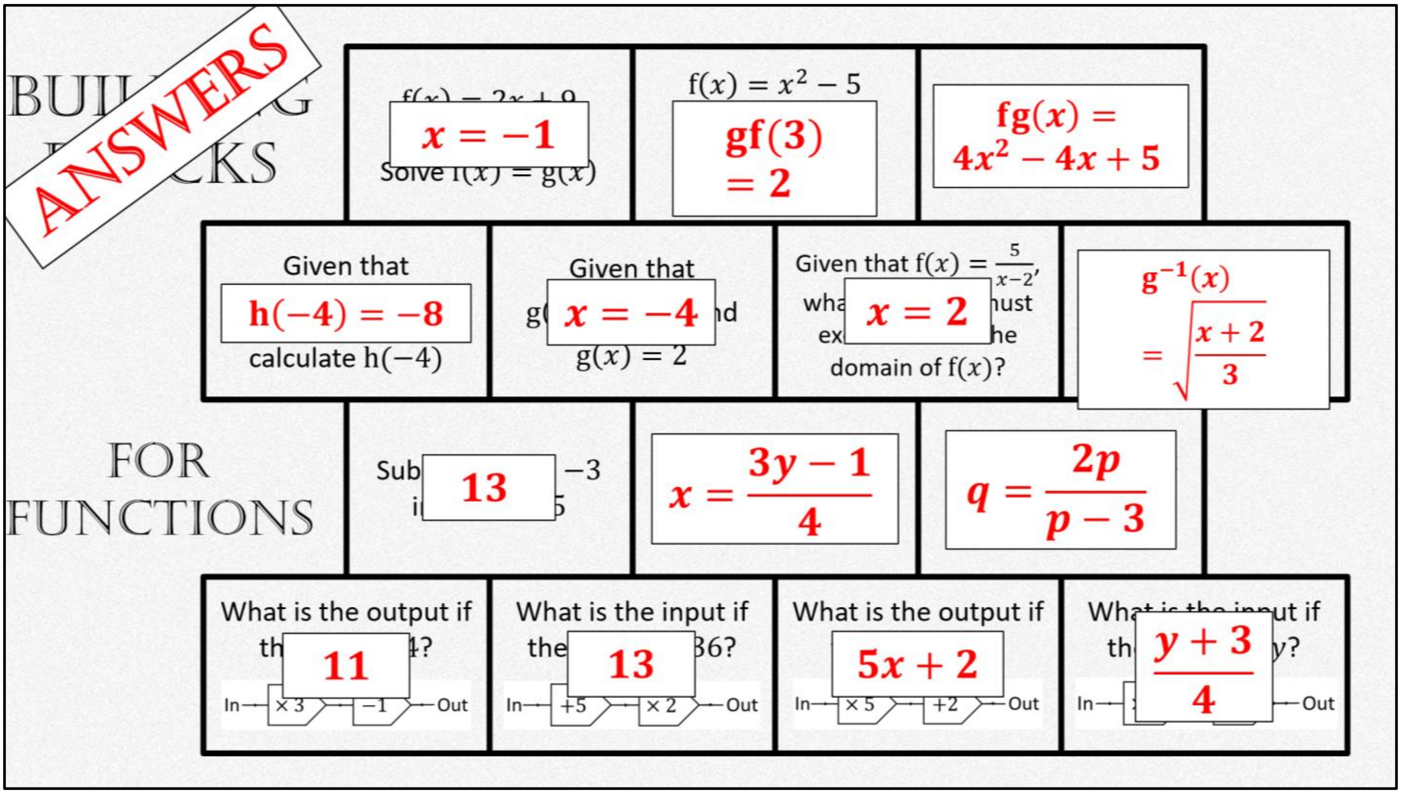
The most effective teachers used this extra time to provide additional explanations, give many examples, check for student understanding, and to provide sufficient instruction so that students could learn to work independently.”

Principles of Instruction: research-based strategies that all teachers should know (2012) American Educator

- Presenting new material in small steps requires time.
- You can see the comments (on slide) in the paper referenced earlier on the research. Effective teaching includes much input from the teacher. The teacher takes the time to provide explanations and respond to the students’ needs.



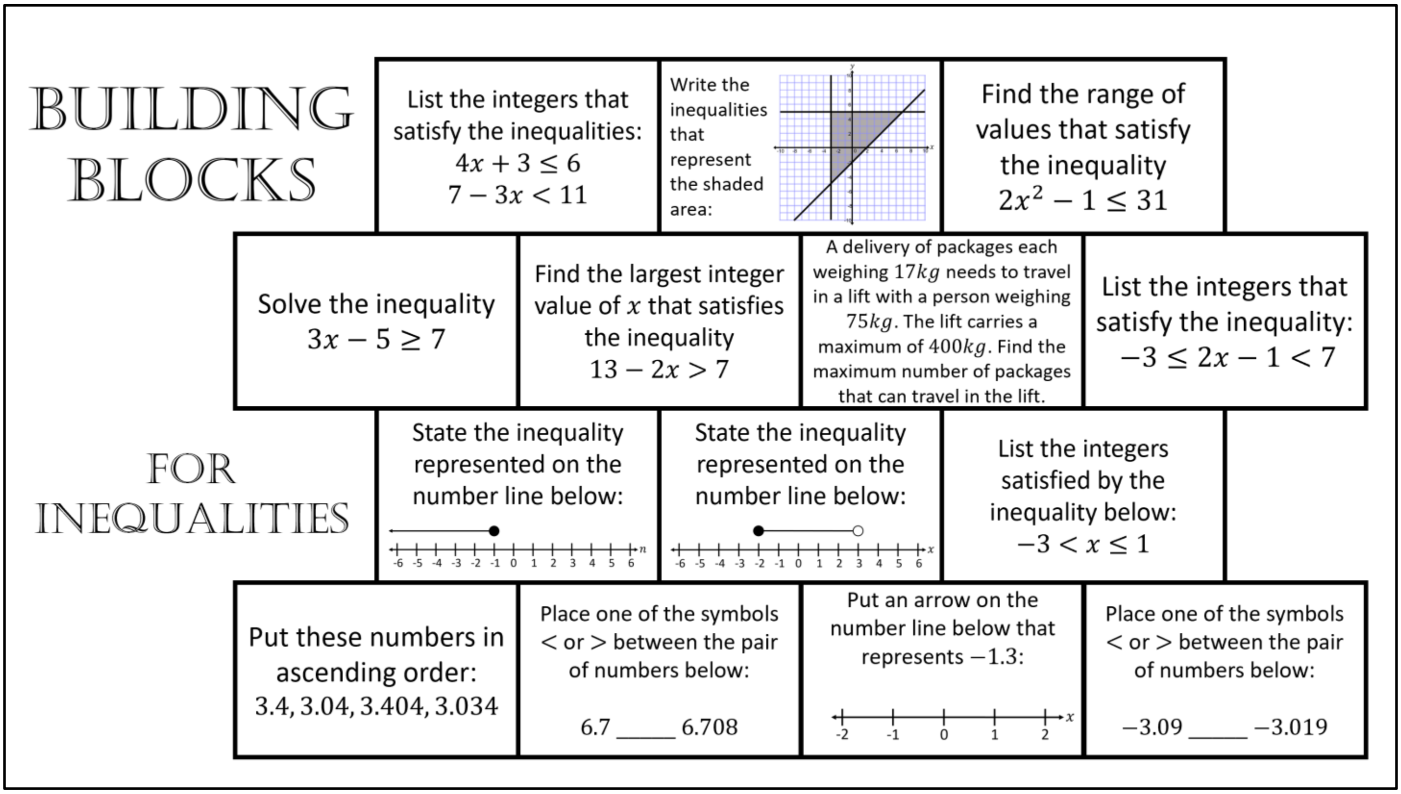
- Small Steps
- An absolute favourite TES resource author. Andy's resources are outstanding and all individual resources are free. He has a whole series of Building blocks resources, reminding us and the students of the small steps needed for a topic and how each builds on the next. If you are thinking about – what are the small steps for a given topic then these resources can be valuable.
- You can see functions illustrated, all of the same format, basics at the base eventually building to composite functions – great for revision for GCSE



- He always provides the answers – so useful for busy teachers.

- Before showing the next example – let's think about Inequalities.

- If you were designing a series of Building Blocks questions What are the small steps? What would you include – where would you start?



- A very good example here for inequalities.

ANSWERS

BUIL[...]NG [...]CKS FOR INEQUALITIES

List the integers that sa[...]es:

$-1, 0$

$7 - 3x < 11$

Write the ine[...] tha[...] rep[...] the area:

$y \geq x - 2$

$y \leq 5$

$x \geq -3$

Find the range of

$-4 \leq x \leq 4$

$2x^2 - 1 \leq 31$

Sol[...]lity

$x \geq 4$

Find[...]eger valu[...]sfies

$x < 3$

so 2

A delivery of packages each weighing $17kg$ needs to travel in a lift[...]eighing 75[...]s a maxim[...] the maximum number of packages that can travel in the lift.

19

List the integers that s[...]:

$-1, 0, 1, 2, 3$

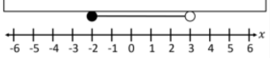
$-3 \leq 2x - 1 < 7$

State the inequality re[...] nu[...]w:

$n \leq -1$

State the inequality represented on the

$-2 \leq x < 3$



List the integers

$-2, -1, 0, 1$

$-3 < x \leq 1$

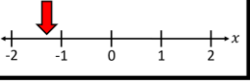
$3.034, 3.04$

$3.4, 3.404$

Place one of the symbols $<$ or $>$ between the pair of numbers below:

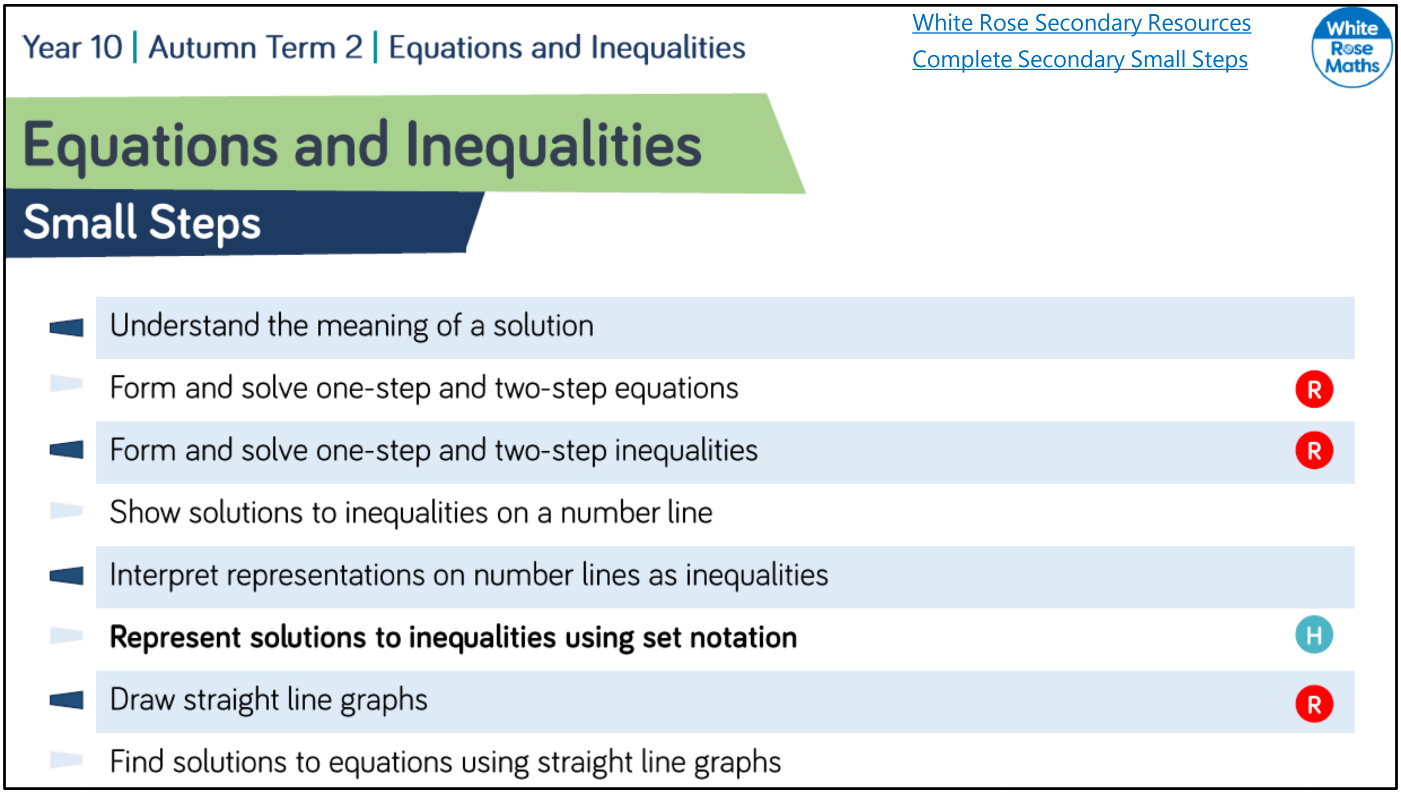
6.7 $\underline{<}$ 6.708

Put an arrow on the number line below that represents -1.3:

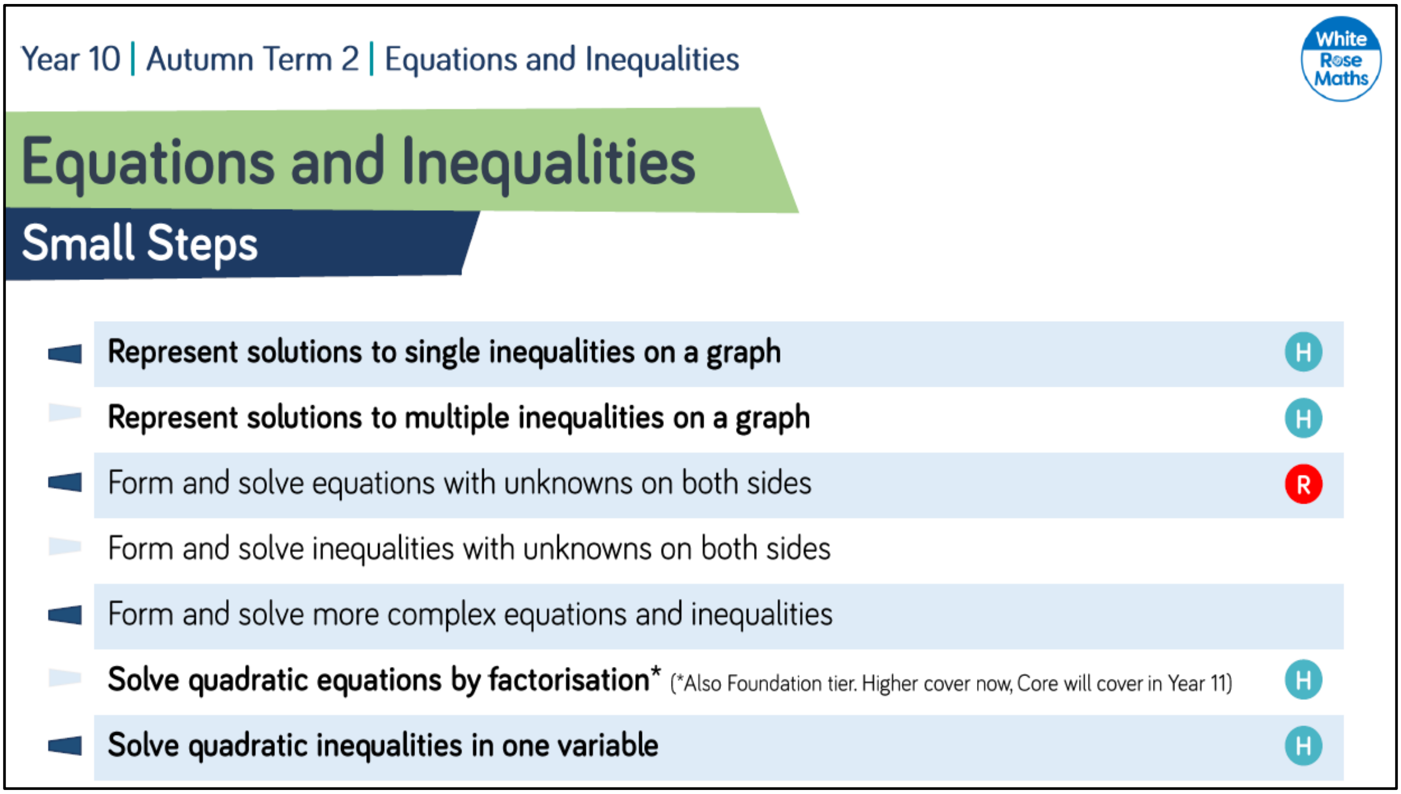


Place one of the symbols $<$ or $>$ between the pair of numbers below:

-3.09 $\underline{<}$ -3.019



- You may be familiar with the White Rose schemes of work.
- Whatever schemes you do use, their ‘Small Steps’ help us think about breaking a topic down.
- A document of small steps is available on the White Rose website for Years 7-11 (Primary also)
- **“What are the baby steps Mrs Young?” (Sixth form student)**



- White Rose schemes of work very detailed with many examples

Instruction

Present new material in small steps with student practice after each step

Limit the amount of material students receive at one time

Give clear and detailed instructions and explanations

Think aloud and model steps

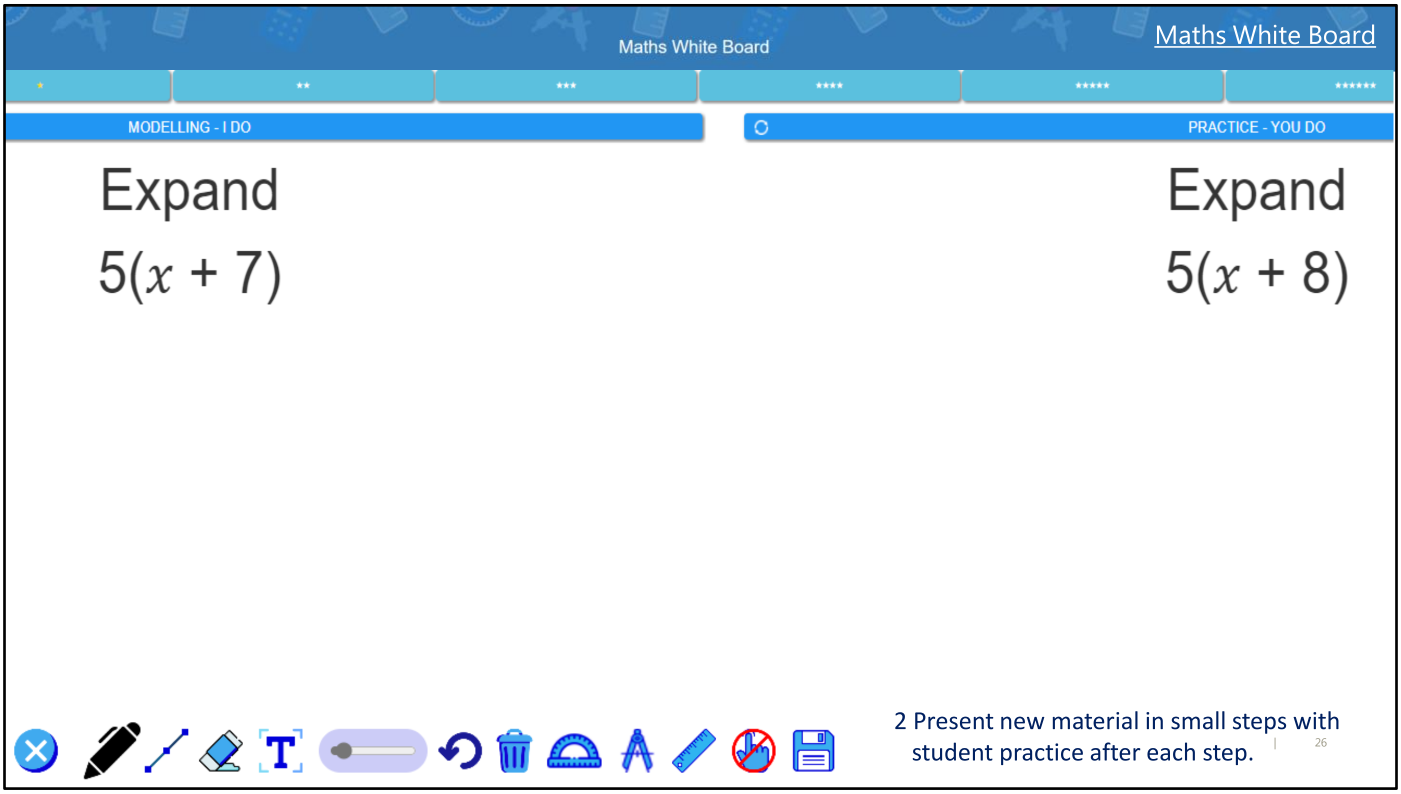
Use more time to provide explanations

Provide many examples

Reteach material when necessary

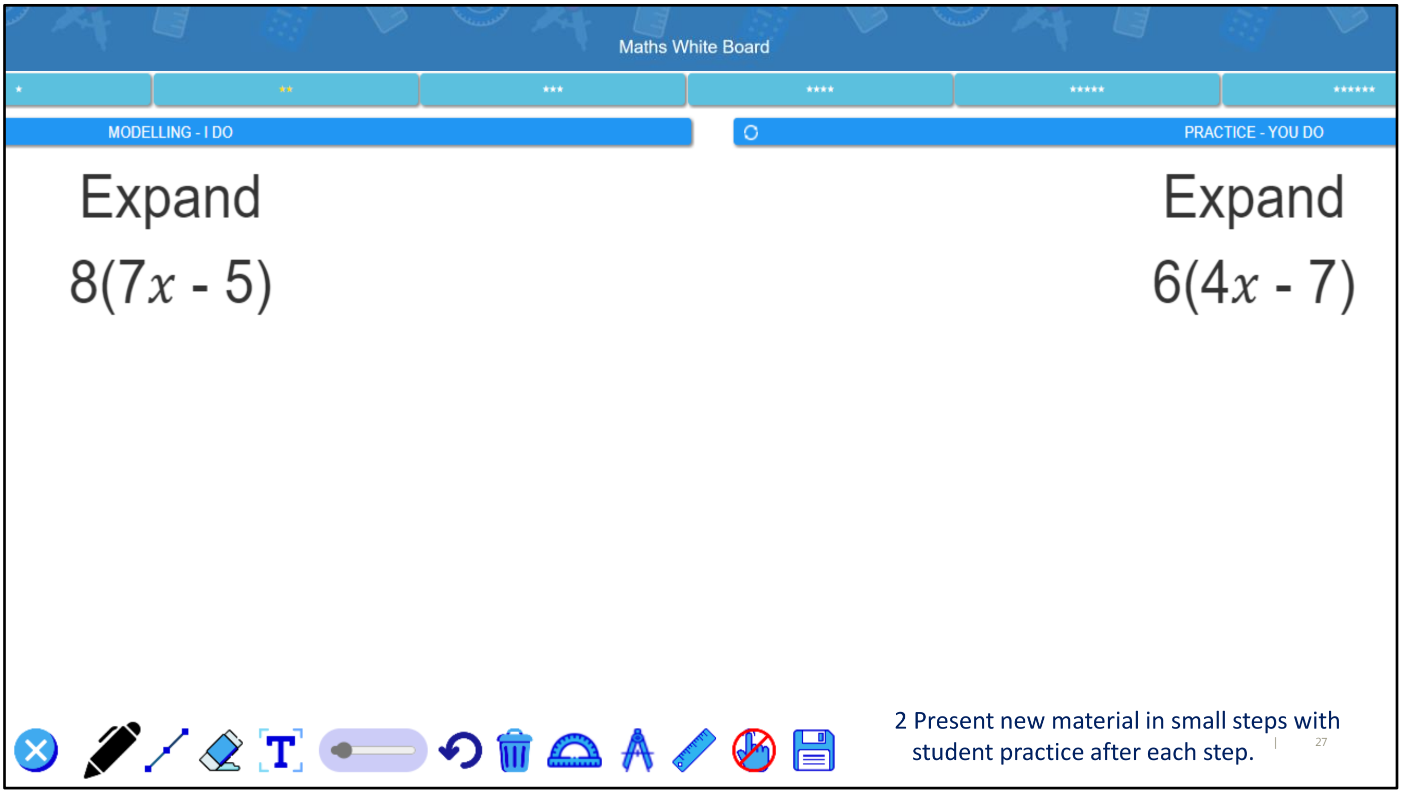
| 25

- A reminder of the of Rosenshine's principles we are considering here.
- Let's think further about presenting new material in small steps with student practice after each step.

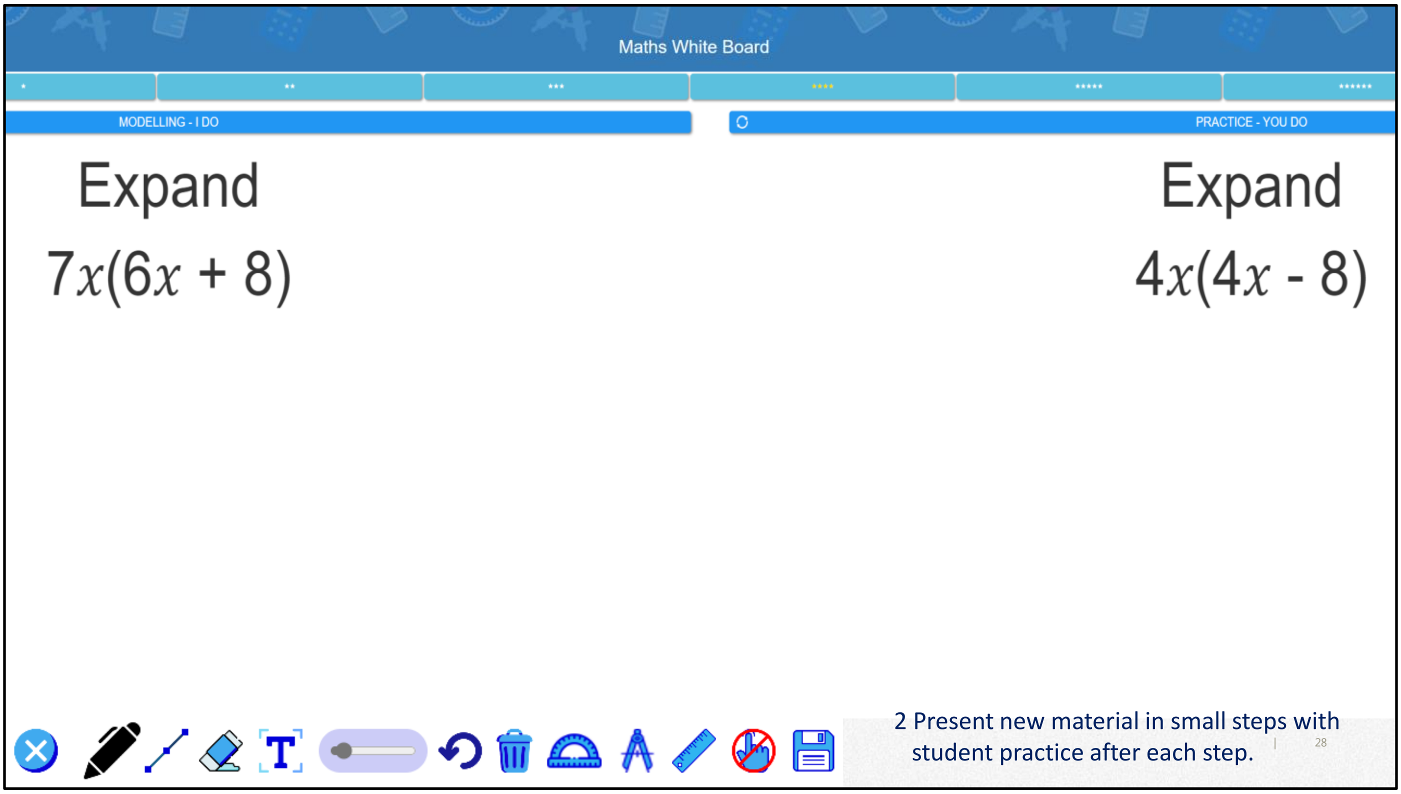


- I do / you do very effective
- Teacher modelling and thinking aloud whilst demonstrating how to solve a problem are effective examples of reducing cognitive load.
- Rosenshine paper: “Modelling and worked examples have been effectively used in mathematics, science, writing and reading comprehension” mathematics right up there – it’s what we

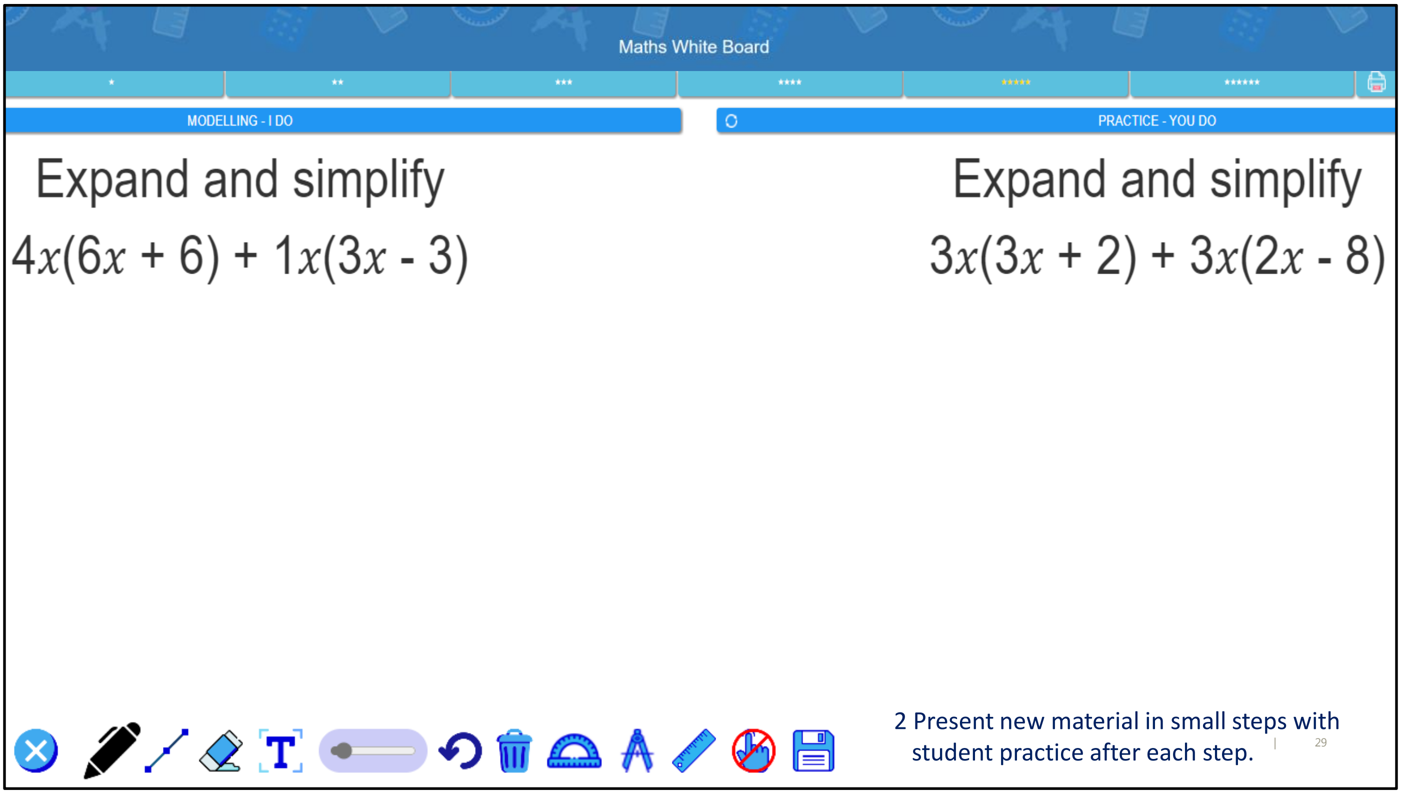
do!



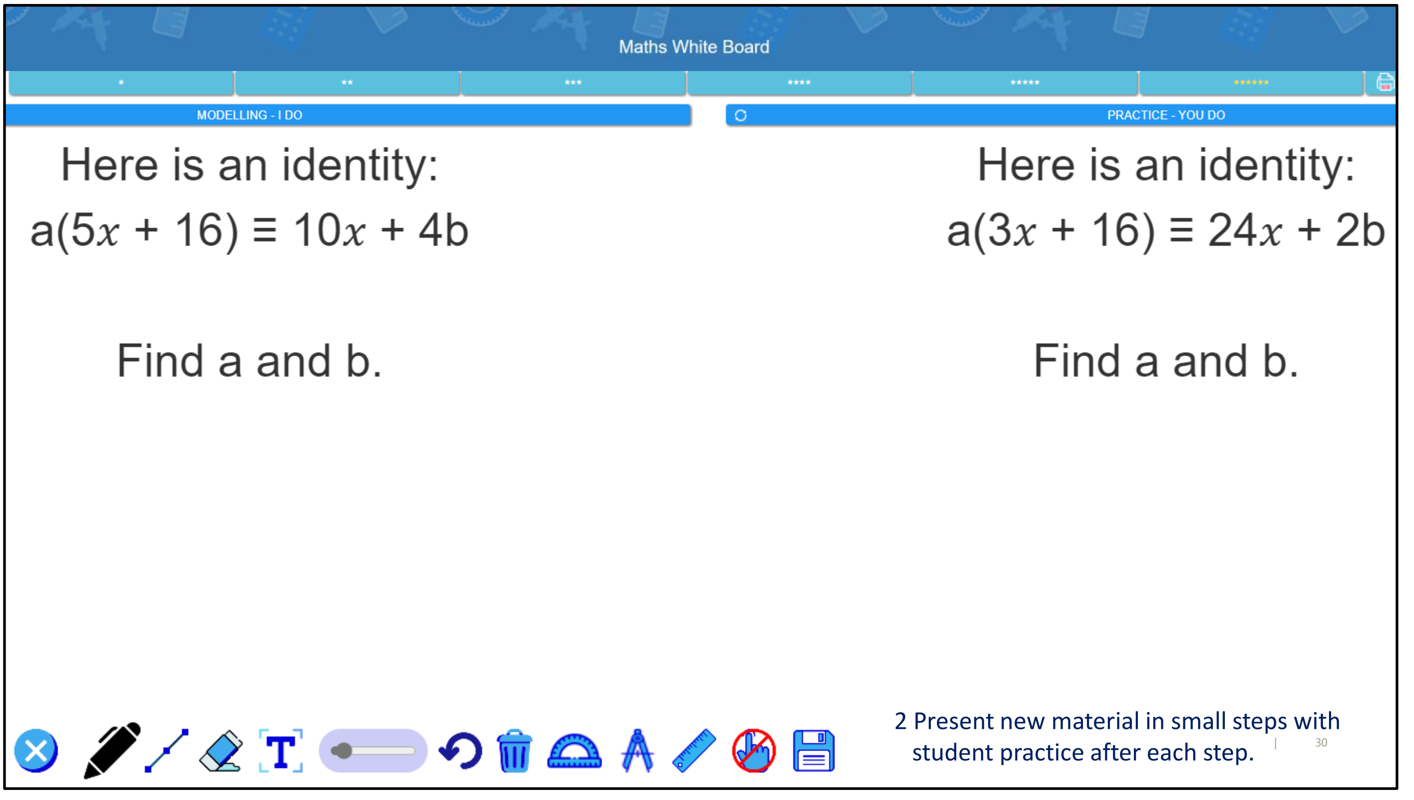
- You are looking at Matt Woodfine’s brilliant Maths White Board, all free and continually more content being added to the already extensive collection
- Note the dots at the top – increasing levels of demand



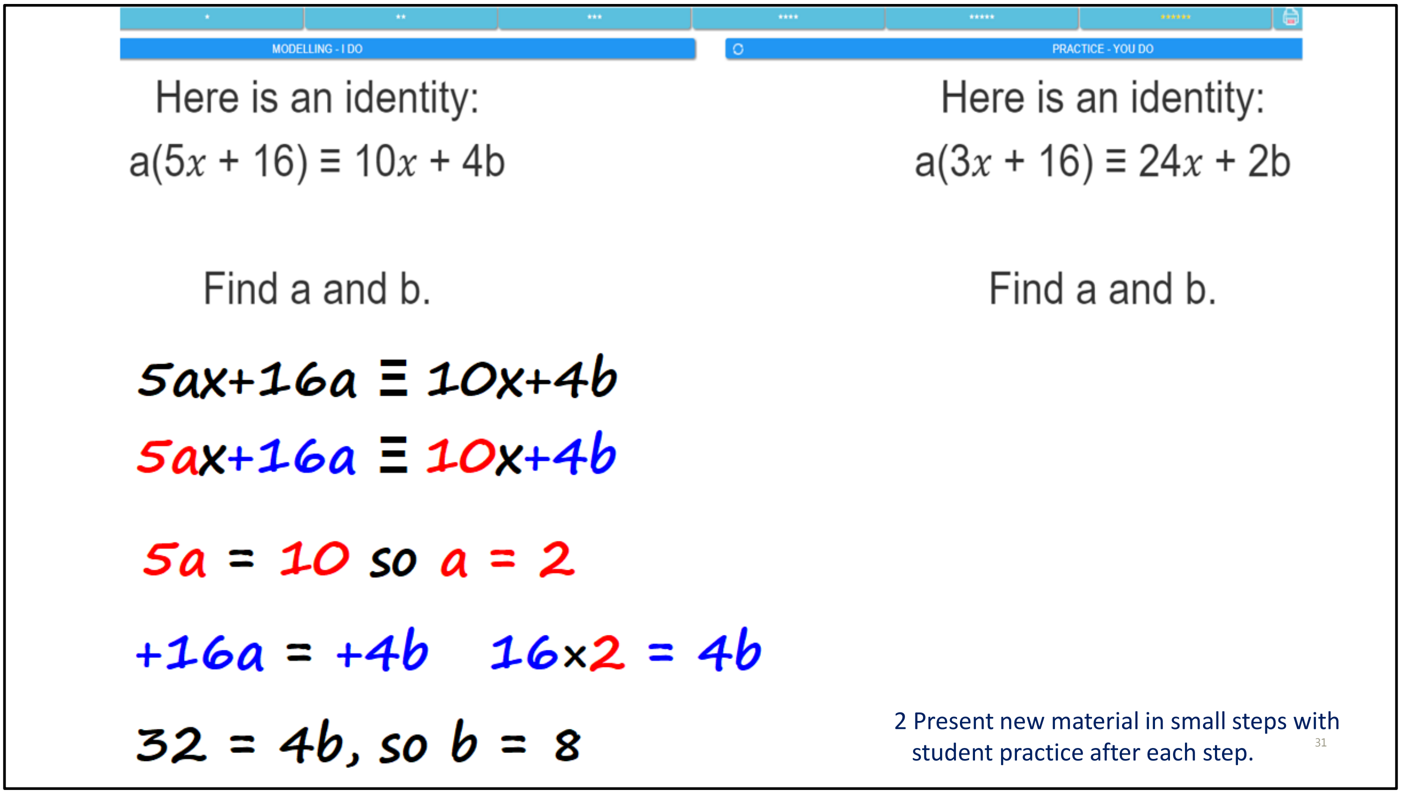
- You can see the gradual increase in demand
- Teacher models, students try a similar example



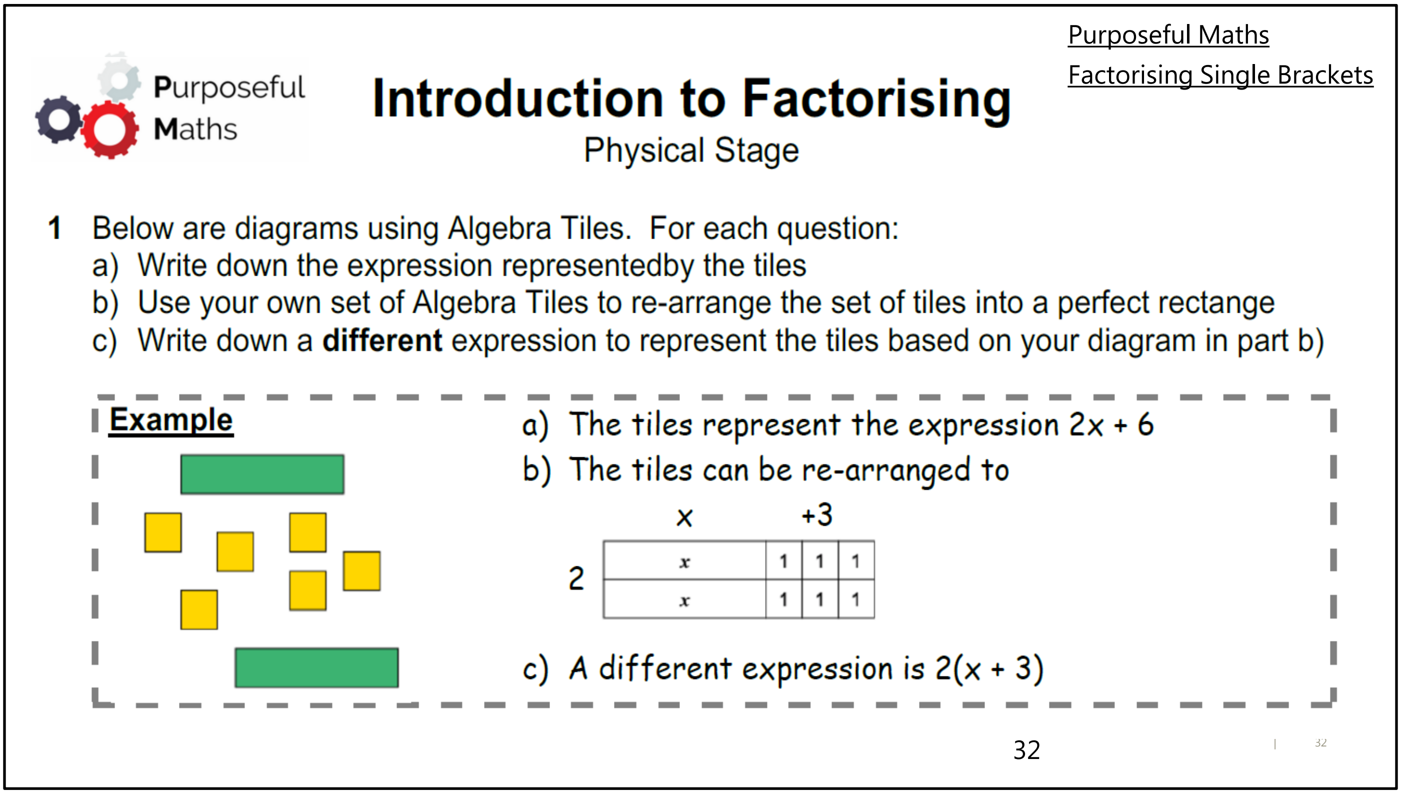
- 4 dots
- Refresh for another example



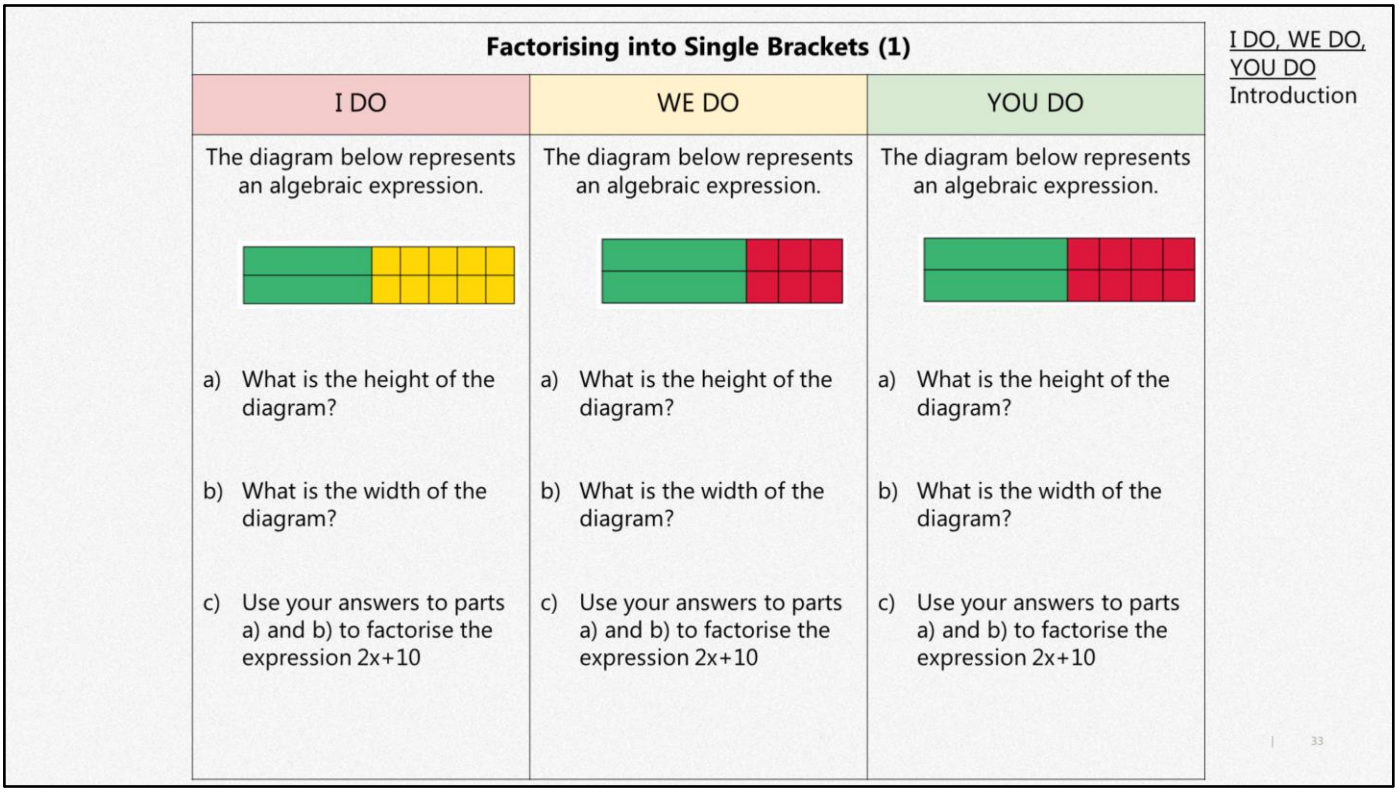
- Here we have the highest level of demand – something students find tricky and certainly seen at higher level GCSE



- Note my use of colour here.
- Thinking about giving clear explanations – something I do a lot is to use colour for clarity in explanations
- The coefficients of x are in red and the constant terms are in blue

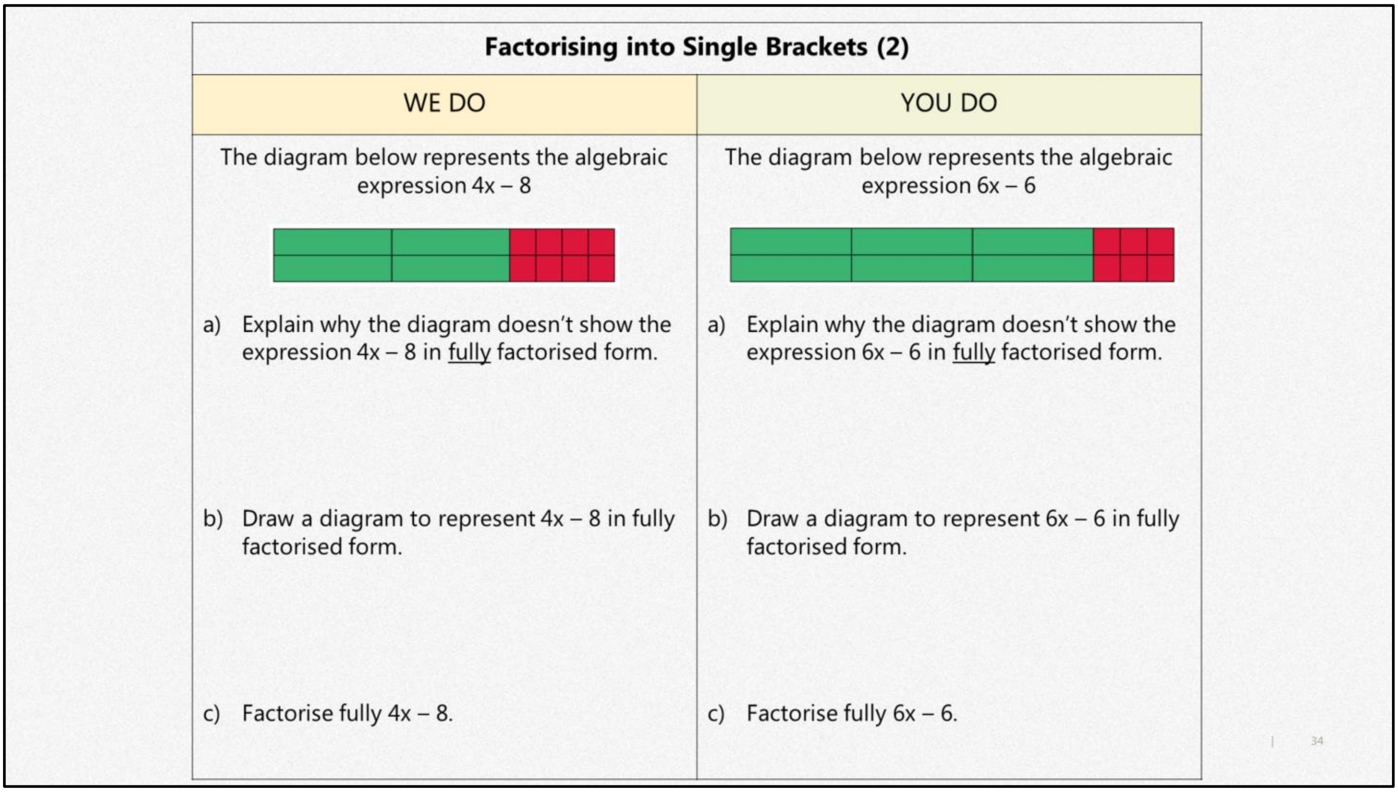


- Still thinking about – small steps with student practice after each step
- New site Purposeful Maths from Phil Bruce and Martin Green
- A library of resources, many of which are in their I do/we do/you do format which you will see on the next slide.
- Before we look at that I just wanted to show the associated resource for Introduction to Factorising, the authors suggest a Physical stage with students using algebra tiles to illustrate expressions



Thinking about presenting examples – this I do, you do approach works really well.
Helpful diagrams – visualisation wherever possible.

From their blog "This is where the IDWDYD resource idea was born. We wanted something to force us to use the silent teacher approach (reference to Craig Barton) (I DO), a further example we could use to check pupil's understanding (WE DO), then a short burst of independent practice to consolidate the new learning idea (YOU DO)."



Continuing with examples
we do/you do

We do phase – can discuss with students – ask questions

Factorising into Single Brackets (3)

I DO	WE DO	YOU DO
Draw a diagram to represent the expression 2x+6. Make the diagram as tall as possible.	Draw a diagram to represent the expression 3x+6. Make the diagram as tall as possible.	Draw a diagram to represent the expressions below. Make each diagram as tall as possible. a) $2x - 6$ b) $3x - 6$ c) $3x - 9$ d) $4x - 12$

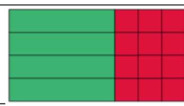
This time aim at students must draw the diagrams given the expressions.

Factorising into Single Brackets (4)		
I DO	WE DO	YOU DO
Draw a diagram to represent the expression 4x+6. Make the diagram as tall as possible.	Draw a diagram to represent the expression 6x+8. Make the diagram as tall as possible.	Draw a diagram to represent the expressions below. Make each diagram as tall as possible. a) 6x – 8 b) 6x – 10 c) 9x – 12

Factorising Single Brackets

Pictorial Stage

1 Complete the table below. Use a set of Algebra Tiles to help you. An example has been done for you.

Expression	HCF	Diagram	Height of Diagram	Length of Diagram	Factorised Expression
$2x + 6$	HCF of $2x$ and 6 is 2		2	x + 3	2(x + 3)
$2x + 8$					
$2x + 12$					
$3x + 12$			3		
$4x + 12$					
$4x - 12$	HCF of $4x$ and -12 is 4				
$12 - 4x$			4		
$12 - 6x$					

- Completion tasks. Effective teachers provide many worked examples, gradually reduce the level of completion.
- Partially completed examples also reduces cognitive load. Effective technique.
- Resource shows a very effective sequence of examples

Worked Example	Your Turn
	Berwick Maths
Expand and simplify $2(x+3)+3(x+2)$	Expand and simplify $4(x+3)+5(x+4)$
	2 modelling/demonstrating new skills or procedures with appropriate scaffolding and challenge; using worked/part-worked examples
Expand and simplify $6(x+1)-2(x+2)$	Expand and simplify $8(x+2)-5(x+3)$
2 Present new material in small steps with student practice after each step.	

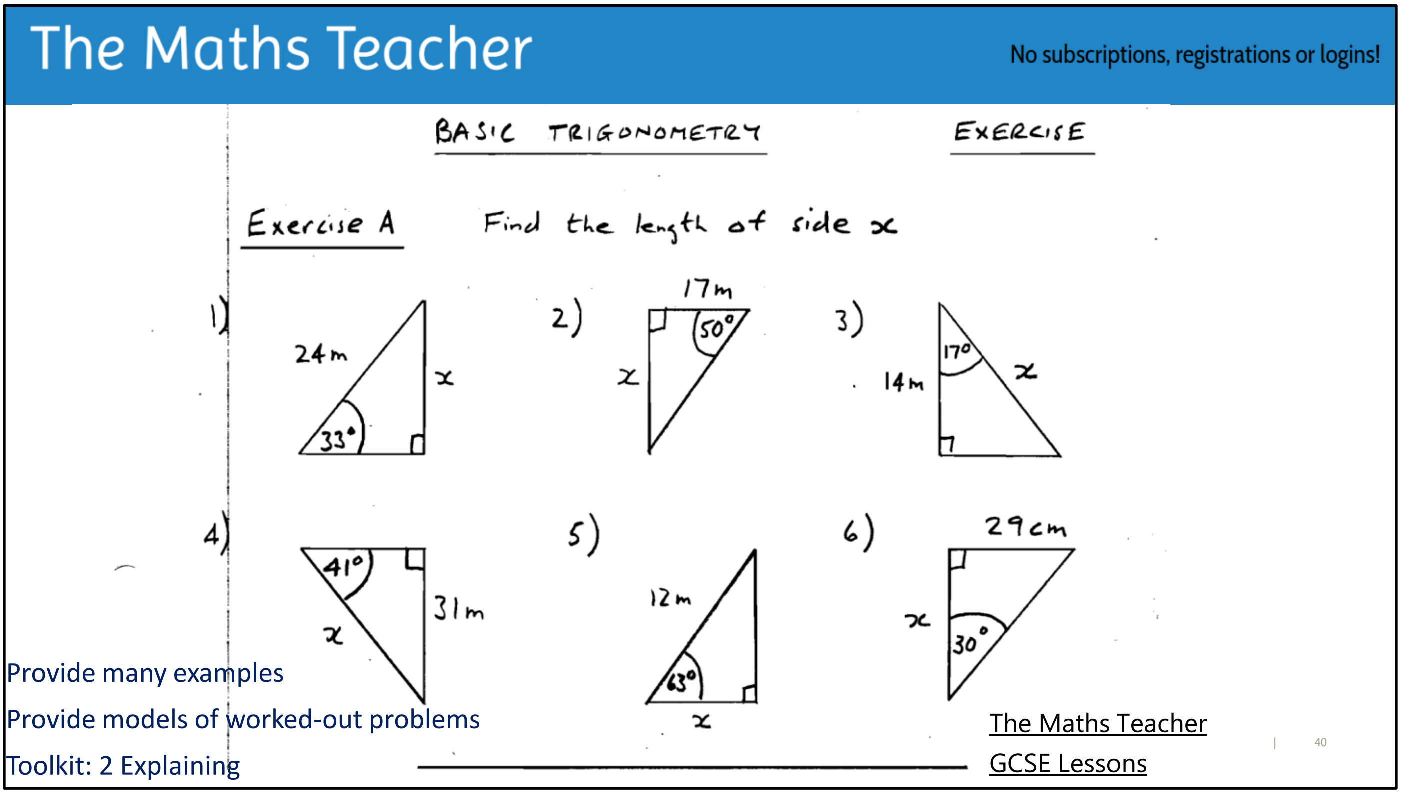
- Thinking about presenting examples – this I do, you do approach works really well. On Joe Berwick's Berwickmaths you can find many such examples with an explanation of how he uses these.
- Craig Barton also discusses this kind of approach in his book How I Wish I'd Taught Maths.
- Board divided into 2 – you do it, they do it. Try in silence, so they all have a go individually.

- **Discussion** – do you use this approach in class – do you find any particular approach works well. Do students copy the worked example so they have a record in their books?

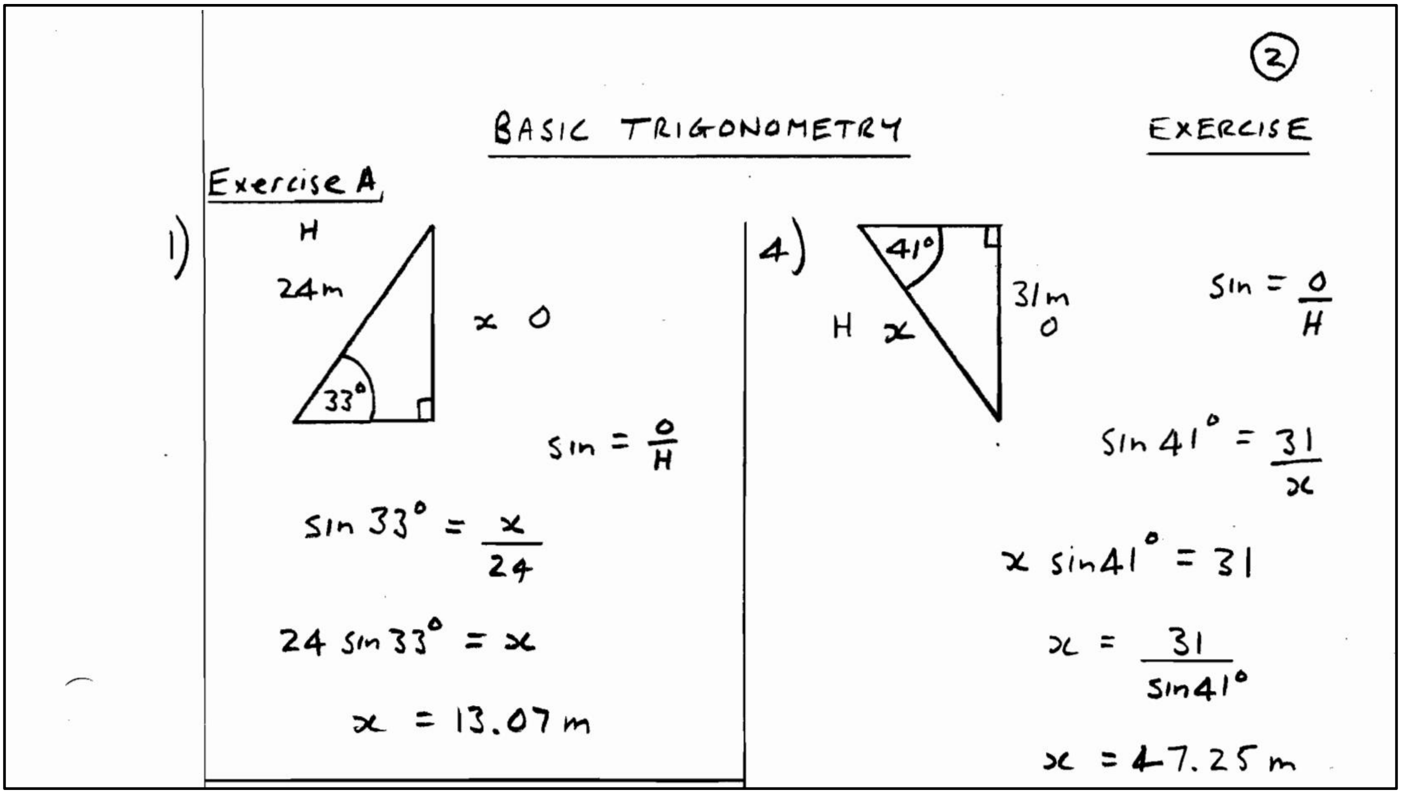
Worked Example	Reflection	Example by Fading	Your Turn
Solve $5x + 7 = 2x + 31$	Why did I subtract $2x$ from each side? Why did I not subtract $5x$ from each side? How many DBRS processes are there?	**Solve** $5x + 7 = 2x + 22$ **Decide** $(-2x)$ **Repair and Simplify Equation** $5x + 7 - 2x = 2x + 22 - 2x$ **Simplify** $3x + 7 = 22$	**Solve** $5x + 7 = 3x + 23$ $\boldsymbol{x = 8}$
Solve $2x - 23 = 7 - x$	Why did I add x to each side? Why did I not subtract $2x$ from each side? How many DBRS processes are there?	**Solve** $2x - 23 = 9 - 2x$ **Decide** $(+2x)$ **Repair and Simplify Equation** $2x - 23 + 2x = 9 - 2x + 2x$ **Simplify** $4x - 23 = 9$	**Solve** $2x - 23 = 12 - 3x$ $\boldsymbol{x = 7}$

- He also has many example where students reflect on the steps as you can see in this example.
- Get them discussing each step – why subtract 2x, not 5x from both sides?

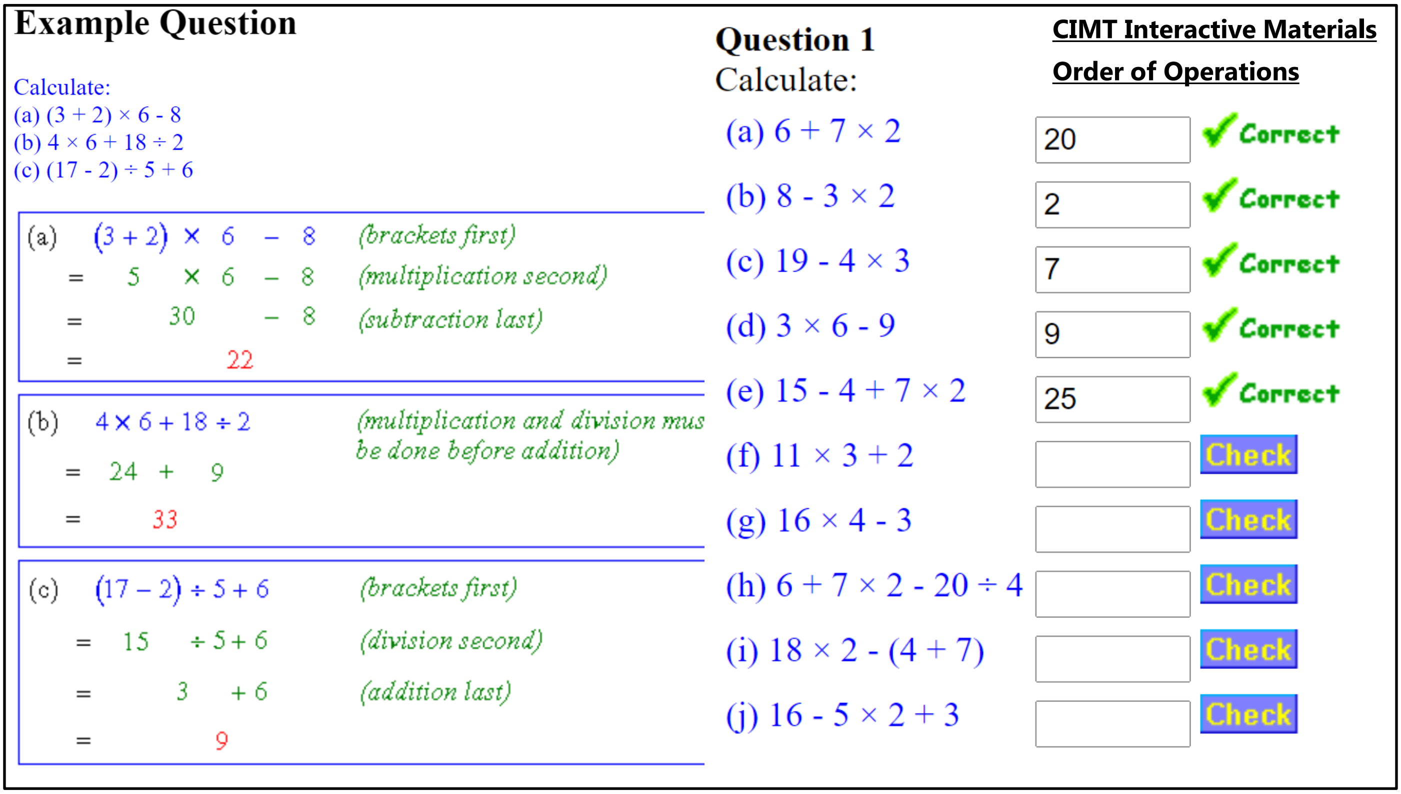
- In case you are wondering about the solve/decide terms, Jo Berwick's approach to solving equations (blog) (Chris Bouton)
- For example, solving the equation 5x+7=2x+22. To do this, we ask students how we get to x on one side only (DECIDE). We BREAK the equation by doing 5x+7-2x=2x+22-2x and then REPAIR and simplify.



- We have so many great resources for providing examples
- I use many Maths resources with students and it can be surprising what they like.
- David Smith's The Maths Teacher.
- I like his No subscriptions, registrations or logins!

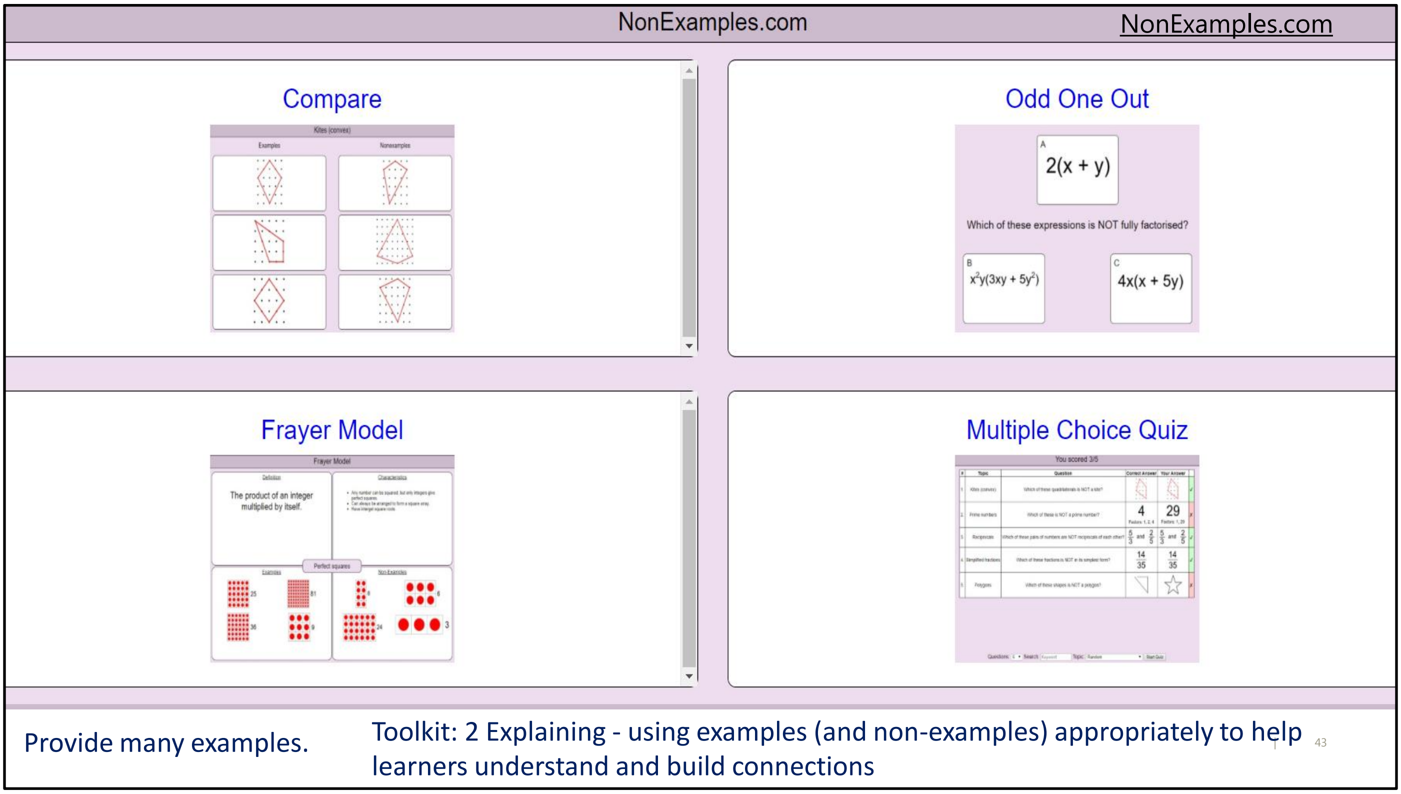


- **Worked examples** are such an important part of what we do as Maths teachers, explaining every step clearly.
- But it's definitely not present several then let them loose on an exercise – that is not effective.
- We must reduce cognitive load for students.
- Hence the I do / you do approach discussed

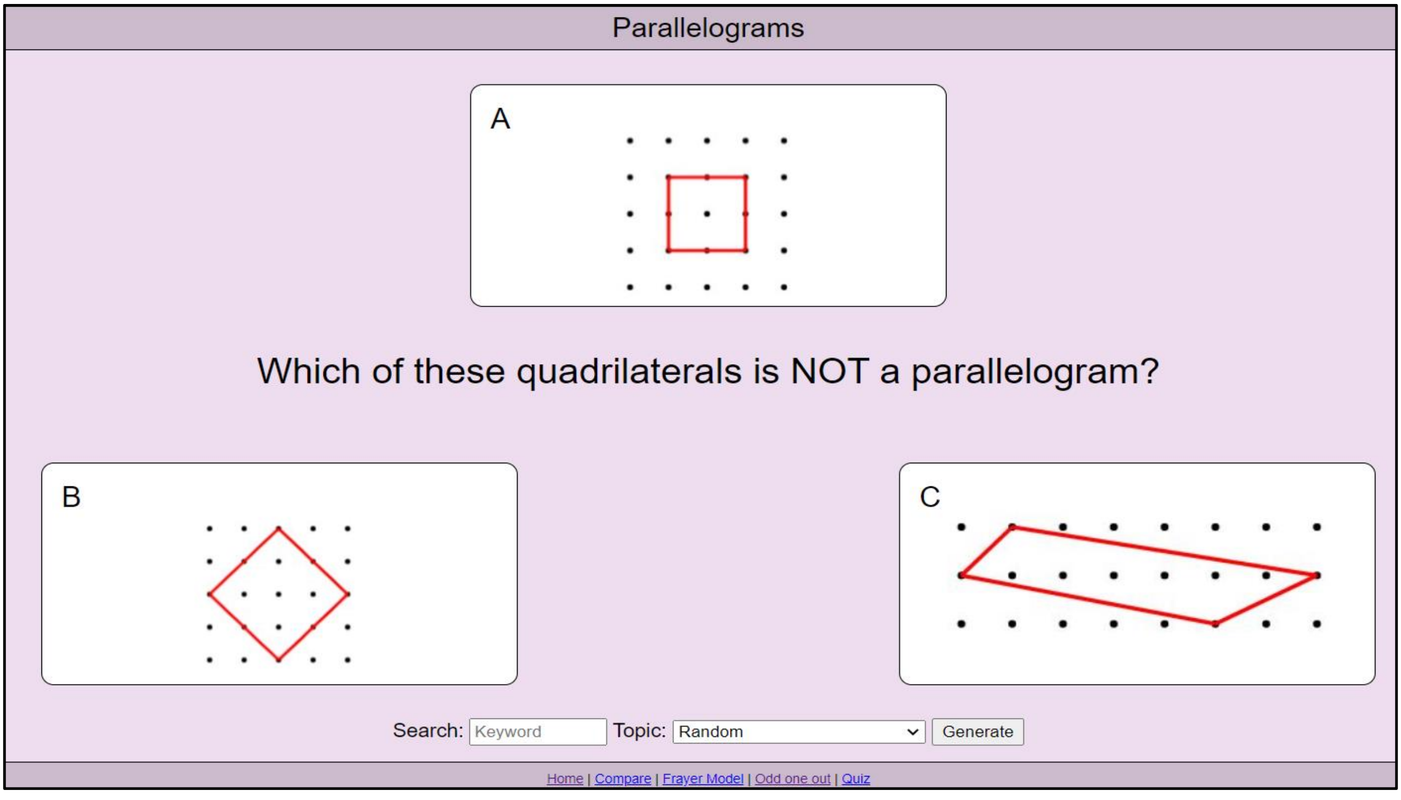


- We have so many sources of worked out problems, for example we have Maths Genie which is a real favourite with students, Mathsbot, Maths4Everyone, the examination board resources, Dr Frost of course, to name just a small number.
- Exam questions and mark schemes.
- Think aloud as you work through examples.
- "If this was me ….in the exam…"
- A site that has been there throughout my teaching career, the CIMT resources have to have a mention.
- Note their Interactive materials with clear explanations for students.
- Importantly, students get immediate feedback anytime.
- Ideal for students studying themselves, particularly in the current climate.
- This does the worked examples / your turn rather well (watch for Flash though – still plenty that work)

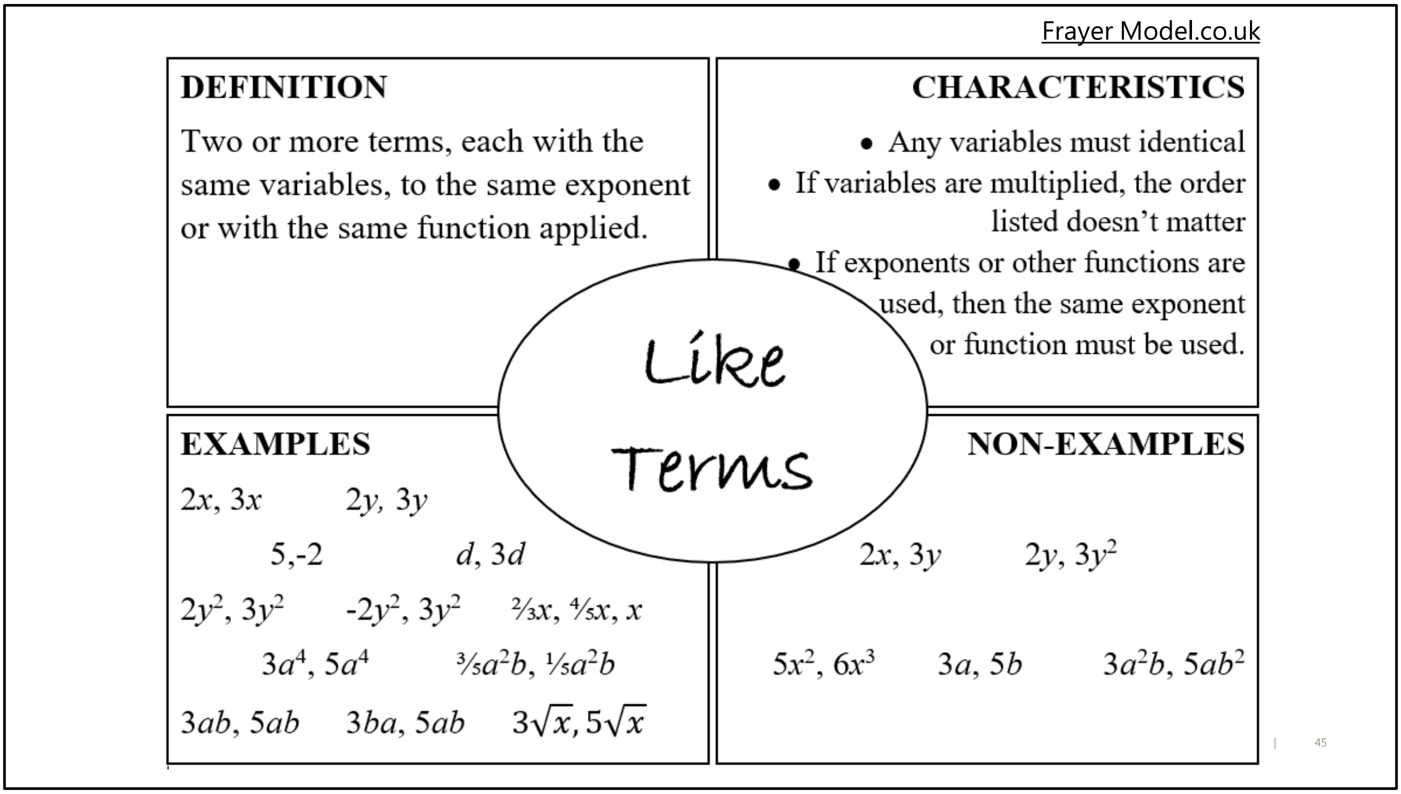
- This works well in class for demonstrations.



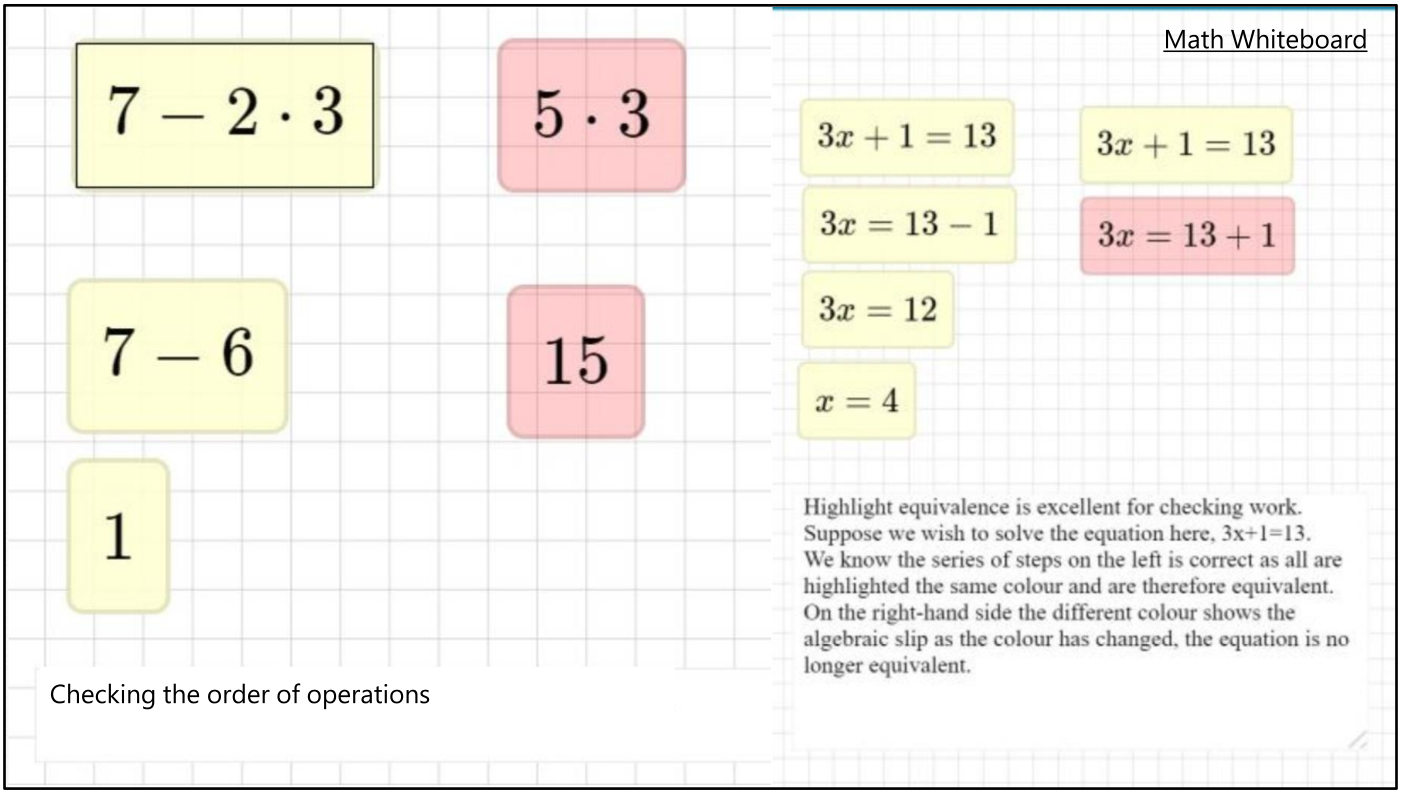
- Provide many examples….and non examples – Jonathan Hall’s (Mathsbot author) excellent site. Can see the different formats available.



- Odd one out format
- Could ask students for more examples and non examples
- Gets them really thinking about properties



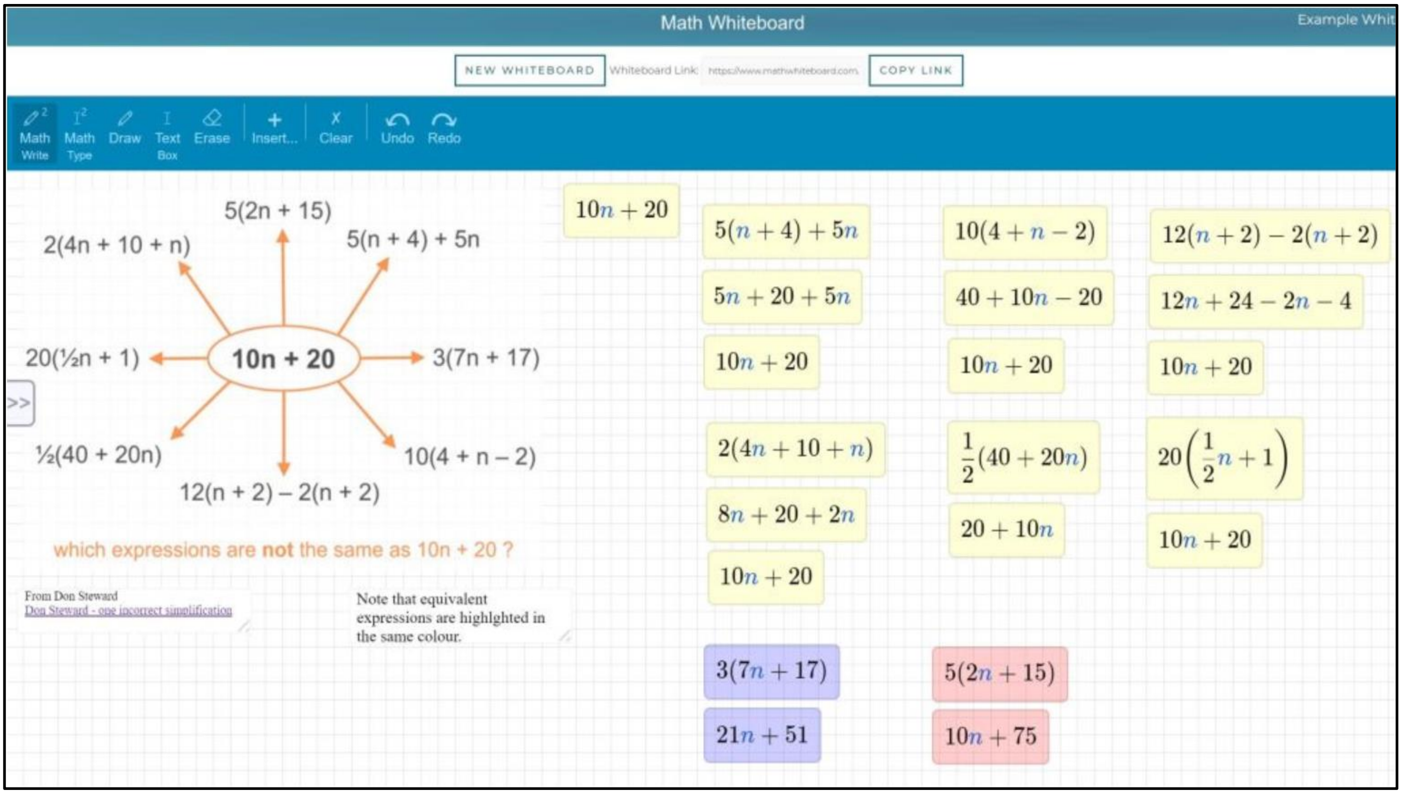
- Many Frayer models available on Pete Matlock's site.
- Headings Algebra, number and so on.
- A great source of examples and non-examples



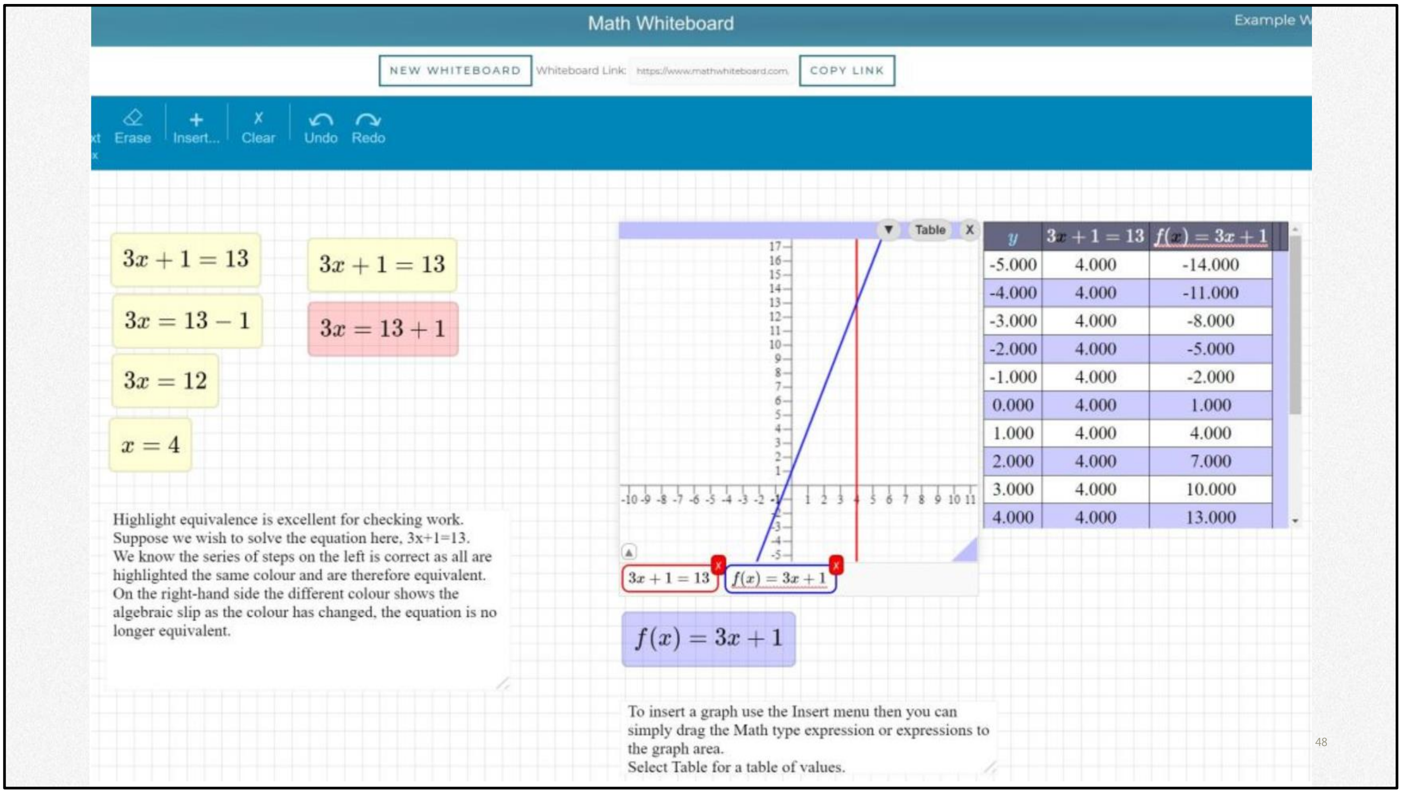
Thinking about explanations and presenting clear worked examples, now on Math Whiteboard (not Maths White Board). Highlight equivalence feature is excellent for checking work.

Suppose we wish to solve the equation here, 3x+1=13.
We know the series of steps on the left is correct as all are highlighted the same colour and are therefore equivalent.

On the right-hand side the different colour shows the algebraic slip as the colour has changed, the equation is no longer equivalent.

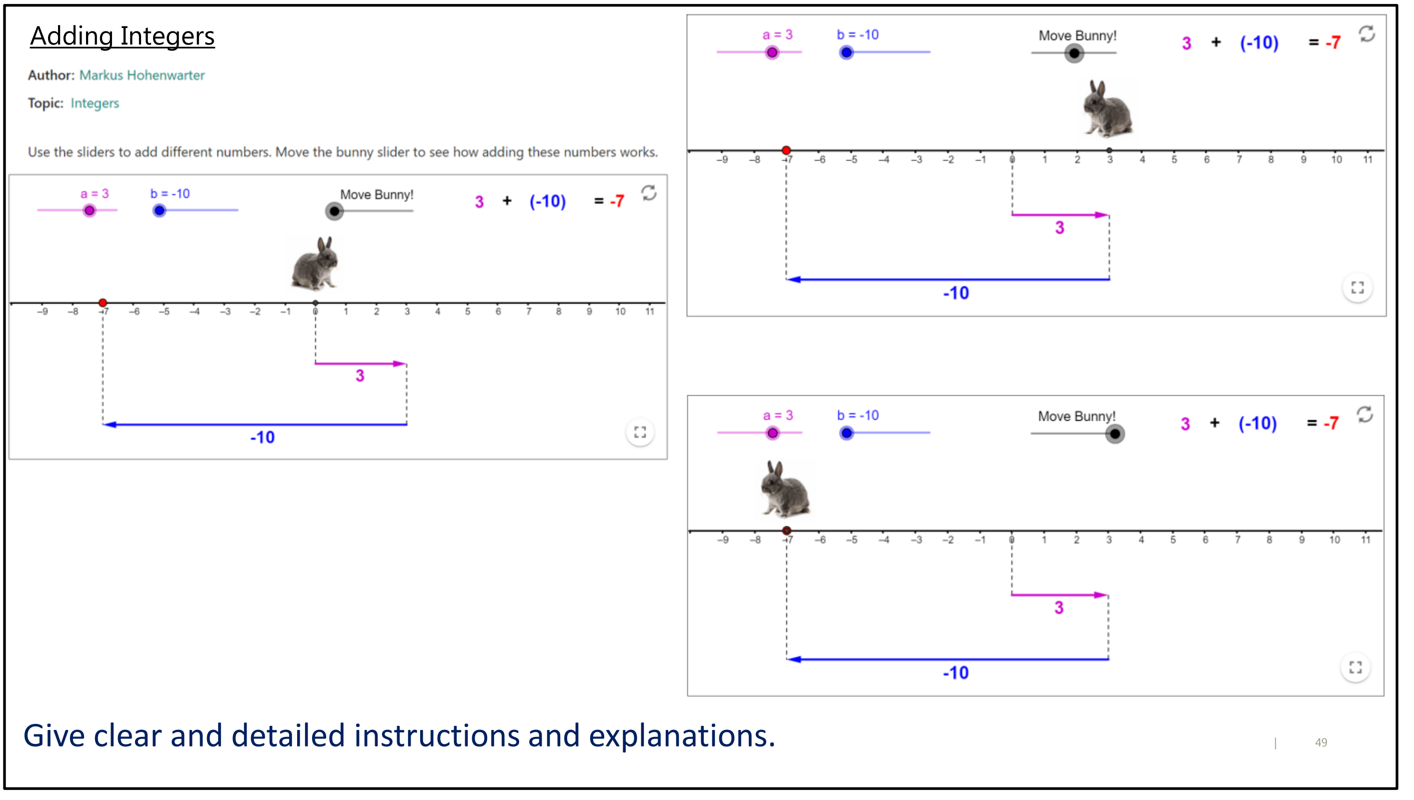


- Demonstrating highlight equivalence again – using a Don Steward resource (legacy)

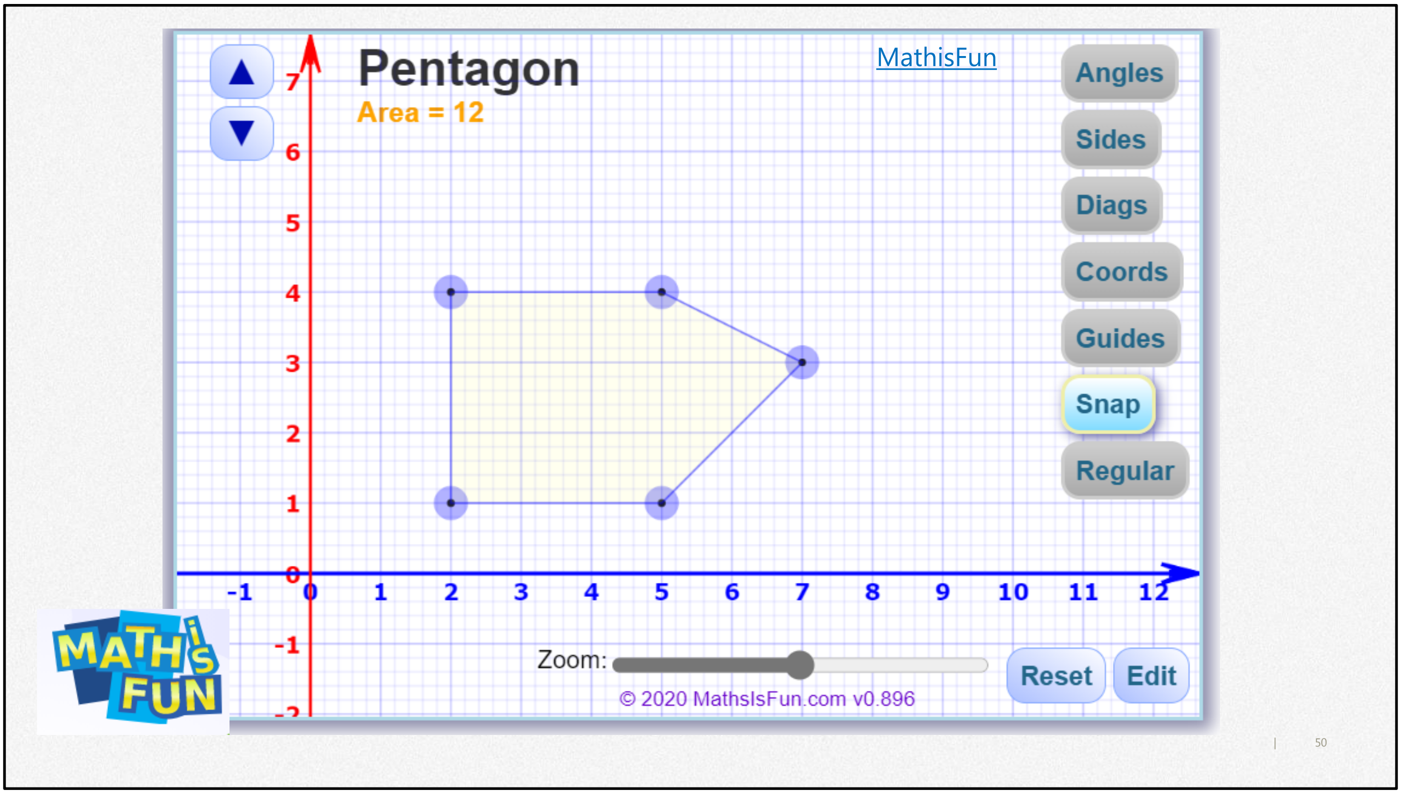


y	$3x+1=13$	$f(x)=3x+1$
-5.000	4.000	-14.000
-4.000	4.000	-11.000
-3.000	4.000	-8.000
-2.000	4.000	-5.000
-1.000	4.000	-2.000
0.000	4.000	1.000
1.000	4.000	4.000
2.000	4.000	7.000
3.000	4.000	10.000
4.000	4.000	13.000

- On Math Whiteboard, can easily show another representation. Multiple representations wherever we can
- Just drag an expression to the graph area



- We have so many resources available to us to help our explanations...
- Following slides illustrate just a few.
- Here adding integers, illustrating 3+-10 on GeoGebra.
- Move slider, bunny goes to 3, turns round then goes back 10 to reach -7

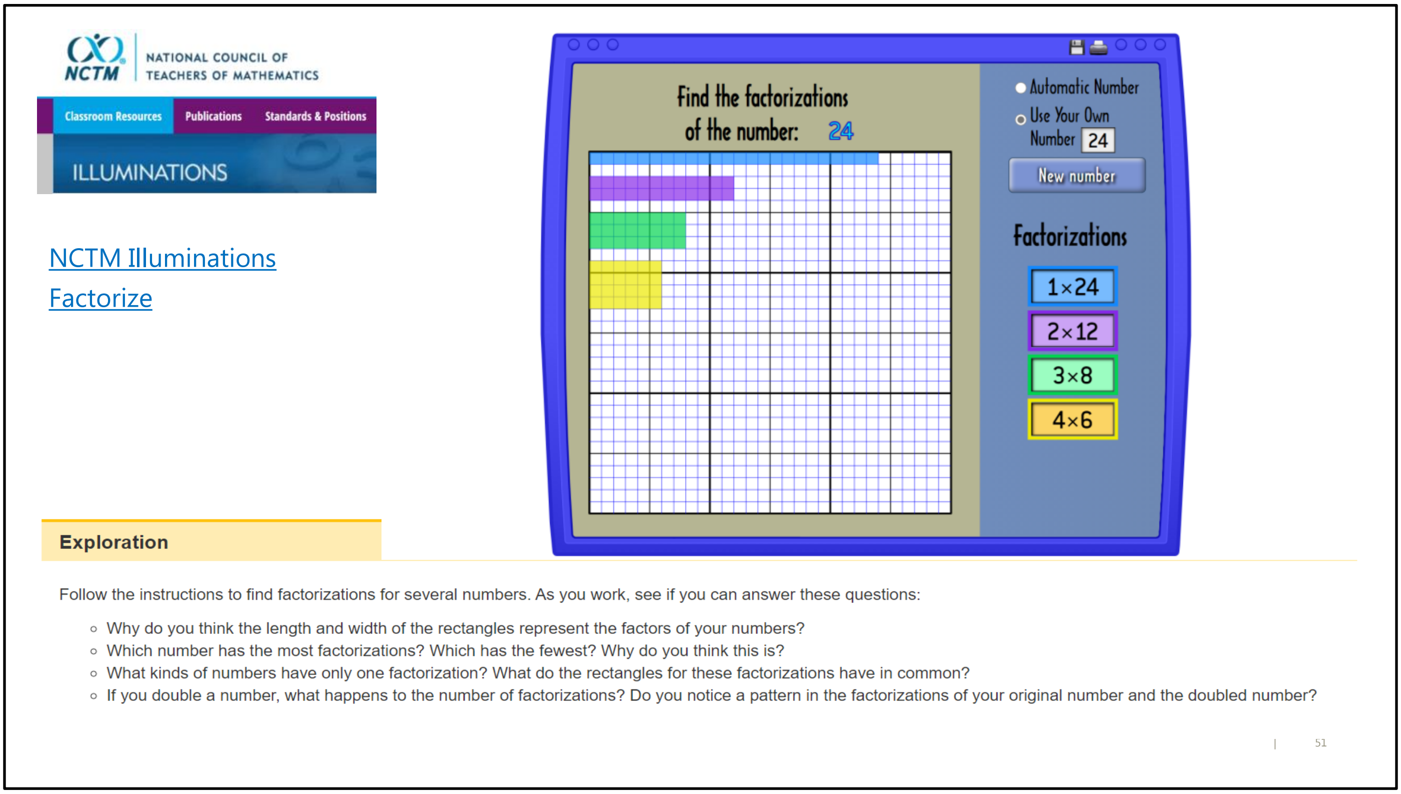


- This is great – on Mathisfun.

- We can see the area.

- Note we also have options to display angles and side lengths for example.

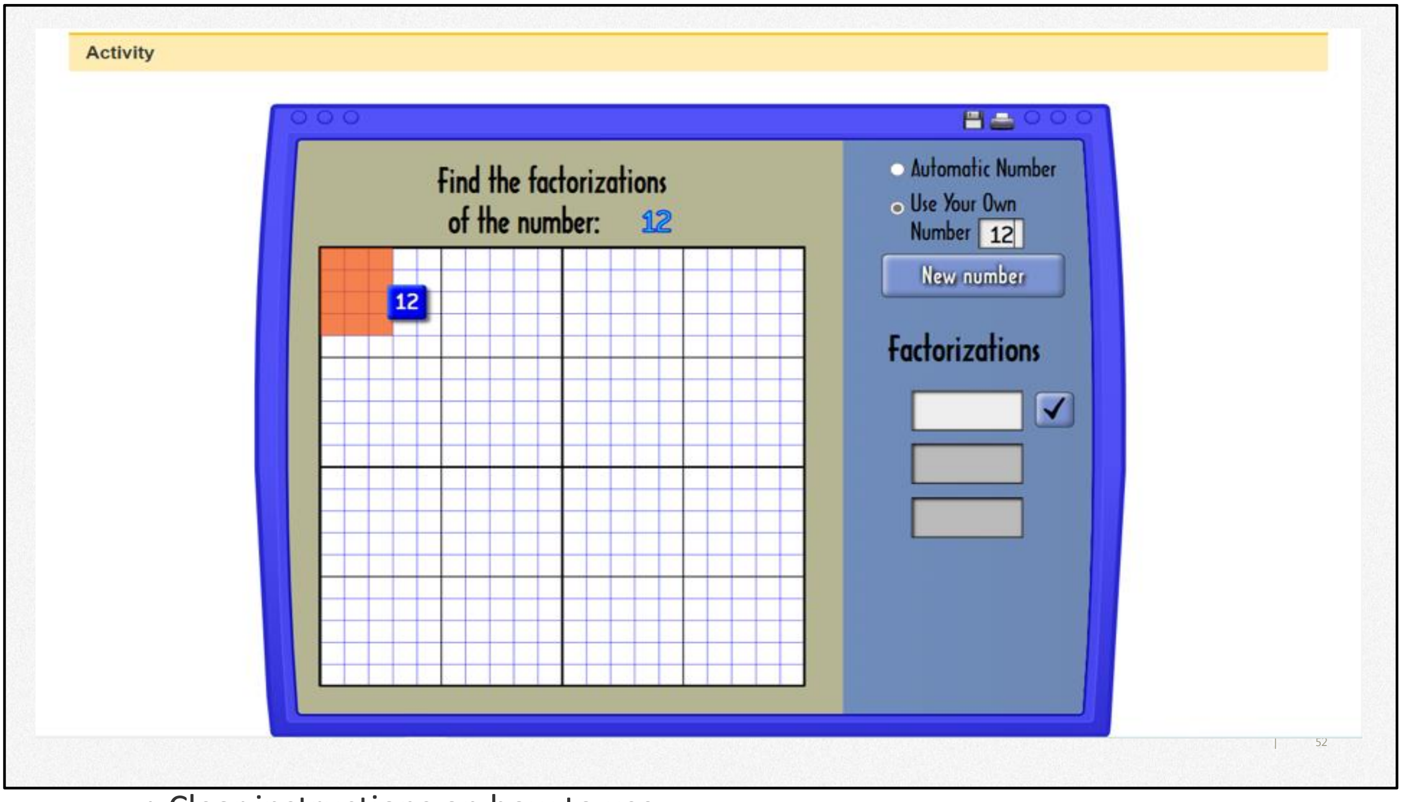
- So much on this site 7 – 13 Further mathematicians – good questions on matrices and inverses.



- Numerous interactives from NCTM with many tasks for students.

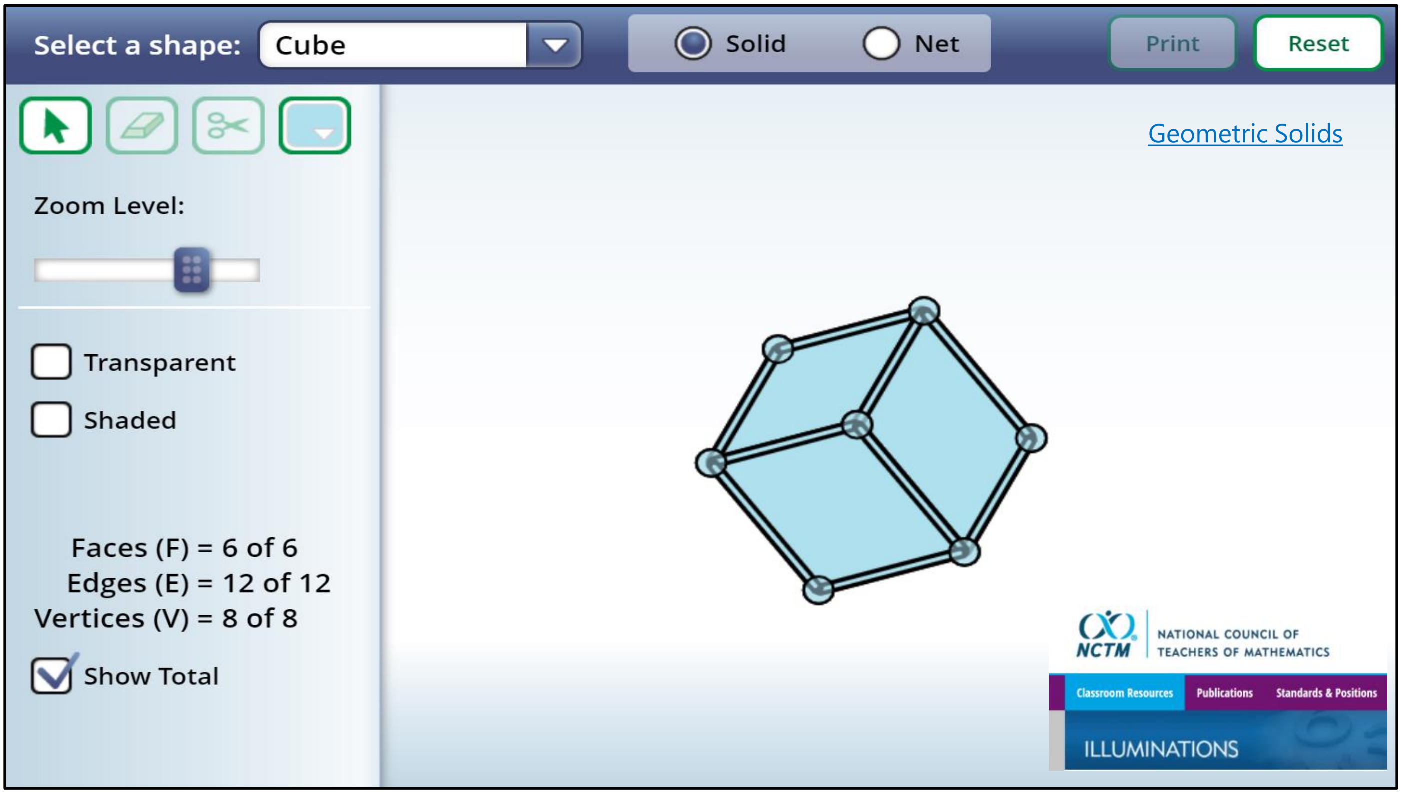
- Obviously we cannot just let students loose with the technology, they need structure / guidance.

- Suggestions are given and questions as you can see here.

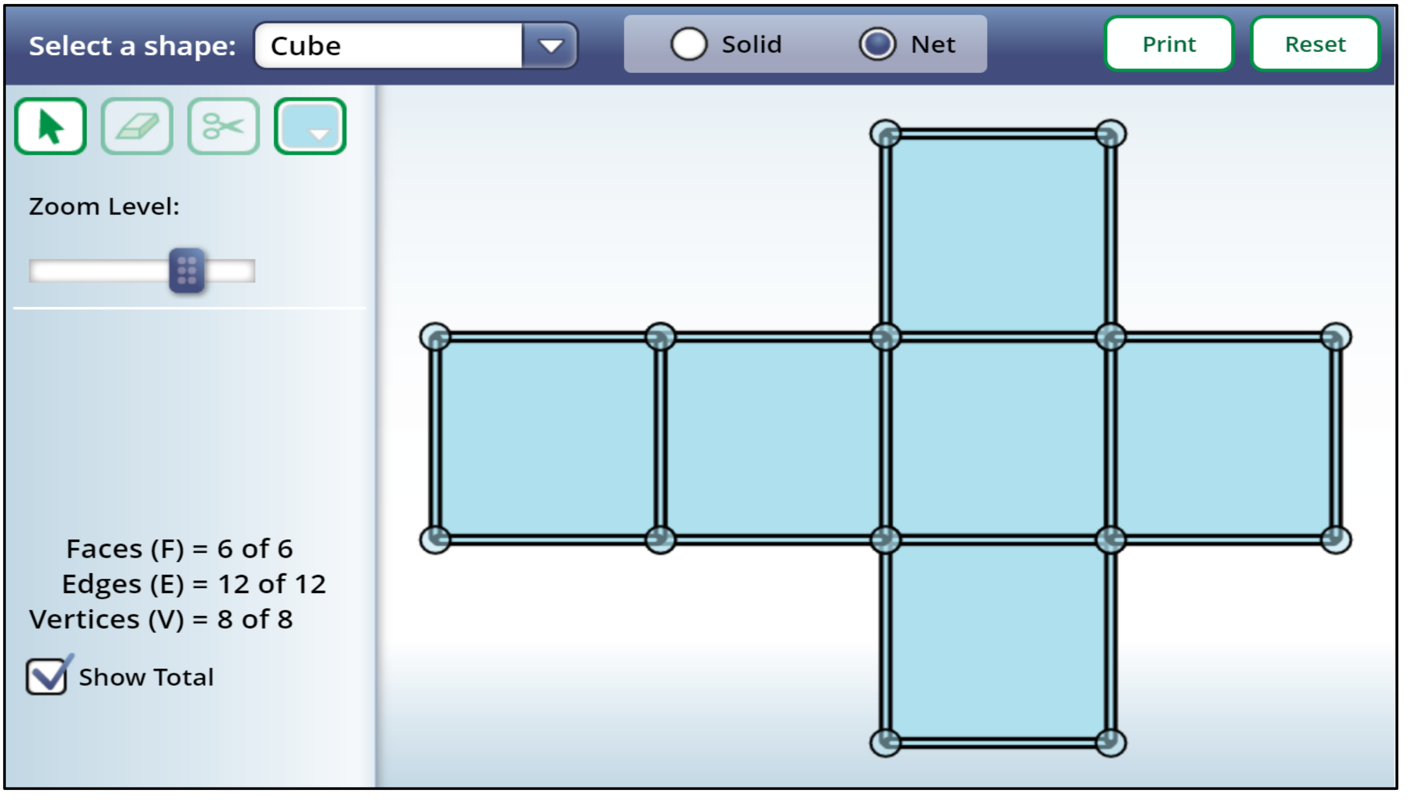


- Clear instructions on how to use
- Need help? Use the grid to help you find the factors. Click and drag to draw a rectangle. As you draw, the area of your rectangle will be displayed. Release the mouse button to check your answer. If the area is equal to your number, the rectangle will stay. If the area is not equal to your number, it will disappear. The length and width of the rectangle are factors of your number.
- When you've entered your factorization, click the **Checkbox** to check your answer. If it is incorrect, the entry will be deleted. If it is correct, the corresponding rectangle will be drawn on the grid (if it's not already there).
- The number of white boxes corresponds to the number of factorization for your number. Try to find them all. The rectangles and factorizations are color coded to help you. The color of the rectangle matches the highlight color of the factorization box.

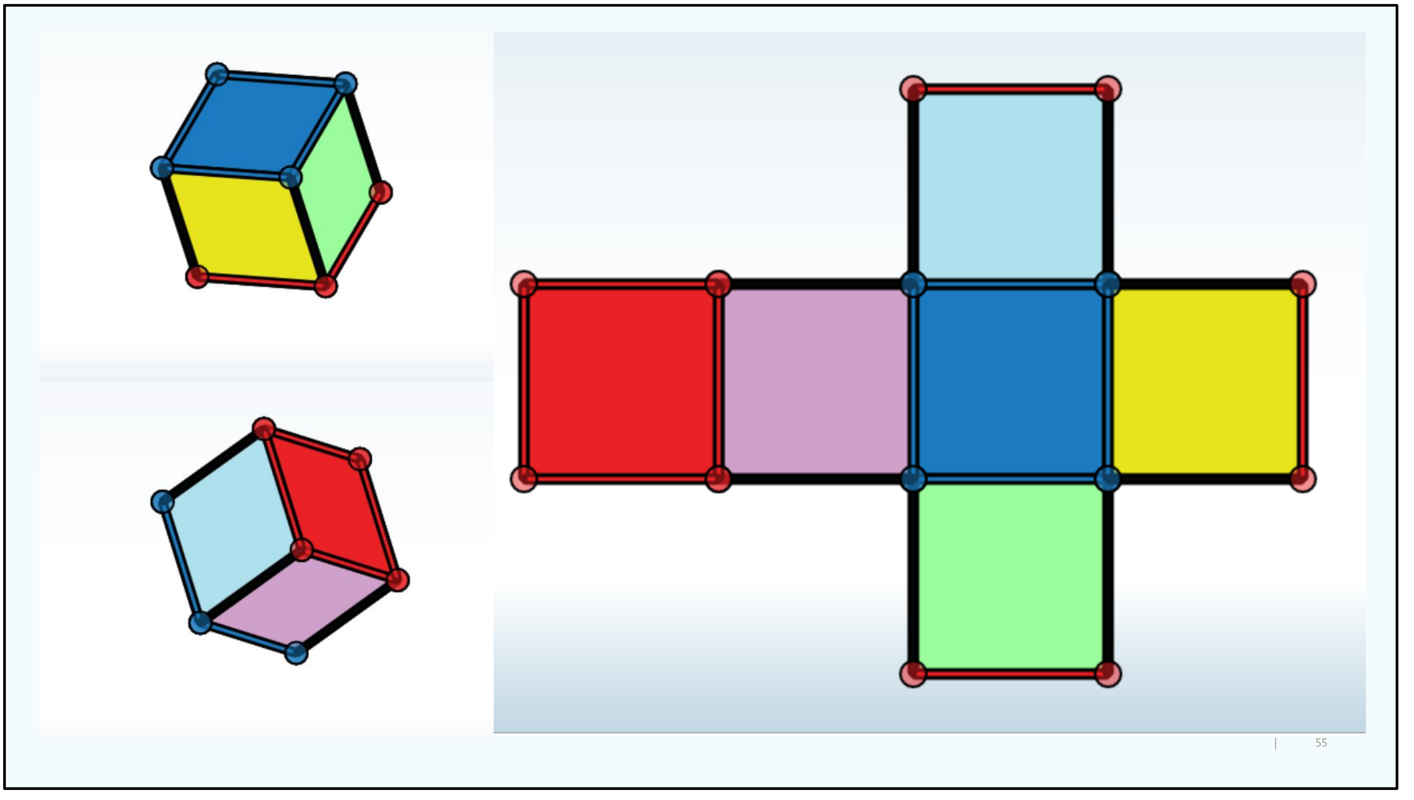
- Click **New Number** or enter a new number into the **Use Your Own Number** box to find the factorizations for a different number.



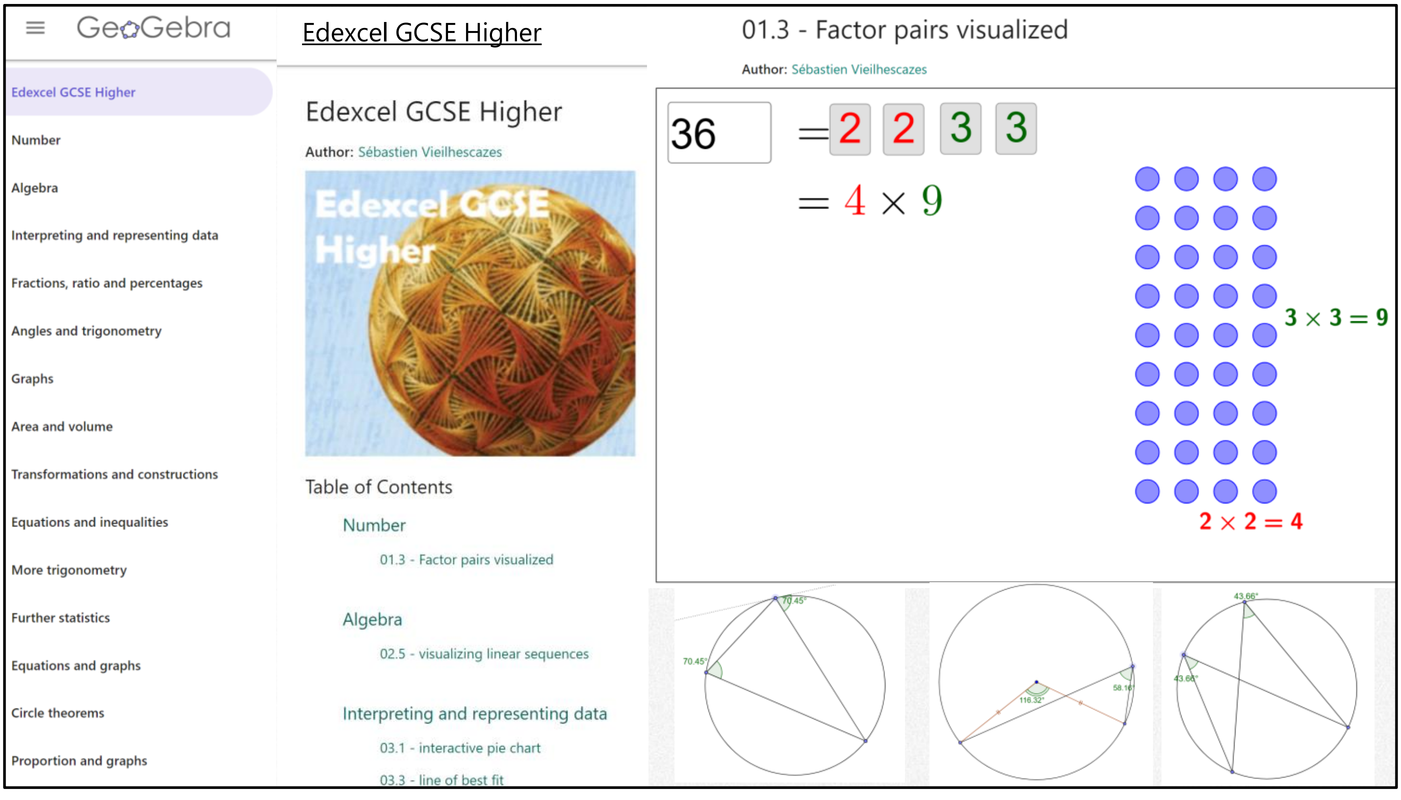
- More geometry
- NCTM illuminations
- Students can explore the relationship between faces edges and vertices, as well as see the net.

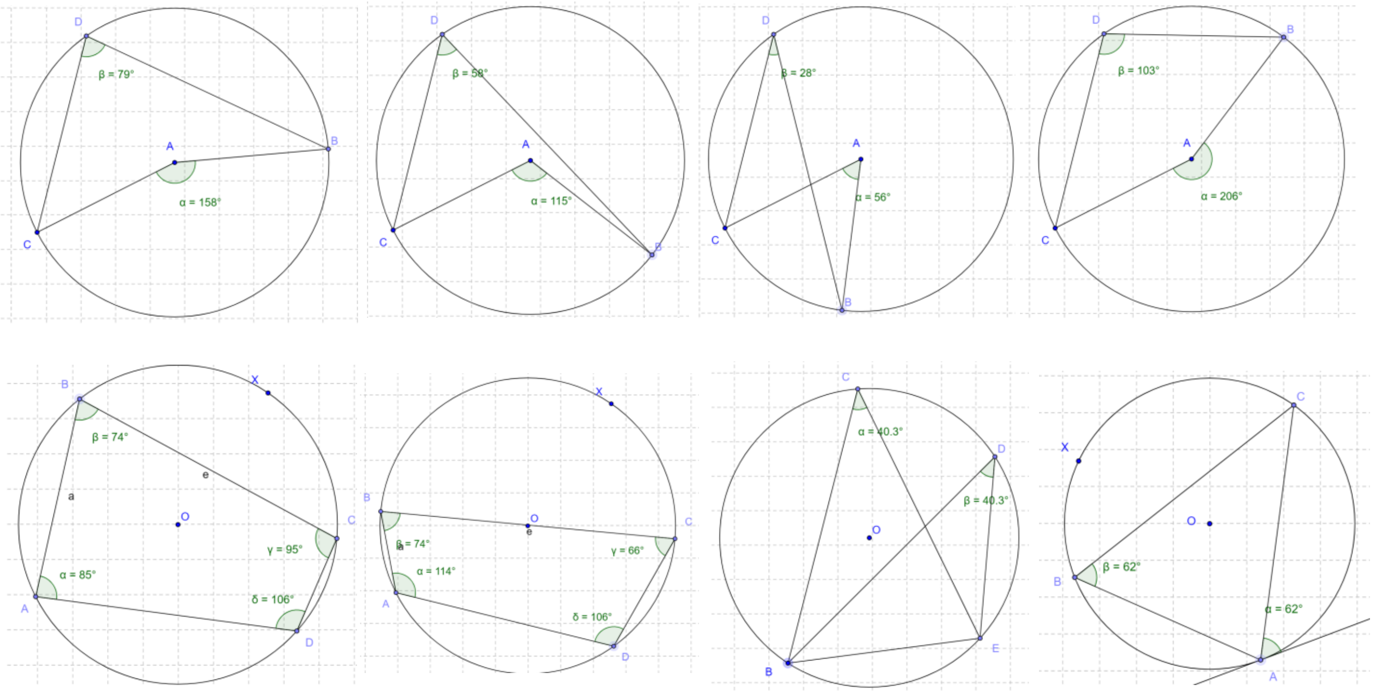


- Show the net
- You can colour individual elements….



- Note use of colour again
- Can rotate 3D model see view from any angle

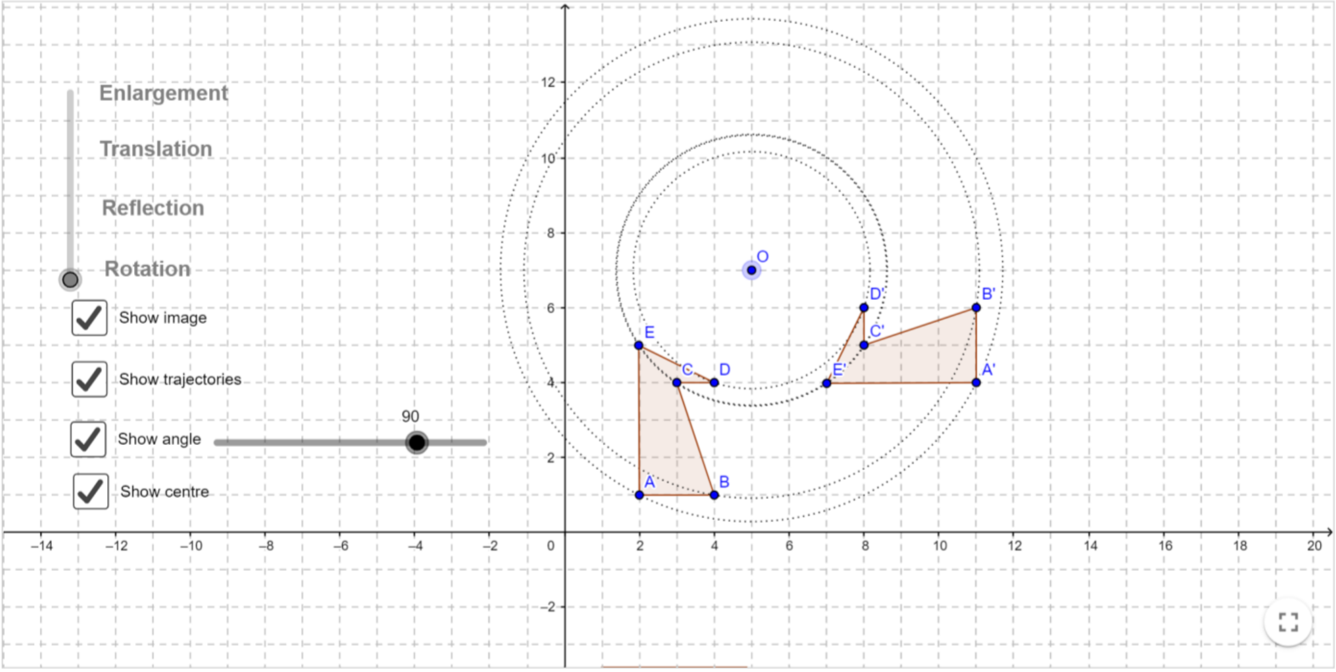

GeoGebra
Edexcel GCSE Higher
Number
Algebra
Interpreting and representing data
Fractions, ratio and percentages
Angles and trigonometry
Graphs
Area and volume
Transformations and constructions
Equations and inequalities
More trigonometry
Further statistics
Equations and graphs
Circle theorems
Proportion and graphs
Edexcel GCSE Higher
Edexcel GCSE Higher
Author: Sébastien Vieilhescazes
Edexcel GCSE Higher
Table of Contents
Number
01.3 - Factor pairs visualized
Algebra
02.5 - visualizing linear sequences
Interpreting and representing data
03.1 - interactive pie chart
03.3 - line of best fit
01.3 - Factor pairs visualized
Author: Sébastien Vieilhescazes
36
= 2 2 3 3
= 4 × 9
3 × 3 = 9
2 × 2 = 4


D
β = 79°
A
B
α = 158°
C
D
β = 58°
A
α = 115°
C
B
D
β = 28°
A
α = 56°
C
B
D
B
β = 103°
A
α = 206°
C
B
X
β = 74°
e
a
O
C
γ = 95°
α = 85°
δ = 106°
A
D
X
B
O
C
β = 74°
γ = 66°
α = 114°
A
δ = 106°
D
C
α = 40.3°
D
β = 40.3°
O
E
B
C
X
O
B
β = 62°
α = 62°
A

08.2 - transformations

Transformations

Author: Sébastien Vieilhescazes

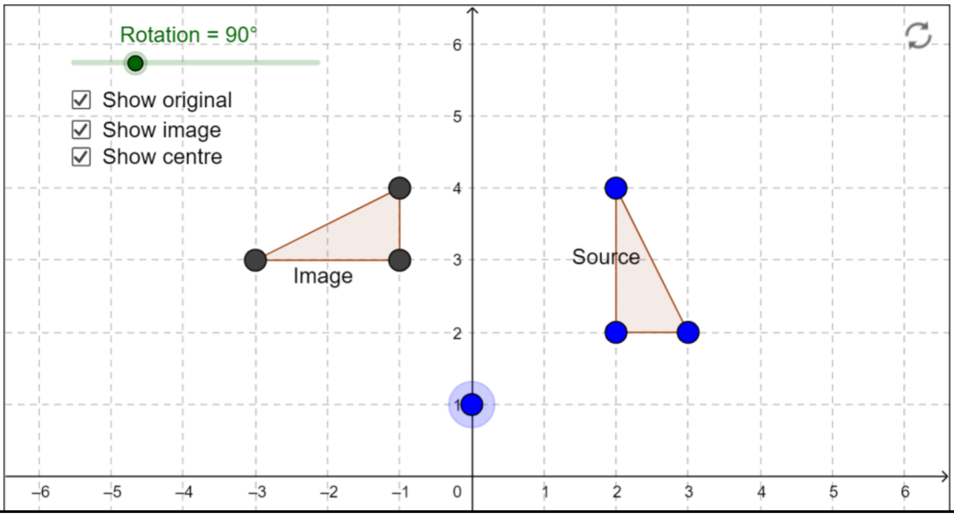


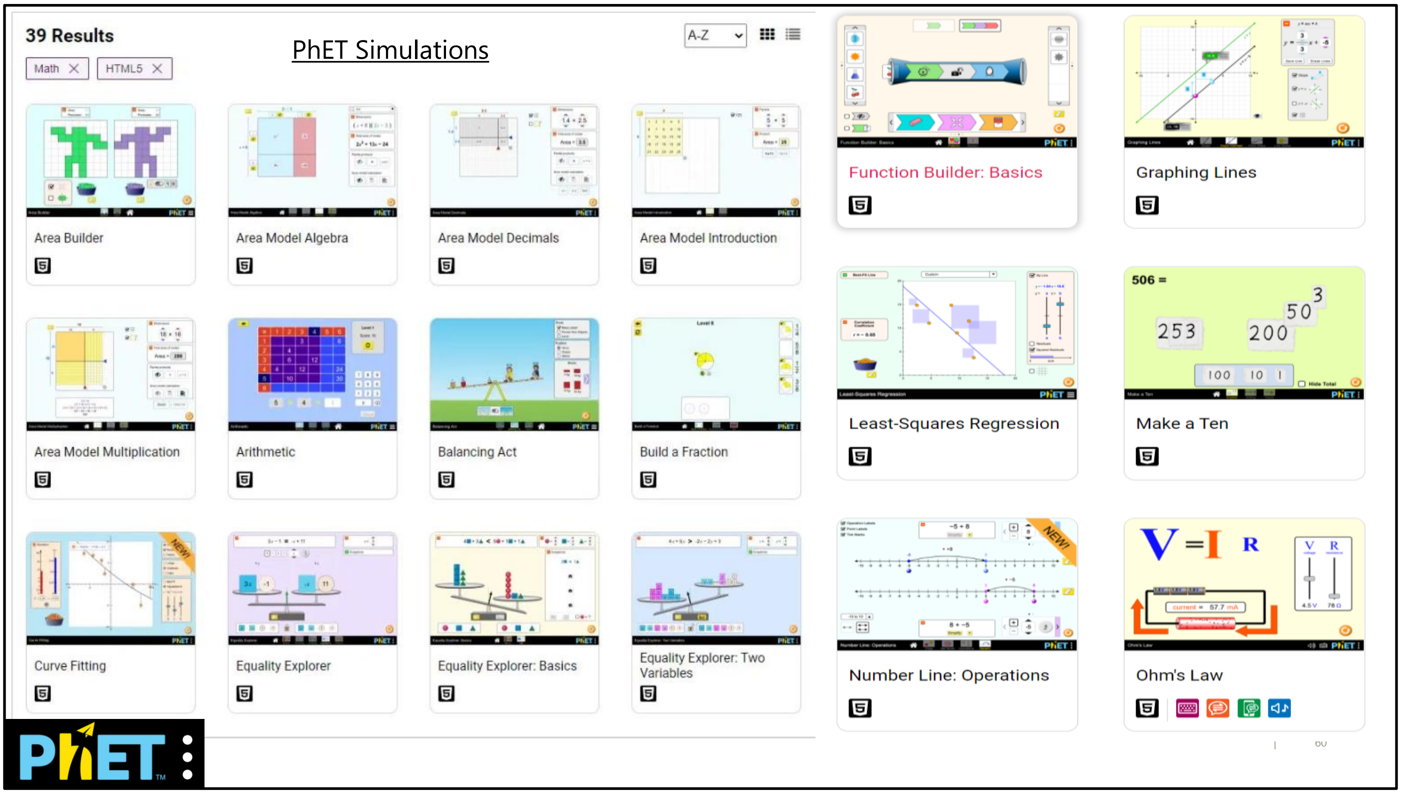
Transformations - Rotation

Author: Jon Ingram

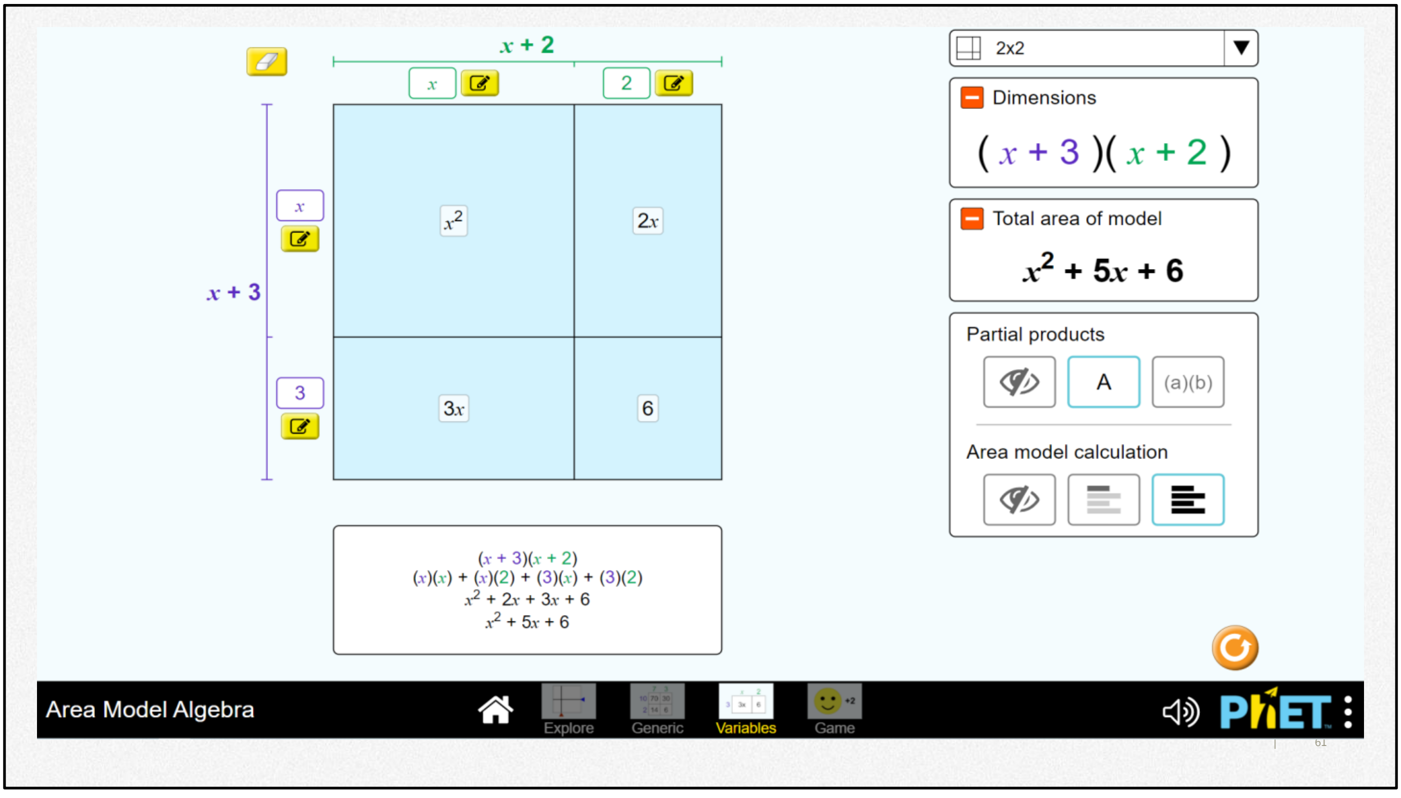
Topic: Rotation

Exploring rotation

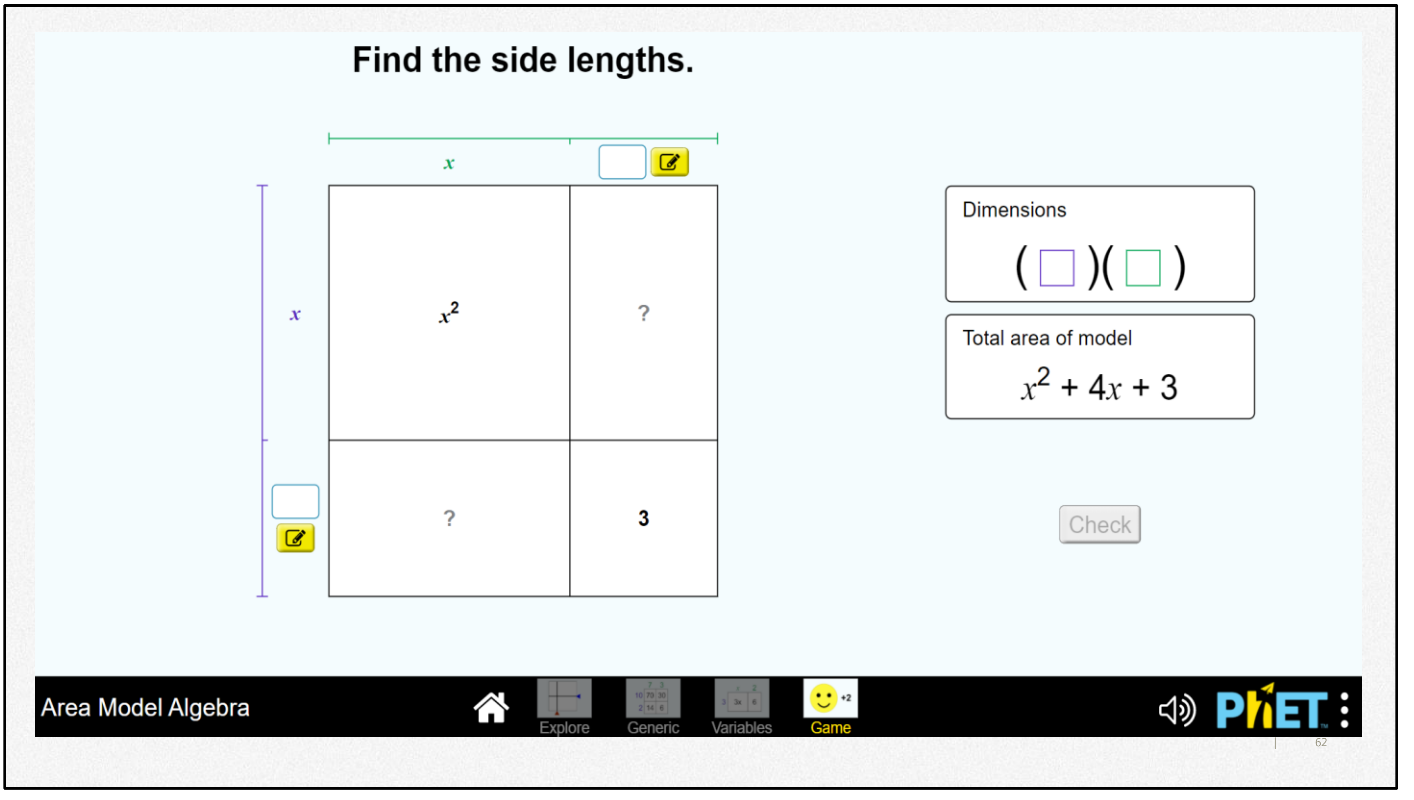




- Now showing PhET Interactive simulations.
- University of Colorado, Boulder
- These are excellent for students to explore.
- Currently 39 HTML sims for Maths

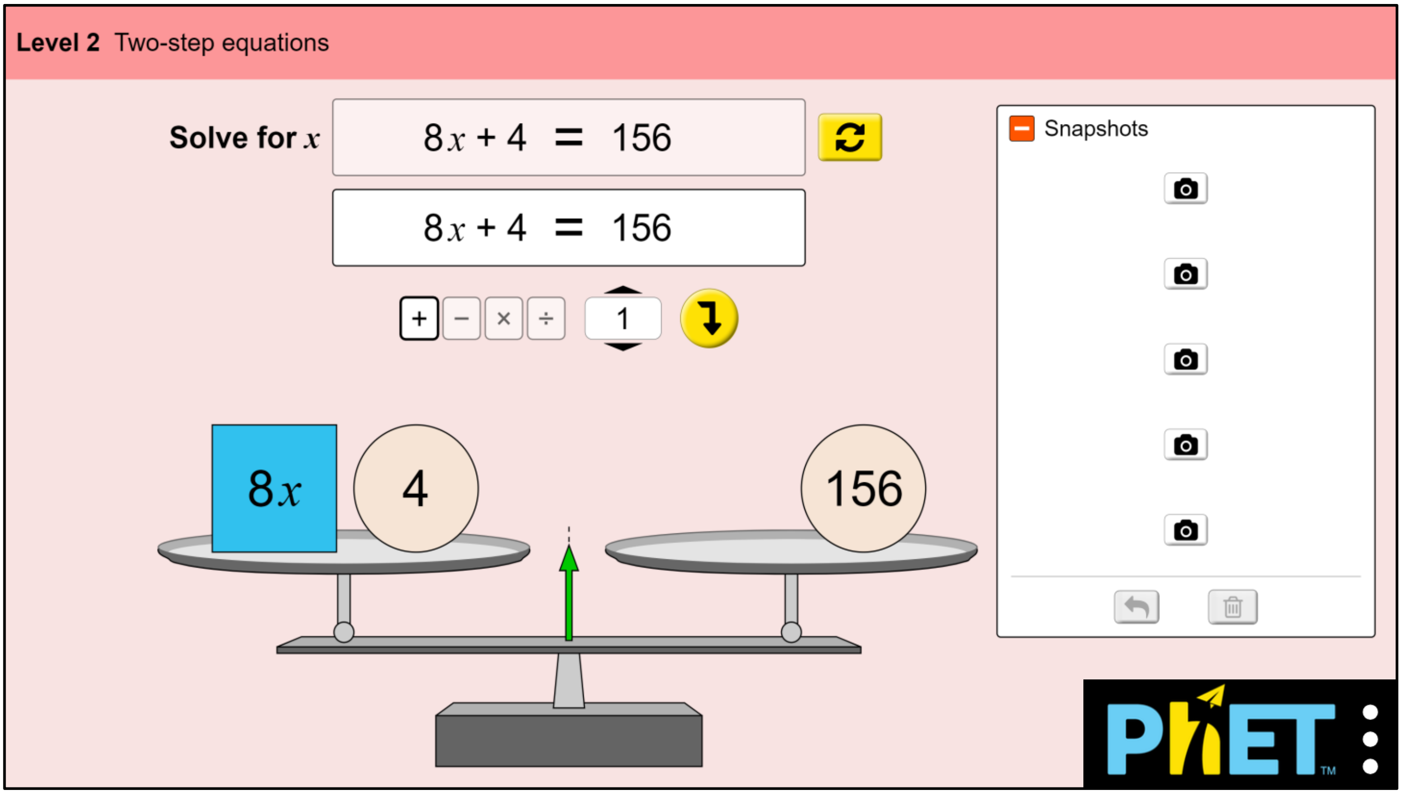


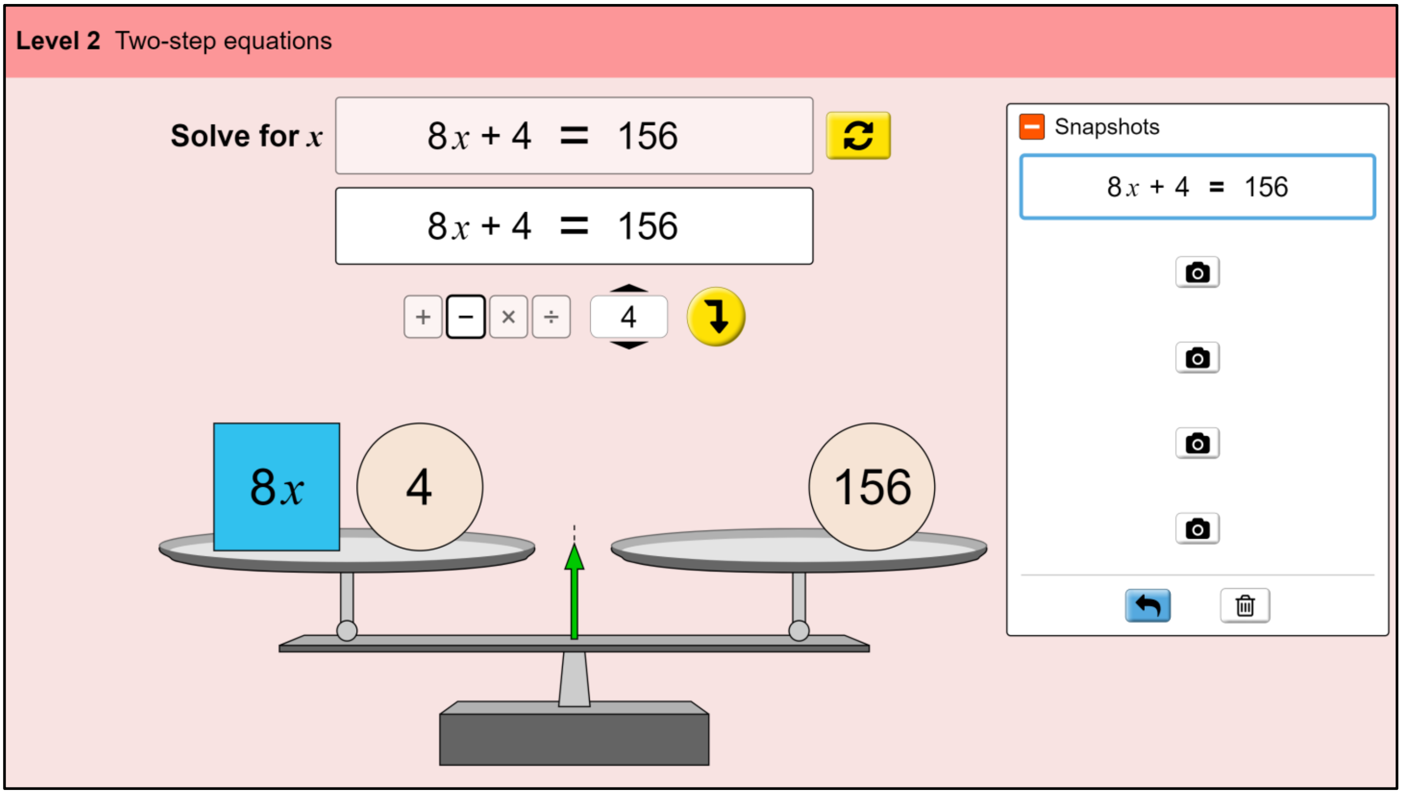
- A further example – area model algebra.
- Ideal you can choose the dimensions yourself.
- Students could try the example themselves then use this area model to check.
- These are very attractively presented.



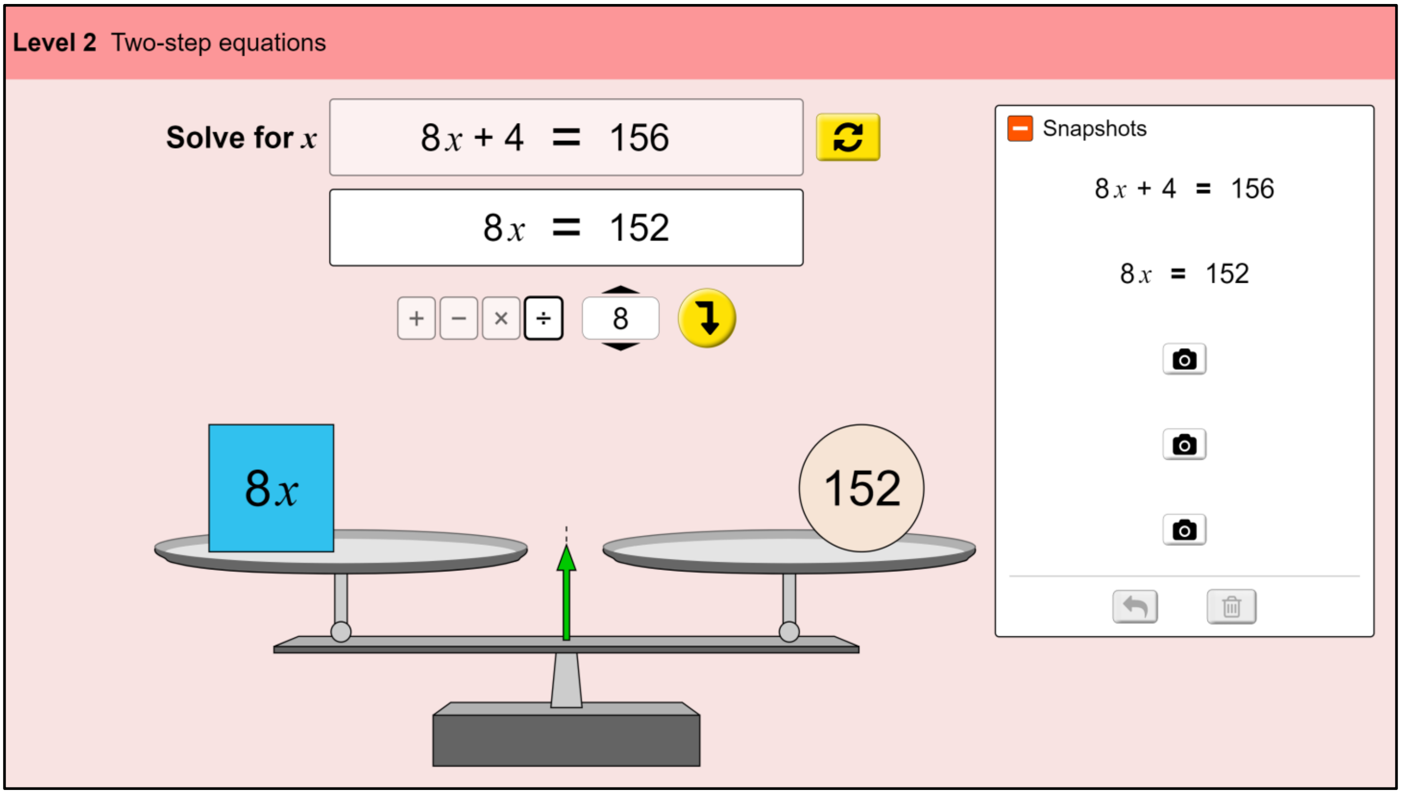
- Could ask them to do the quiz at various levels and have a Google or Microsoft Form for them to enter their answers.

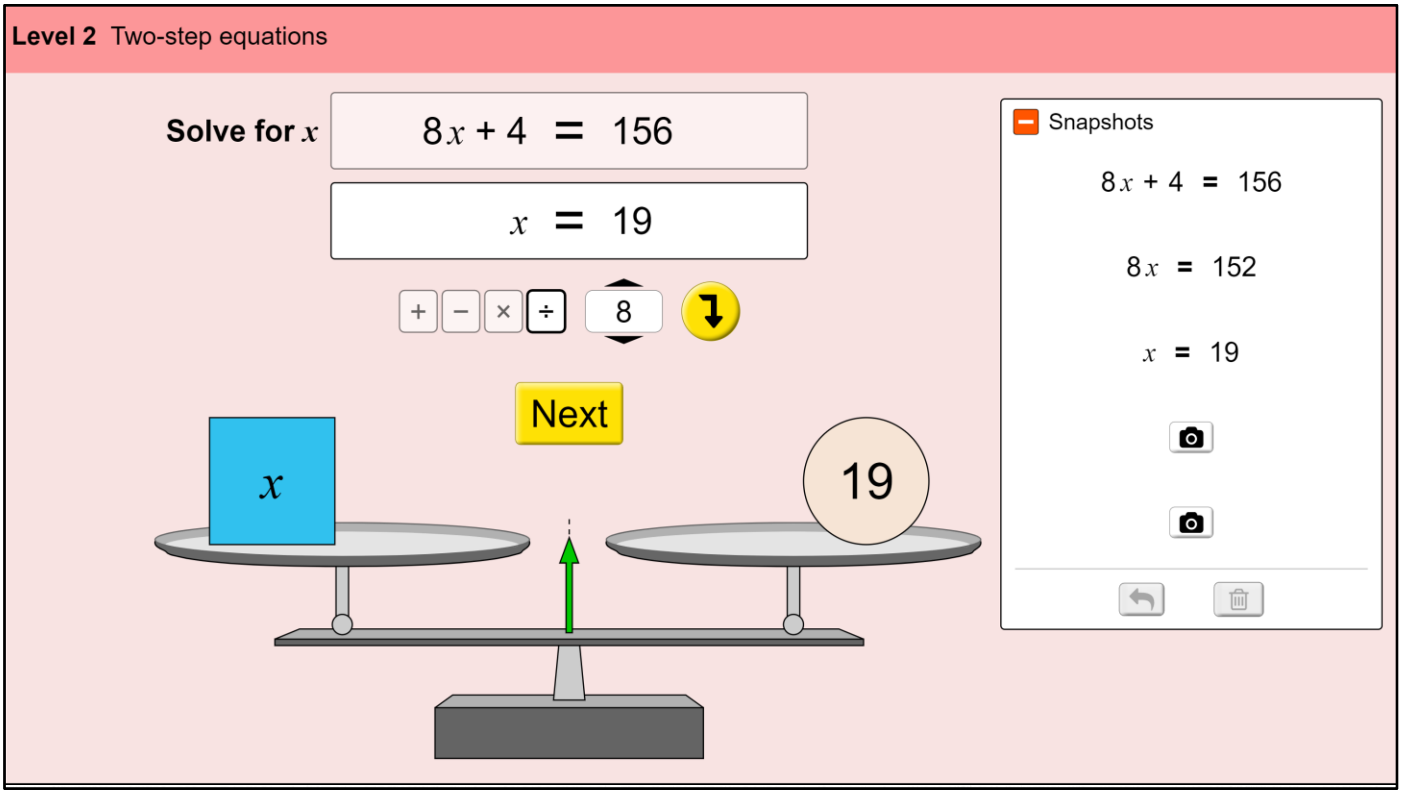
- Going backwards is always a good exercise, this is part of the game. 6 levels, this is level 6.

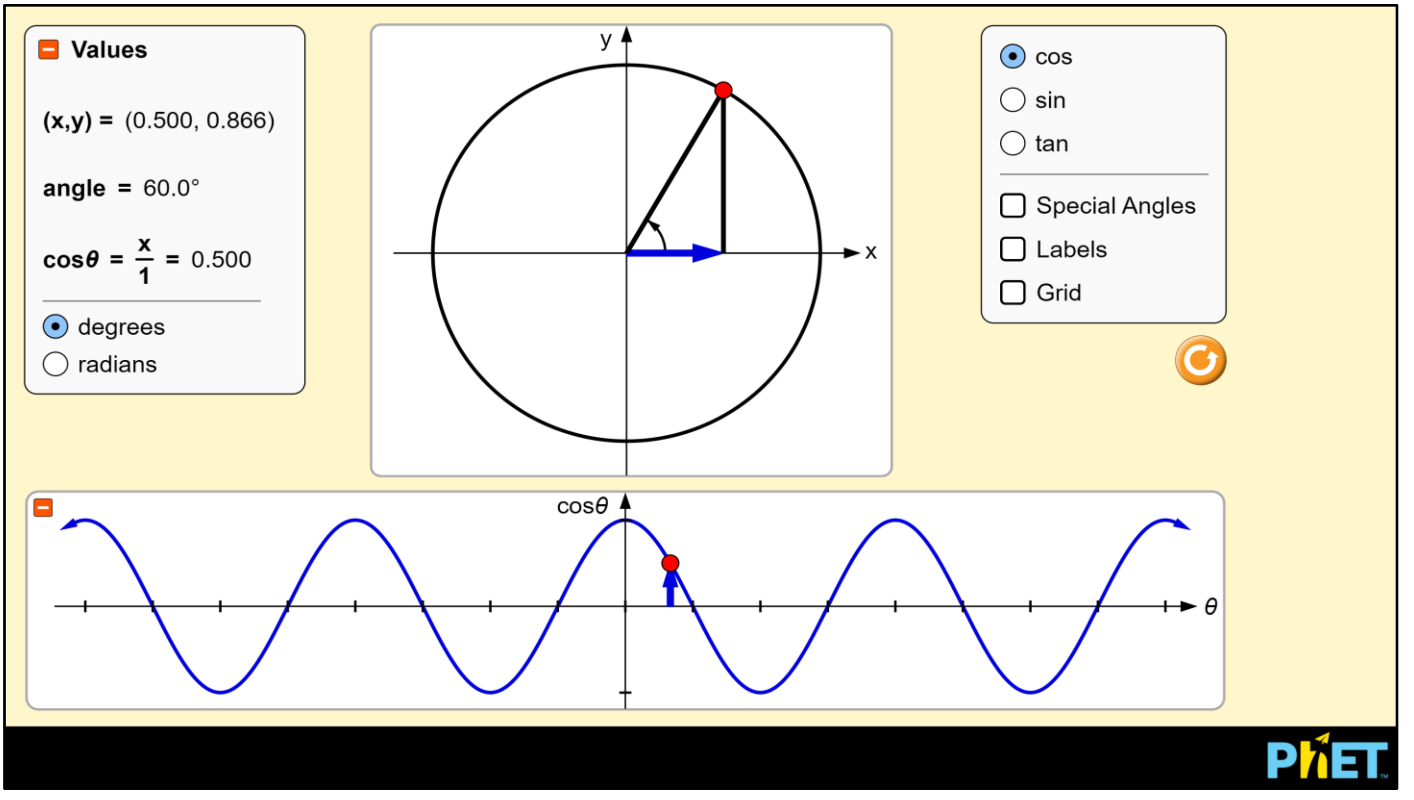

Level 2 Two-step equations
Solve for x
$8x + 4 = 156$
$8x + 4 = 156$
+ − × ÷
1
$8x$
4
156
Snapshots
PhET



Level 2 Two-step equations
Solve for x
$8x + 4 = 156$
$8x + 4 = 156$
+ − × ÷
4
Snapshots
$8x + 4 = 156$
$8x$
4
156

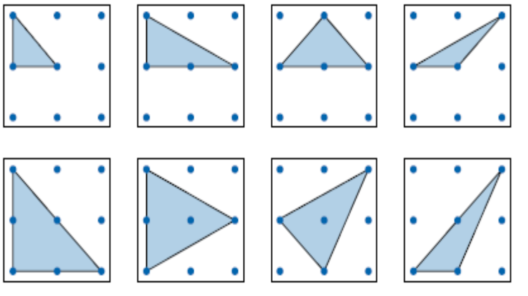

Level 2 Two-step equations
Solve for x
$8x + 4 = 156$
$8x = 152$
+ − × ÷ 8
$8x$
152
Snapshots
$8x + 4 = 156$
$8x = 152$


Level 2 Two-step equations
Solve for x
8x + 4 = 156
x = 19
+ − × ÷
8
Next
x
19
Snapshots
8x + 4 = 156
8x = 152
x = 19


Values
(x,y) = (0.500, 0.866)
angle = 60.0°
cosθ = x/1 = 0.500
degrees
radians
y
x
cos
sin
tan
Special Angles
Labels
Grid
cosθ
θ

GEOMETRY AND MEASURES | Geometrical reasoning

Pupils should learn to:	As outcomes, Year 7 pupils should, for example:
Identify and use the geometric properties of triangles, quadrilaterals and other polygons to solve problems; explain and justify inferences and deductions using mathematical reasoning (continued) GeoBoard Activities	Triangles, quadrilaterals and other polygons Review the properties of triangles and quadrilaterals. For example: • Using a 3 by 3 array on a pinboard, identify the eight distinct triangles that can be constructed (eliminating reflections, rotations or translations). Classify the triangles according to their side, angle and symmetry properties.



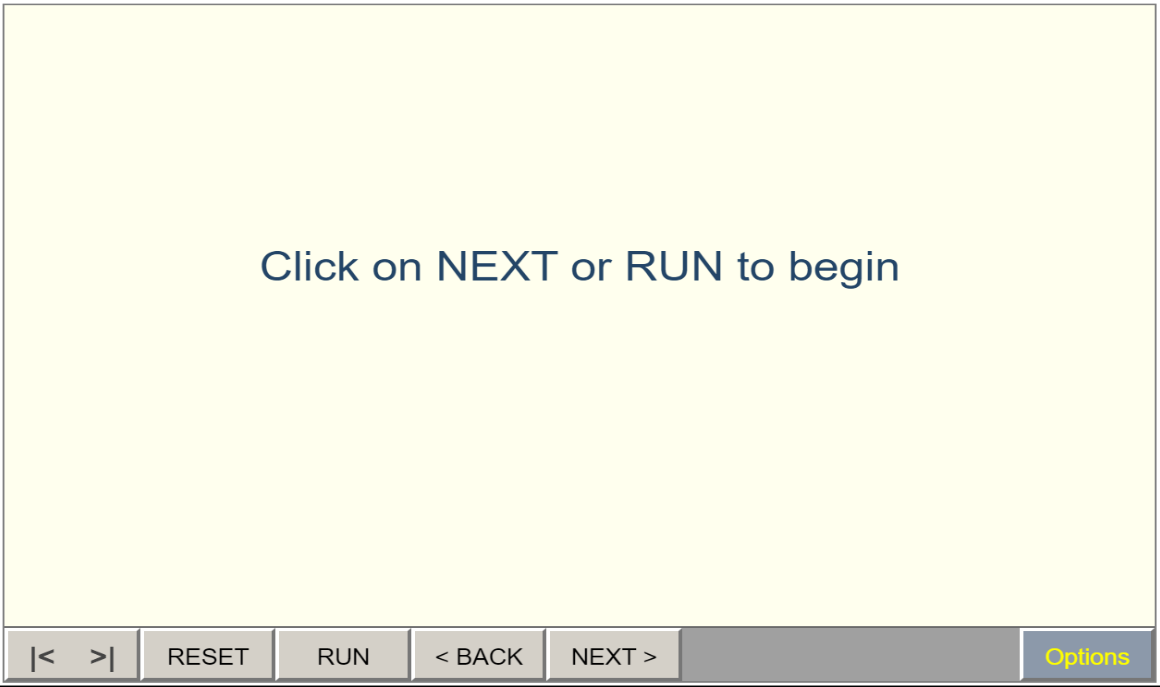
- I have always liked this task from the national curriculum exemplification examples.

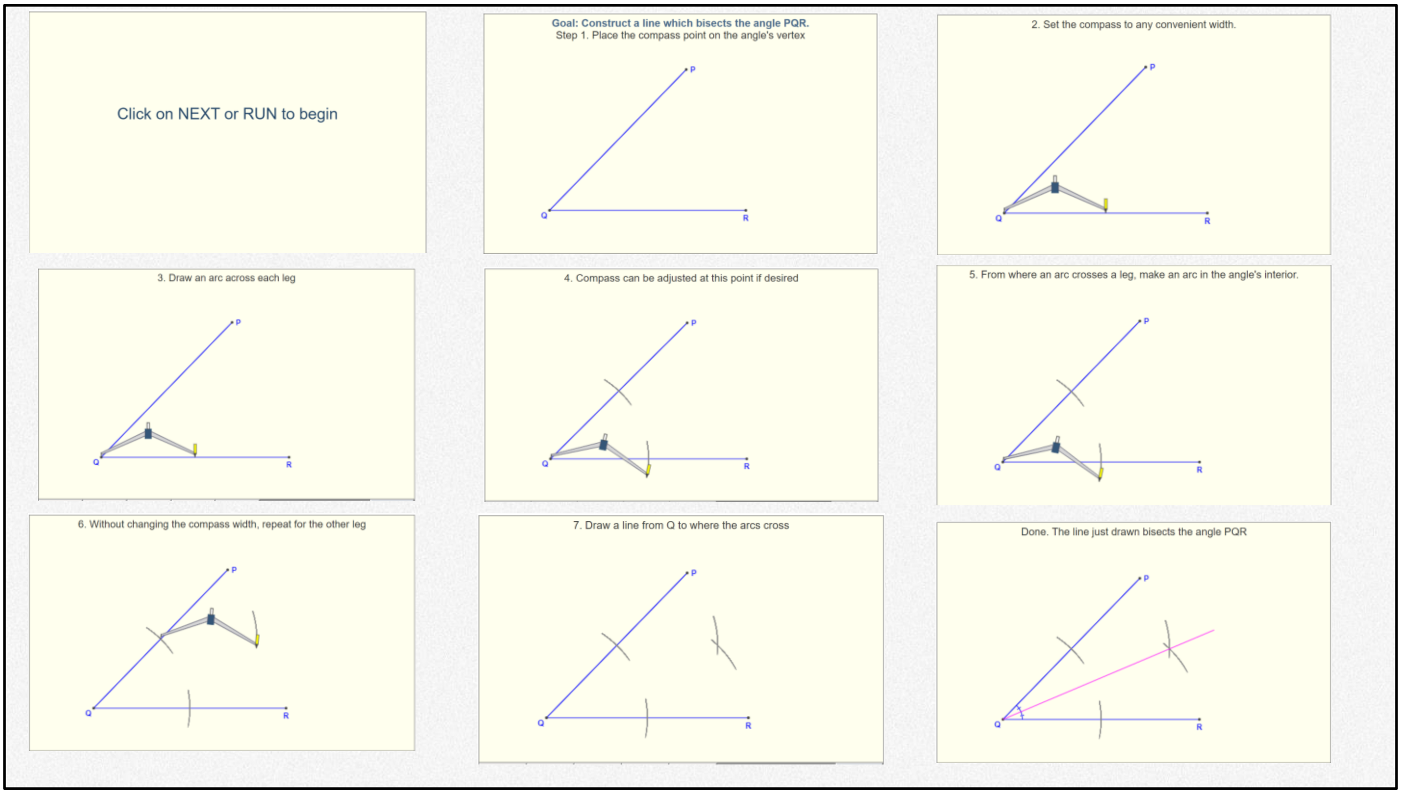
- Great when looking at properties of triangles.

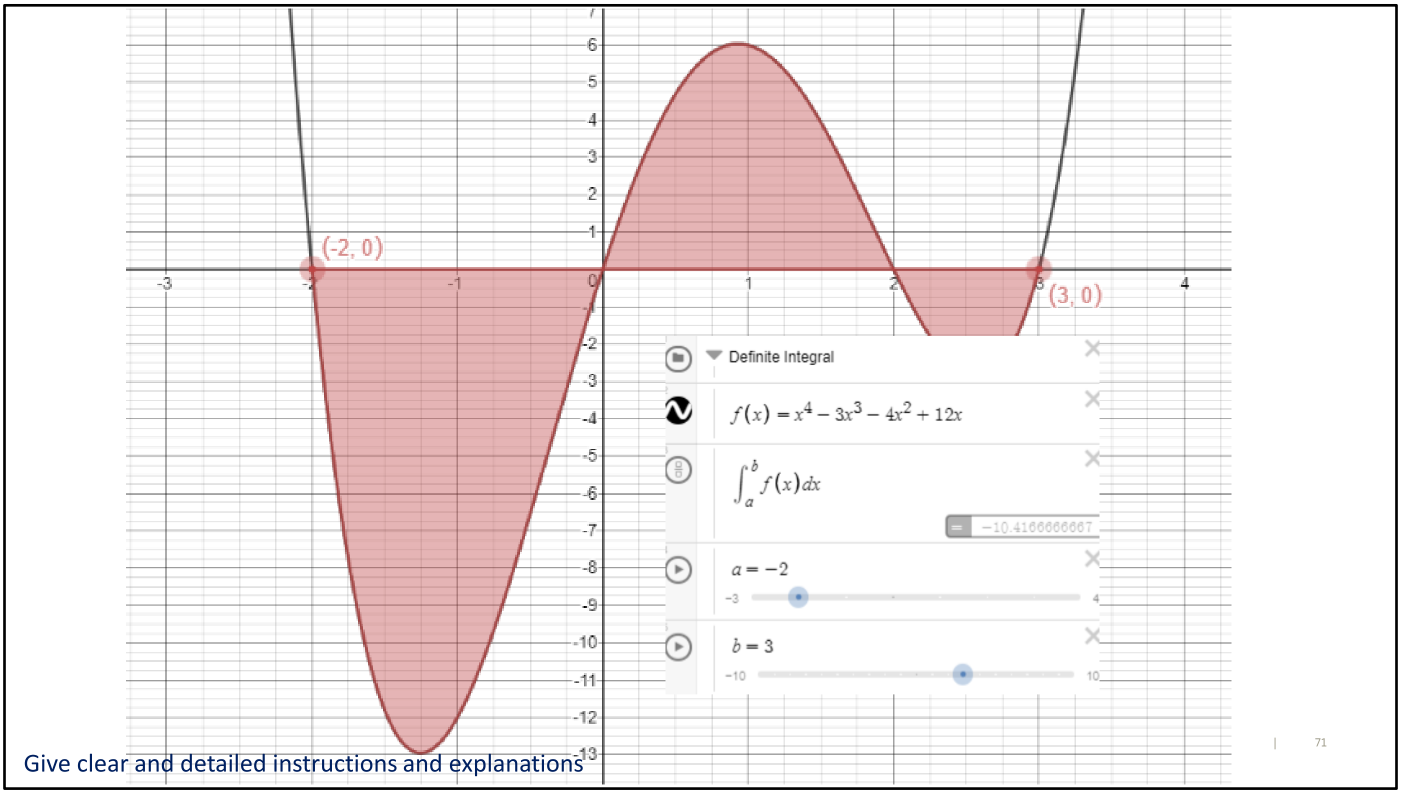
- Doing this on a geoboard is ideal. In a computer room - makes it easy for students to create the triangles – so they can spend their time creating different ones and looking at properties

Bisecting an Angle

Page, John D “Bisecting an Angle" From Math Open Reference
https://mathopenref.com/constbisectangle.html

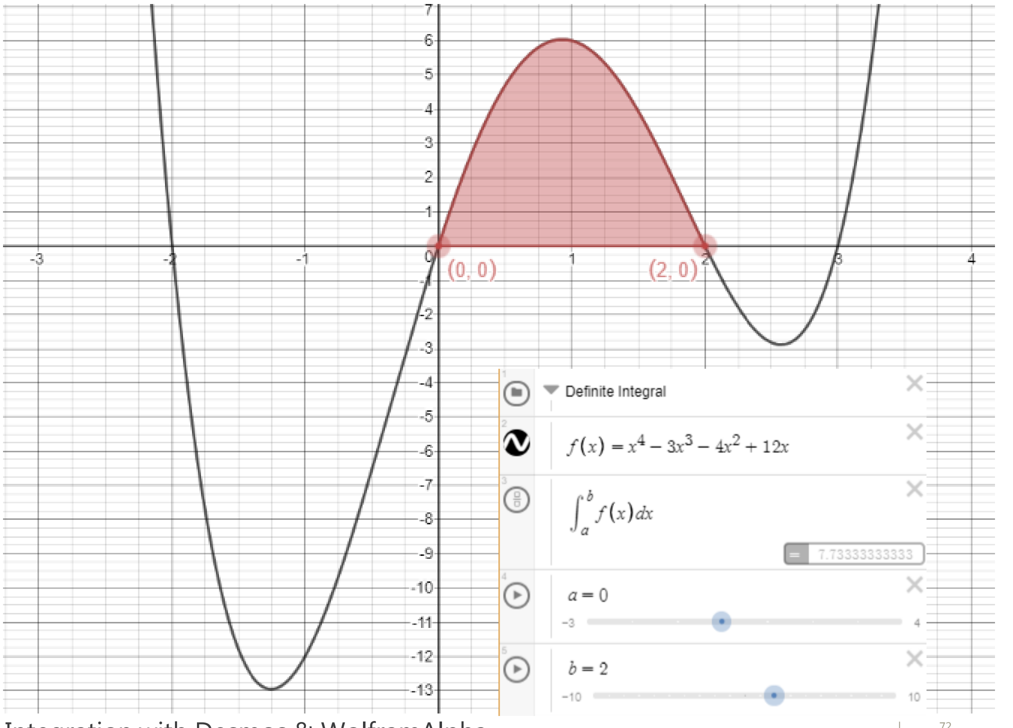



Click on NEXT or RUN to begin
Goal: Construct a line which bisects the angle PQR.
Step 1. Place the compass point on the angle's vertex
2. Set the compass to any convenient width.
3. Draw an arc across each leg
4. Compass can be adjusted at this point if desired
5. From where an arc crosses a leg, make an arc in the angle's interior.
6. Without changing the compass width, repeat for the other leg
7. Draw a line from Q to where the arcs cross
Done. The line just drawn bisects the angle PQR
P
Q
R



- I added this, thinking about explanations. This particular example showing the areas above and below the axes for a question on Integration.

Return to index



Integration with Desmos & WolframAlpha

- Change the limits

Questioning

Ask a large number of questions and check for understanding.

Ask students to explain what they have learned.

Check the responses of all students.

Provide systematic feedback and corrections.

Great Teaching Toolkit Elements
4. Activating hard thinking
3: Questioning and 4: Interacting

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- Essential for us to check understanding, checking regularly for understanding can help students learn the material with fewer errors.
- So we need to ask questions and make sure all students participate
- Questions allow us to determine how well the material has been learned and whether we need additional instruction or perhaps reteach prior knowledge
- How do you make sure everybody participates.

Questioning

3 Questioning: using questions and dialogue to promote elaboration and connected, flexible thinking among learners (e.g., 'Why?', 'Compare', etc.); using questions to elicit student thinking; getting responses from all students; using high-quality assessment to evidence learning; interpreting, communicating and responding to assessment evidence appropriately

4 Interacting: responding appropriately to feedback from students about their thinking/ knowledge/understanding; giving students actionable feedback to guide their learning

Ask a large number of questions and check for understanding.

Ask students to explain what they have learned.

Check the responses of all students.

Provide systematic feedback and corrections.

- Illustrating the relevant toolkit elements
- Questioning and Interacting

Standards Unit

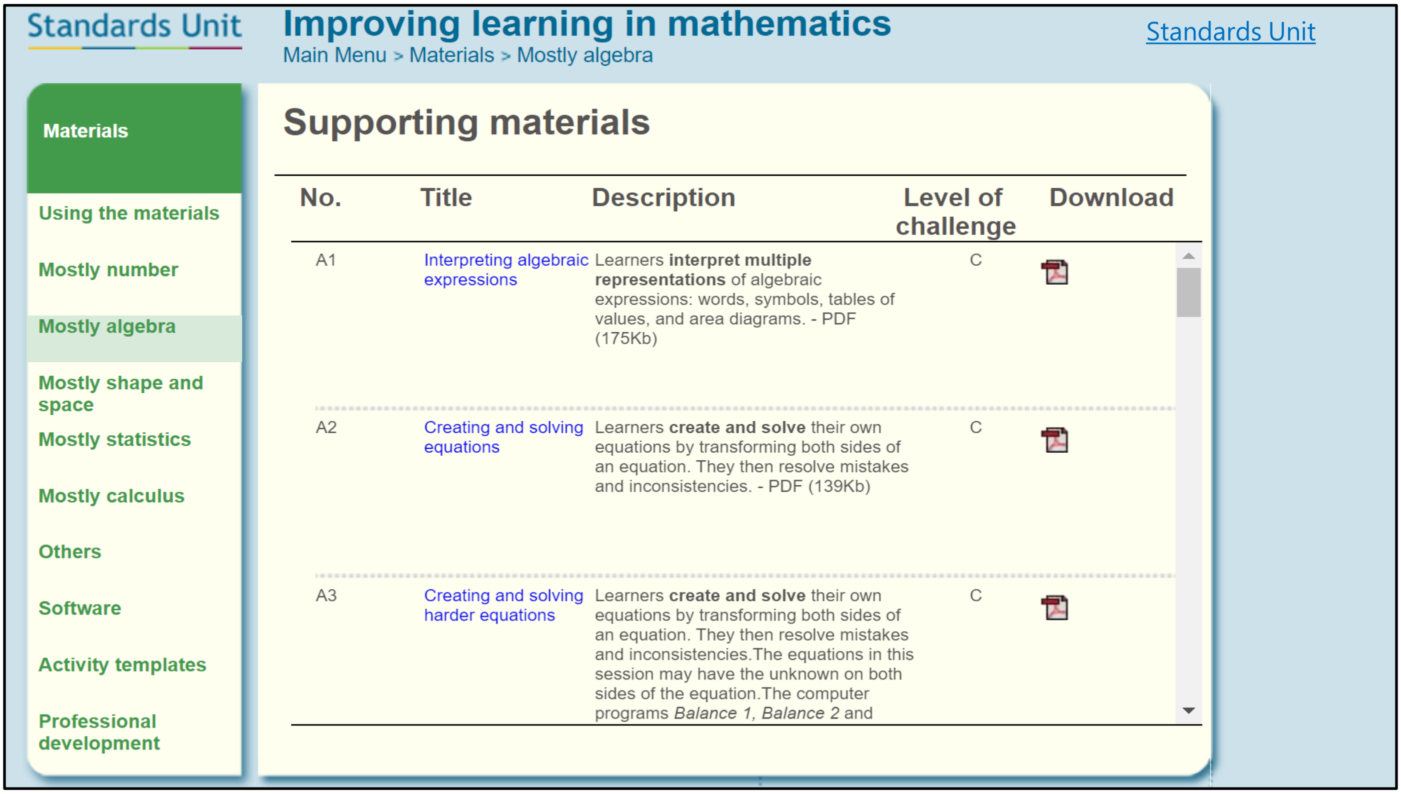
Improving learning in mathematics: challenges and strategies

(vi) Use rich collaborative tasks

Rich tasks:

- are accessible and extendable;
- allow learners to make decisions;
- involve learners in testing, proving, explaining, reflecting, interpreting;
- promote discussion and communication;
- encourage originality and invention;
- encourage 'what if?' and 'what if not?' questions;
- are enjoyable and contain the opportunity for surprise. [1]

- Thinking now about **sources of good questions**, I'll mention the standards unit as the tasks have excellent Teachers' notes including questions and activities for students



- Favourite source for the Standard Unit – University of Nottingham

GCSE Mathematics [MEI Tasks]

Topic	Student tasks ***For use with the app on laptops, tablets or smartphones***	Classroom activities ***Activities from teacher.desmos.com that require an internet-connected laptop or tablet***
Algebra: straight line graphs	Equation of a line: y=mx+c Intersection of two lines Parallel lines	Mini golf marbleslides Marbleslides: lines Polygraph lines Land the plane Card sort: Linear systems
Algebra: other graphs	Roots of quadratic functions Completed square form Transformation of functions Equations of tangents to circles	Marbleslides: parabolas Will it hit the hoop? Graphing stories Function transformations
Algebra: inequalities		Inequalities collection (5 activities)
Geometry	Transformations Properties of quadrilaterals Circle theorems	Polygraph: Polygons Laser challenge (angles) Puzzling it out (angles) Sector area

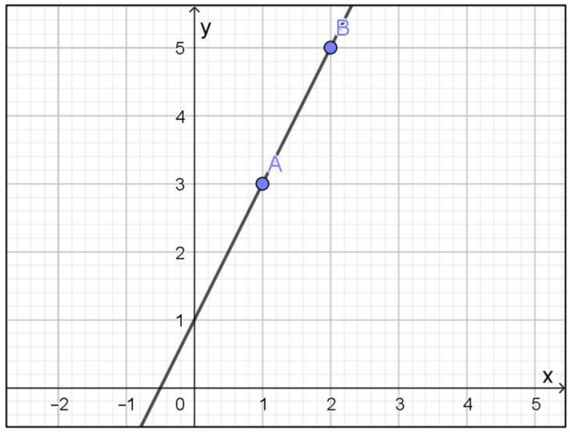
- A source of good questions can be found in MEI's GCSE and A Level tasks

MEI GeoGebra Tasks for GCSE Mathematics

Task 1: Algebra – Equation of a line: $y = mx + c$

1. In the input bar enter: **y=mx+c**
   If prompted select *Create Sliders*.
2. Use the **Point** tool to add two points to the line, **A** and **B**.
3. Vary the line with the sliders and the points by dragging them.

The points should move along the line as you drag them



- There are tasks available for Autograph, GeoGebra, Desmos or calculators. Clear instructions given

Questions for discussion

- How does changing c affect the line?
- How does changing m affect the line?
- What is the link between the difference of the x-coordinates and the difference of the y-coordinates?
- How could you find the equation of the line from the two pairs of coordinates?

Try setting m and c to values such as 1, 2, 3…
What do you notice – what stays the same and what changes?

Write down the coordinates of A and B and then subtract the x and y parts separately. Use this to predict a different point on the line.

Problem (Try the problem with pen and paper first then check it on your software)

Find the equation of the line through the points with coordinates $(2,1)$ and $(4,5)$.

Further Tasks

- Investigate how to find the equation of a line from the gradient of the line and a point on it, e.g. find the equation of the line with gradient 3 that passes through $(1,5)$.
- Investigate lines with negative gradients.
- Investigate the equations of vertical and horizontal lines.

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- Importantly, questions are given on the tasks.
- Could be useful for homework / remote learning

Task 4 – Algebra: roots of quadratic functions

Questions for discussion

- Why does $y = (x+p)(x+q)$ cut the x-axis at $x = -p$ and $x = -q$?

  What is the y-value when $x = -p$ or $x = -q$?

- How can you find values of b, c, p and q so that the two graphs are the same?

  Try changing b and c and then predicting what p and q would need to be.

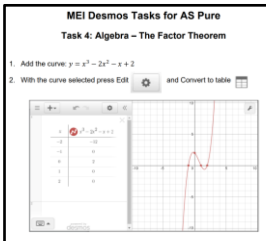
- Are there any values of b and c where $y = x^2 + bx + c$ can't be written as $y = (x+p)(x+q)$?

  Is it possible for a quadratic graph not to have roots?

Problem *(Try the problem with pen and paper first then check it on Desmos)*

Solve the quadratic equation $x^2 - x - 6 = 0$ and hence sketch the curve with equation $y = x^2 - x - 6$.

- Further examples of questions



Questions for discussion

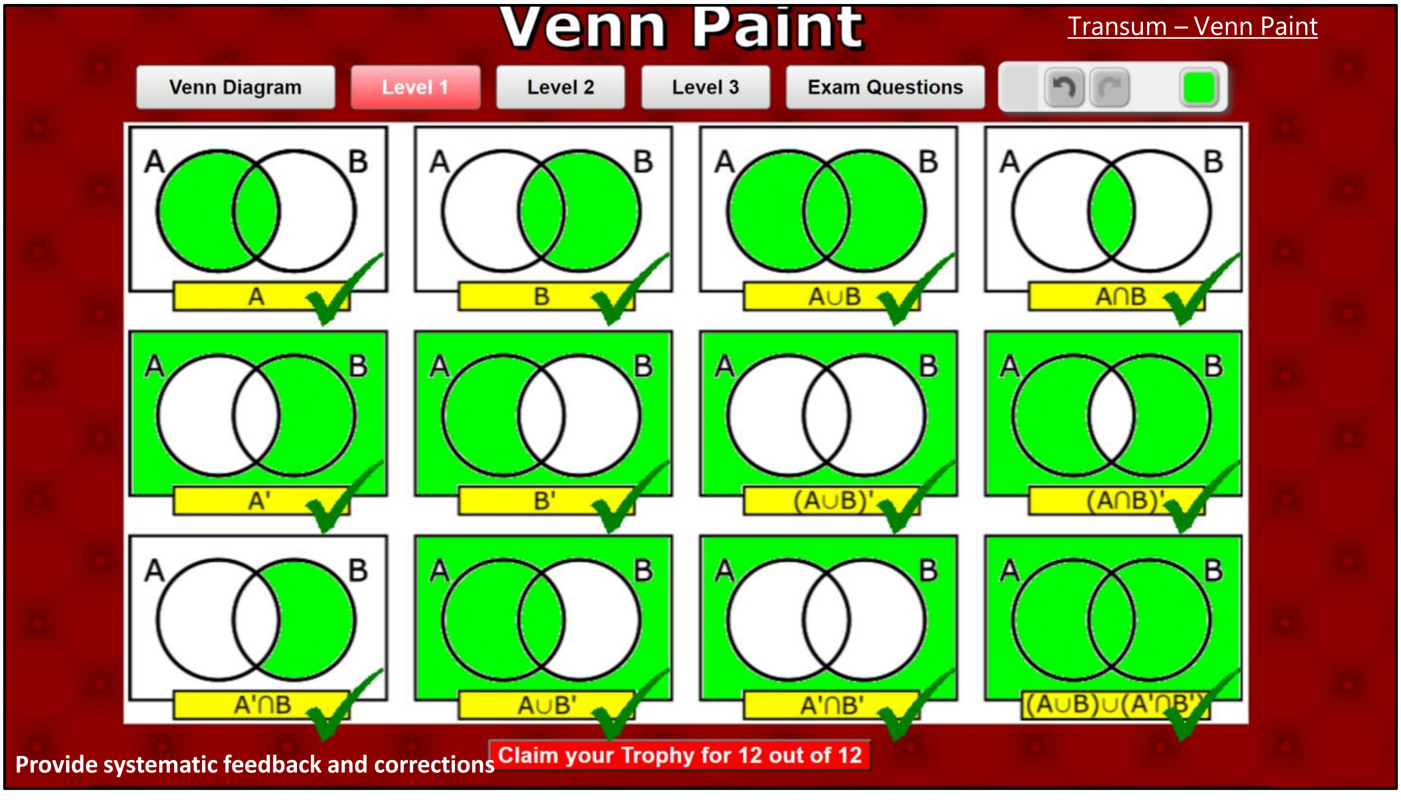
- What feature of the graph shows that $x^3 - 2x^2 - x + 2 = (x + 1)(x - 1)(x - 2)$?
- What feature of the table shows that $x^3 - 2x^2 - x + 2 = (x + 1)(x - 1)(x - 2)$?
- How can you use a table and/or a graph to find the factors of the following cubic expressions:
  $x^3 + 4x^2 + x - 6$ $\quad$ $x^3 - 4x^2 - 11x + 30$
  $x^3 - x^2 - 8x + 12$ $\quad$ $x^3 - 7x^2 + 36$

Problem (*Try the problem with pen and paper first then check it on your software)*

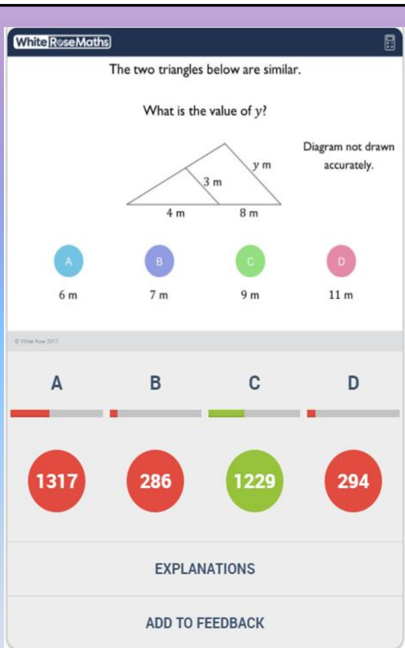
Show that $(x - 2)$ is a factor of $x^3 + 4x^2 - 3x - 18$.
Hence find all the factors of $x^3 + 4x^2 - 3x - 18$.

Further Tasks

- Find examples of cubics that only have one real root.
- Investigate using the factor theorem for polynomials of other degrees, e.g. quadratic or quartic polynomials.



- Students need feedback, many sites check answers – Transum has many such activities



Great Teaching Toolkit Elements
4. Activating hard thinking
3: Questioning and 4: Interacting

Questioning

Ask a large number of questions and check for understanding.

Ask students to explain what they have learned.

Check the responses of all students.

Provide systematic feedback and corrections.

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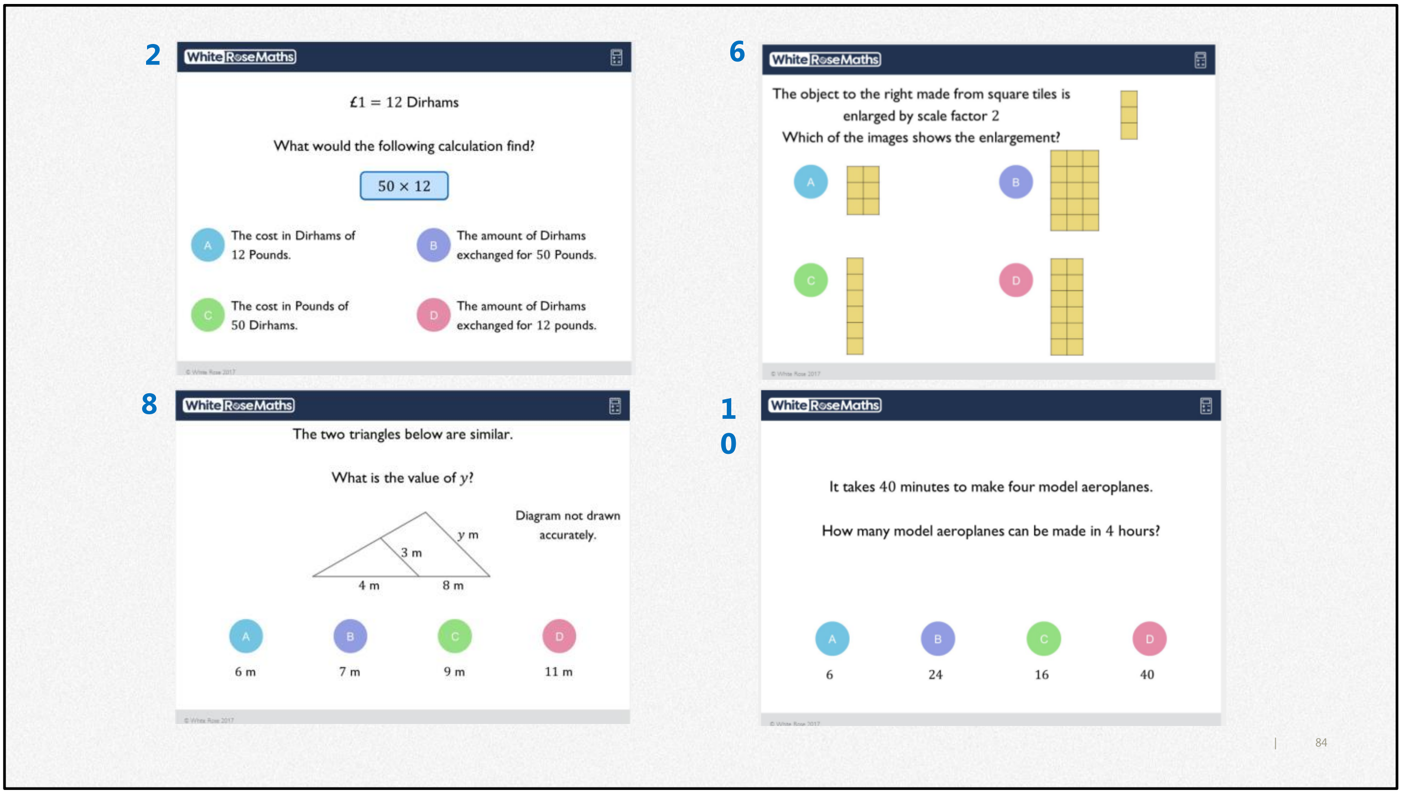
- Essential for us to check understanding, so we need to ask questions and make sure all students participate
- Diagnostic questions excellent for this and with the insights will help us understand misconceptions



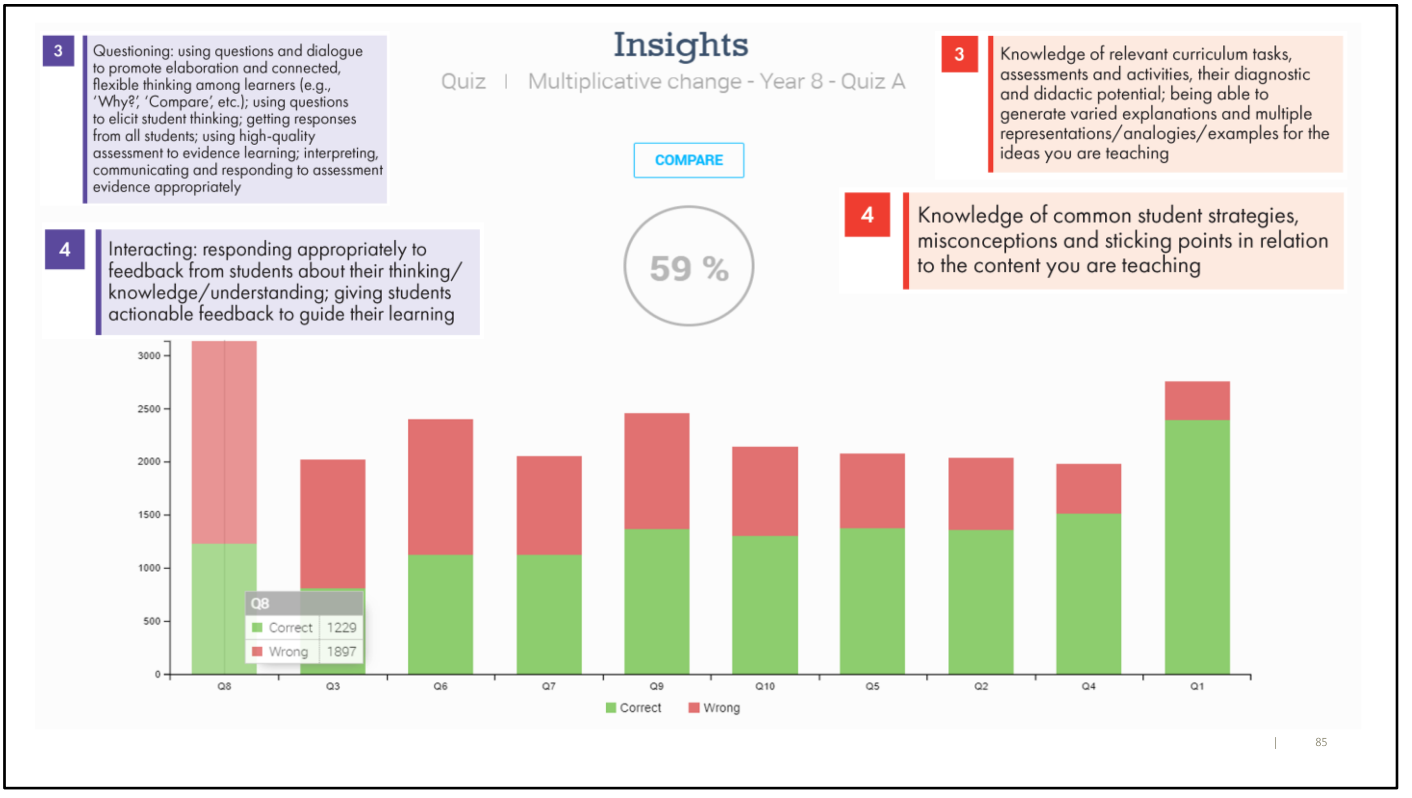
- So now we come to **misconceptions.**

- And of course the ultimate here has to be Craig Barton's Diagnostic Questions.

- Now we can **do something I have seen Craig Barton do**.

- Have a look at those questions – order them by which you think students found the most difficult.

- Brilliant exercise in understanding students' misconceptions.

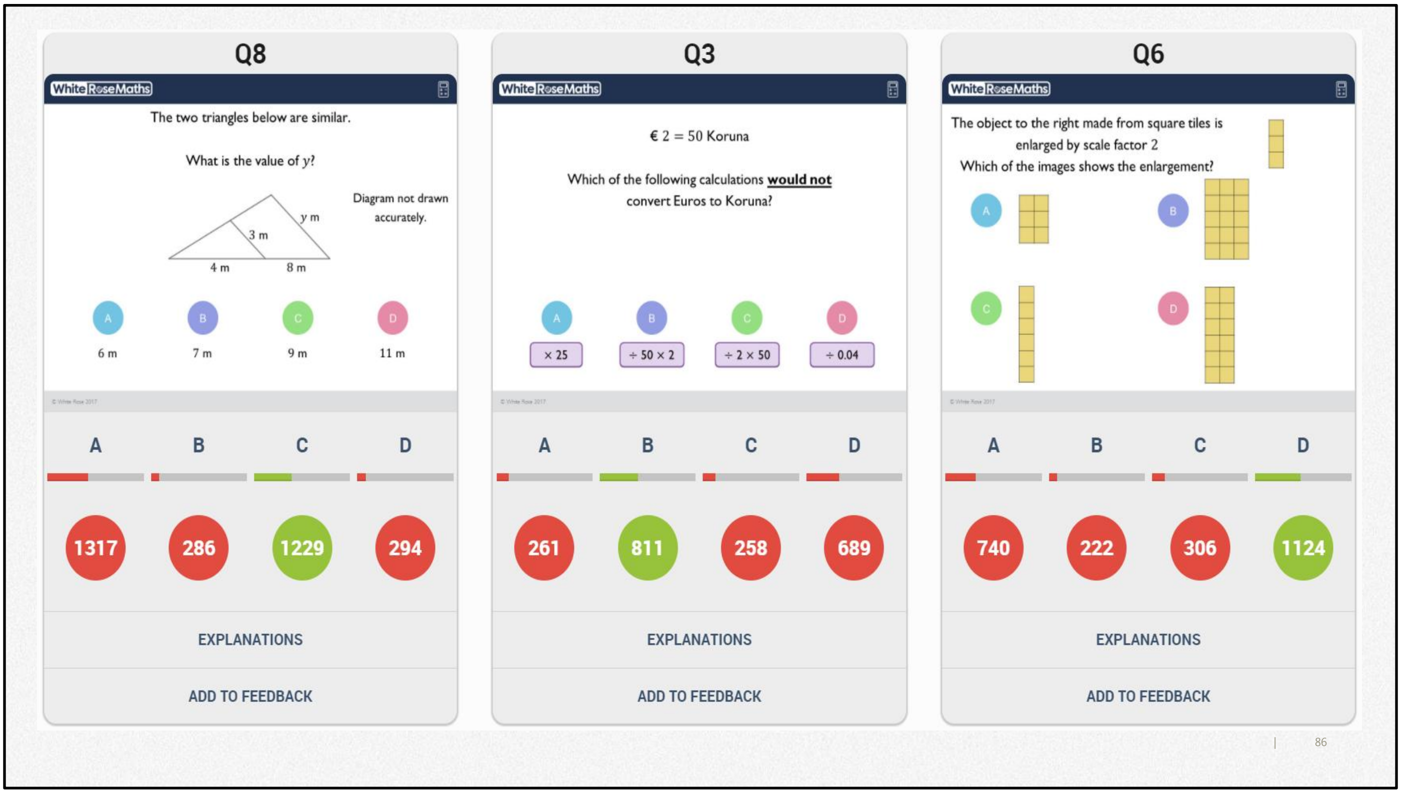


8 6 10 2 Note Quiz A – give quiz B for homework once feedback on quiz A – tell them will have a chance to do it again.

- I would say that in using Diagnostic Questions we can address several toolkit elements. We are using questions which promote discussion, setting your class a quiz for homework then using the insights is so helpful and can form such a good basis for feedback to the class.

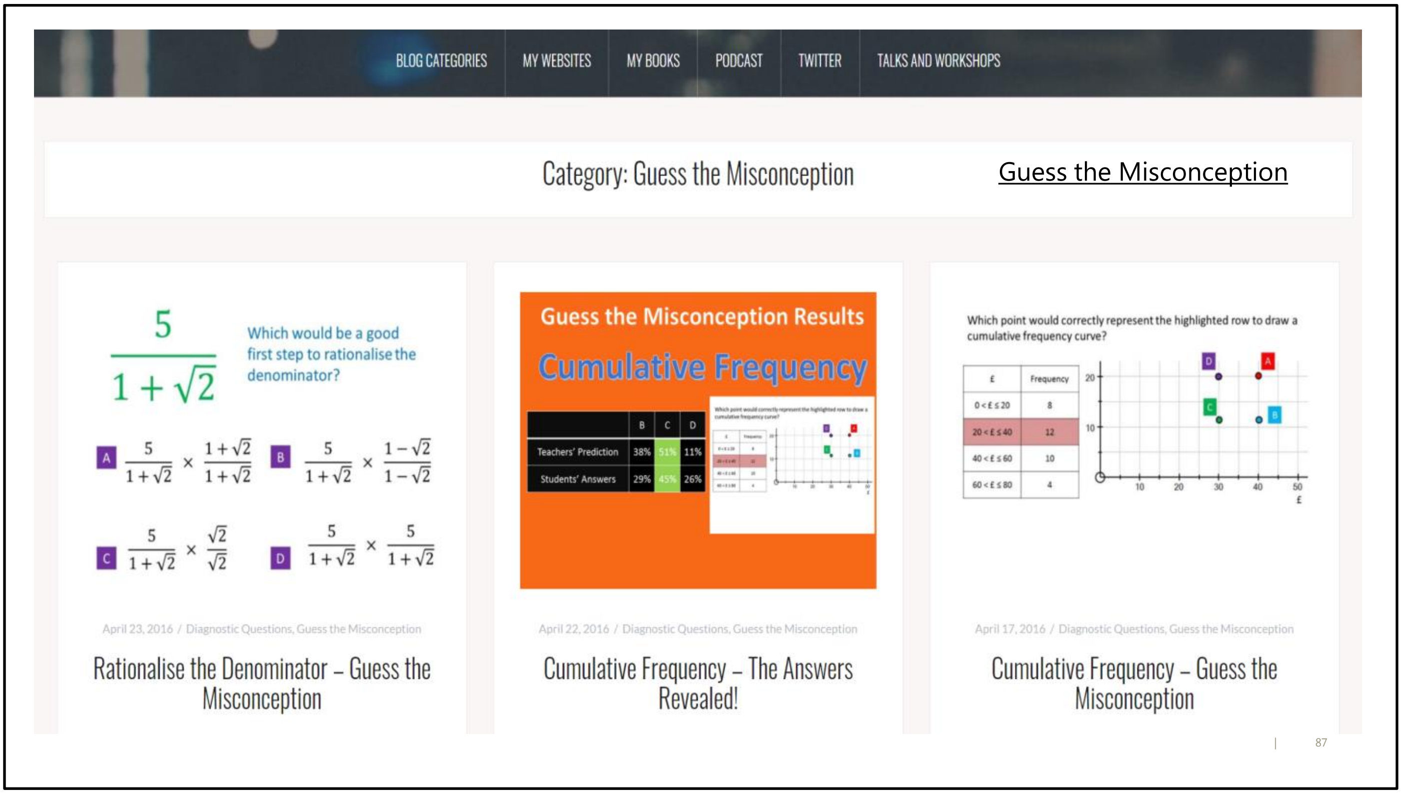
- When going through questions we can discuss the misconceptions.

- I have successfully set homework where students had to write a short quiz in the diagnostic questions format. They had to give four responses and explain why they had included each.



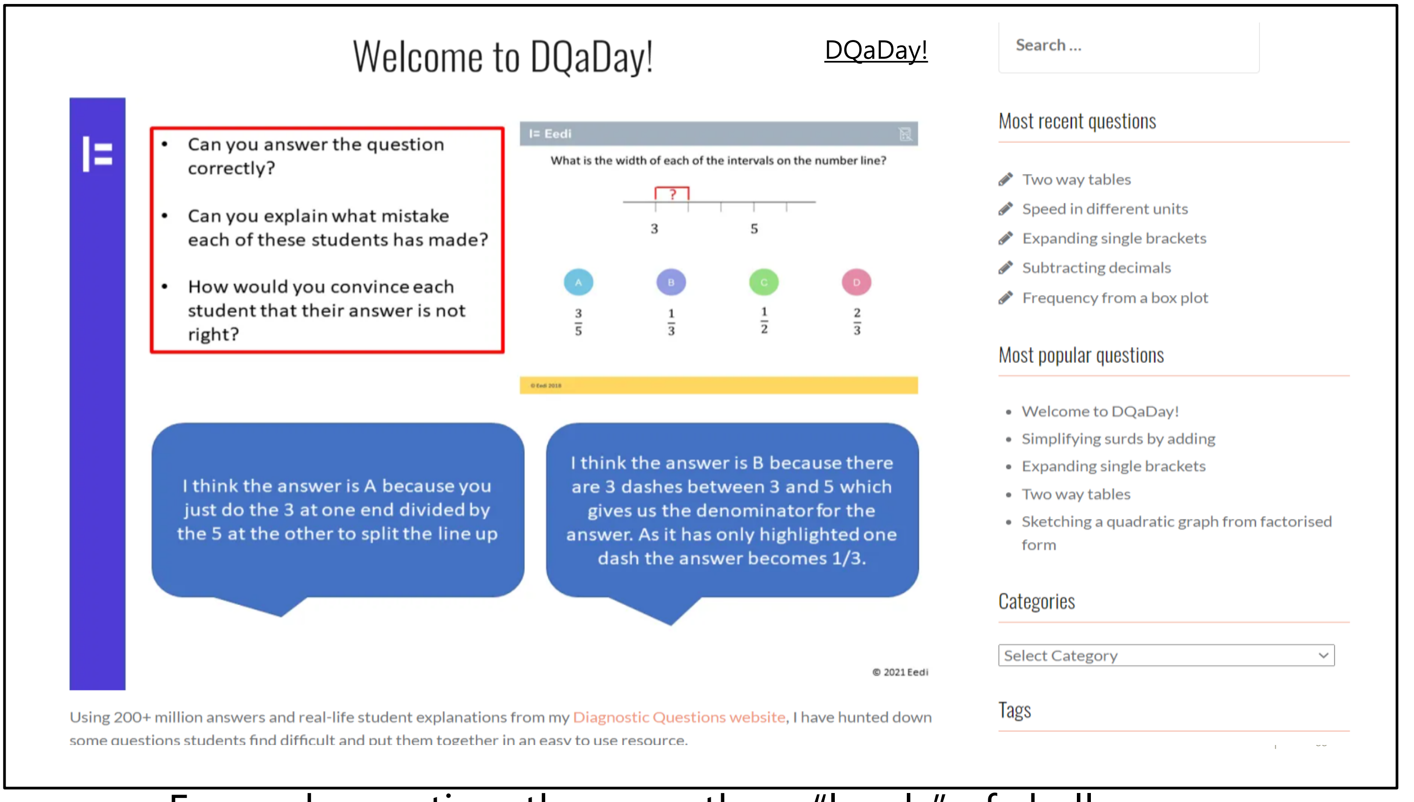
- Insights very informative.

- Note the explanations option – author explains the different responses and the misconception associated with each.



- Brilliant for professional development.

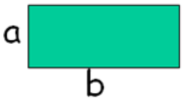
- **A whole site – guess the misconception!**



- For each question, there are three “levels” of challenge:
- Uses suggested by Craig Barton
- *As a starter to ensure students hit the lesson running with some good, hard thinking*
- *Mid-way through the lesson to break up a task*
- *At the end of a lesson/topic to assess understanding*
- *As an interesting and challenging homework task*

Spot the Mistake

1) $a + a + a + a =$ **$4a$**
2) $3a \times 2b =$ **$5ab$**
3) $c \times c =$ **$2c$**
4) $4d + 2e - d + 3e =$ **$3d + 5e$**
5) $8f - 3g + 2f - 6g =$ **$10f - 3g$**
6) $5y - y =$ **5**
7) Find the perimeter of this shape



a^2b^2

8) $b \times b \times b \times b =$ **b^4**
9) $3(2k + 3) =$ **$6k + 3$**
10) $a(a + 3) =$ **$a^2 + 3a$**

- I find Spot the mistake type activities really useful for discussing corrections – the whole class can discuss such activities – less stressful marking some fictional character.

- I have used this little gem many times (Craig Barton)

Clumsy Clive On Function Notation

Clive is tackling his functions homework and knows that he's made mistakes somewhere.
Can you spot and correct the mistakes Clive has made?
Can you explain what mistakes Clive has made, and maybe give him some tips so that he (hopefully) doesn't make them again?

Question 1: If $f(x) = 3x - 2$, find: a. $f(2)$ b. $f(-2)$	
Clive's answer:	*Your answer:*
Substitute $x = 2$. *Answer:* $f(2) = 4$ Therefore $f(-2) = -4$	
What mistake has Clive made?	

- Still looking at understanding student misconceptions
- Back to Andy Lutwyche again who has clearly seen many misconceptions and incorporated them well into his resources
- Brilliant series – Clumsy Clive

- And at A level – Erica's errors.

Question 1:

If $f(x) = 3x - 2$, find:

a. $f(2)$

b. $f(-2)$

Clive's answer:	*Your answer:*
Substitute $x = 2$. *Answer:* $f(2) = 4$ Therefore $f(-2) = -4$	Substitute $x = 2$. *Answer:* $f(2) = 4$ Substitute $x = -2$. *Answer:* $f(-2) = -8$

What mistake has Clive made?

He hasn't substituted in $x = -2$, he has just assumed that $f(-2) = -f(2)$ which it isn't.

Question 3: $f(x) = 2x + 1$ $g(x) = \frac{5}{x+3}$ Find $fg(7)$	
Clive's answer:	*Your answer:*
$f(7) = 2 \times 7 + 1 = 15$ Substitute this answer in to $g(x)$: $g(15) = \frac{5}{15+3}$ *Answer:* $fg(7) = \frac{5}{18}$	
What mistake has Clive made?	

Question 3: $f(x) = 2x + 1$ $g(x) = \frac{5}{x+3}$ Find $fg(7)$	
Clive's answer:	*Your answer:*
$f(7) = 2 \times 7 + 1 = 15$ Substitute this answer in to $g(x)$: $g(15) = \frac{5}{15+3}$ *Answer:* $fg(7) = \frac{5}{18}$	We need to do $g(7)$ and substitute that answer in to $f(x)$. $g(7) = \frac{5}{7+3} = \frac{5}{10} = \frac{1}{2}$ $f\left(\frac{1}{2}\right) = 2 \times \frac{1}{2} + 1$ *Answer:* $fg(x) = 2$
What mistake has Clive made? He has performed the functions in the wrong order. $fg(x)$ means that you do "f of $g(x)$".	

Algebra
By Example

Name: ________________ Date: ___________

Teacher: _______________ Section: __________

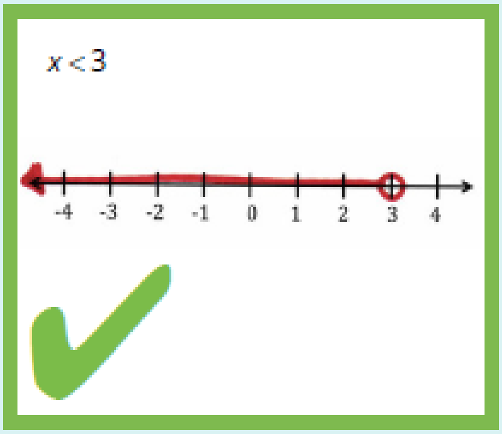
AlgebraByExample
Assignment 5.3

For each set, first examine the problem on the left and answer the question(s) about it. Then complete the similar problem on the right.

graphing inequalities

SET 1: Graph each inequality on the number line.

Lina graphed this inequality **correctly**.
Here is her work:



- How did Lina know which way to draw her arrow?
- Why did Lina make the circle around the 3 open instead of closed?

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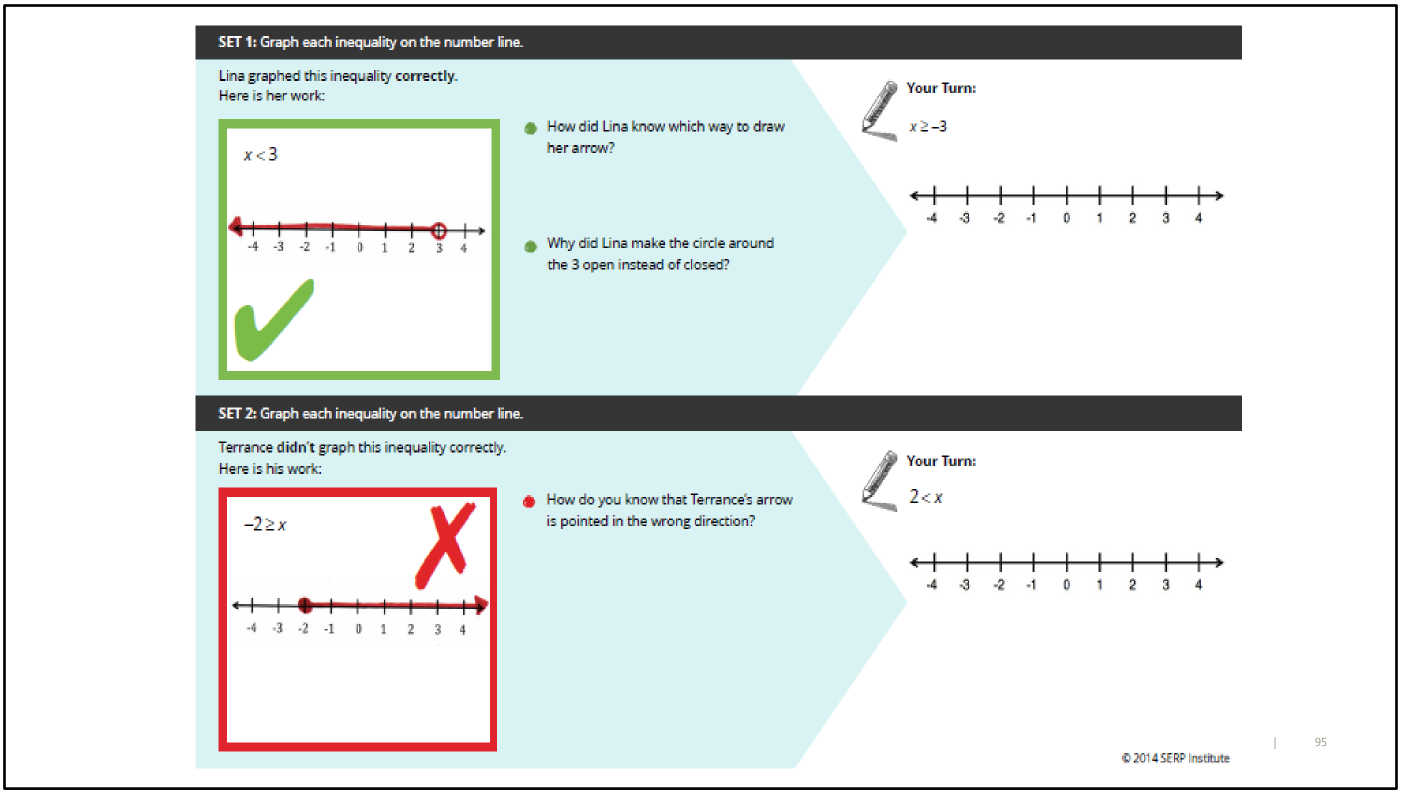
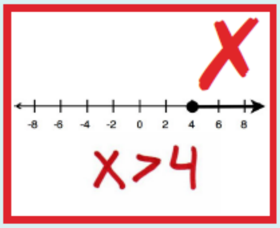
- And a whole series on Algebra…
- A lovely mix.
- We have explanations / misconceptions / practice
- Algebra by example



- Excellent for question prompts

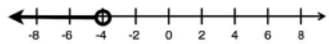
SET 3: Write an inequality represented by the graph.

Nevaeh **didn't** write the inequality correctly.
Here is her work:



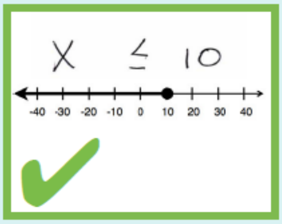
- What part of the inequality that Nevaeh wrote is incorrect?

Your Turn:



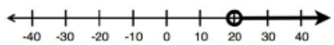
SET 4: Write an inequality represented by the graph.

Franco wrote this inequality **correctly**.
Here is his work:

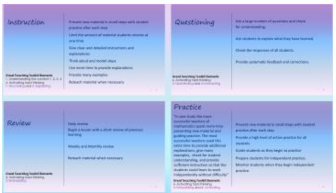


- How did Franco know that the inequality symbol should open towards the 10?
- If Franco had written 10 ≥ x, would his answer still be correct? Explain.

Your Turn:



Return to index



CHECK FOR UNDERSTANDING

Checking for understanding at each point can help children learn material with fewer errors. Check to see if they are all learning the new material or developing misconceptions.

Ask questions, ask them to summarise, repeat procedures, or ask them to think aloud as they work to solve problems or plan writing.

Checking has two purposes:
1) It tells you when material needs re-teaching
2) Answering questions means that children have to elaborate which strengthens links to other learning in their long-term-memory.

Guided practice, after teaching small amounts of new material, and checking for understanding, can limit the development of misconceptions.

Dunkin, M.J. (1978).
Student characteristics, classroom processes, and student achievement. Journal of educational psychology, 70(6), 998– 1009.

Fisher, D.; Frey, A. (2007).
Checking for understanding: formative assessment techniques for your classroom.
Arlington, VA: Association for Supervision and Curriculum Development.

Research in 100 Words

TLC Education Services Ltd

Daily review: Appropriate first activity to make sure all are able to understand new learning in the day's lesson

Daily review (could also be weekly and/or monthly – Rosenshine additional suggestions:

- Correct homework.
- Review the concepts and skills that were practiced as part of the homework.
- Ask students about points where they had difficulties or made errors.
- Review material where errors were made.
- Review material that needs overlearning (i.e., newly acquired skills should be practiced well beyond the point of initial mastery, leading to automaticity)

Review

Think about how we get the learning out of our students' heads!

5 Embedding: giving students tasks that embed and reinforce learning; requiring them to practise until learning is fluent and secure; ensuring that once-learnt material is reviewed/revisited to prevent forgetting

Daily review

Begin a lesson with a short review of previous learning

Weekly and Monthly review

Reteach material when necessary

4. Activating hard thinking

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The main difference between daily review and weekly/monthly review is the purpose. Daily review is a process for reviewing any prior learning needed for he current lesson.

Weekly and monthly review makes sure that we are spacing practice over time.

2.Quality of instruction (Strong evidence of impact on student outcomes)
"Includes elements such as effective questioning and use of assessment by teachers. Specific practices, like reviewing previous learning, providing model responses for students, giving adequate time for practice to embed skills securely *3* and progressively introducing new learning (scaffolding) are also elements of high quality instruction."

Student comments

A teacher who provides the student with the opportunity to see what they need to revise. Regular tests and quizzes do this.

Doesn't mind repeating things.

Tests that don't have further impact on levels / grades. Just there for you to know what you don't know.

Low stakes tests are really good because there is not much pressure and at the end of them I can see how I'm doing and what I need to improve on for later formal tests.

Retrieval Practice

Students need to recall information and the evidence suggests that testing is a better way of doing this than simply rereading material, a method often favoured by students.

Use low stakes 'Self-checks' - a learning tool, not something to be stressed by.

Aristotle apparently wrote
"exercise in repeatedly recalling a thing strengthens the memory."

Retrieval Practice

“Active recall, pulling something out of memory, not just recognising something from a list or multiple choice question, improves future performance, something we have known for a century (Gates 1917).

The act of active recall develops and strengthens memory. It also improves the process of recall in ways that passive recall – reading, listening and watching - do not.

In practice, it is active recall that really matters in knowledge and skills, not recognition.”

Donald Clark – White Paper on Spaced Practice

Retrieval Practice – Research Summaries

See Retrieval Practice site for Research Snapshots

Example takeaway: "**Educators are encouraged to incorporate brief in-class quizzes in lieu of reviewing already-presented content. Retrieval practice does not take more time than reviewing; instead, it is a more effective and efficient use of classroom time**."

Use Retrieval Practice….

- As a regular part of lessons
- Including those odd moments…
- For reviewing one or a small number of topics
- For reviewing several topics
- As a revision tool for tests / exams
- To provide a revision list
- To check feedback from previous lesson
- Following homework to review a topic
- Retrieval Practice can in fact be used for more than just recall but also to help students make links between topics. Sophisticated questions requiring a deeper understanding can be asked.

- Odd moments – this could be in the Questions section as well.
- At the end of a lesson, pack up.
- Whilst waiting for the bell – choral response.:

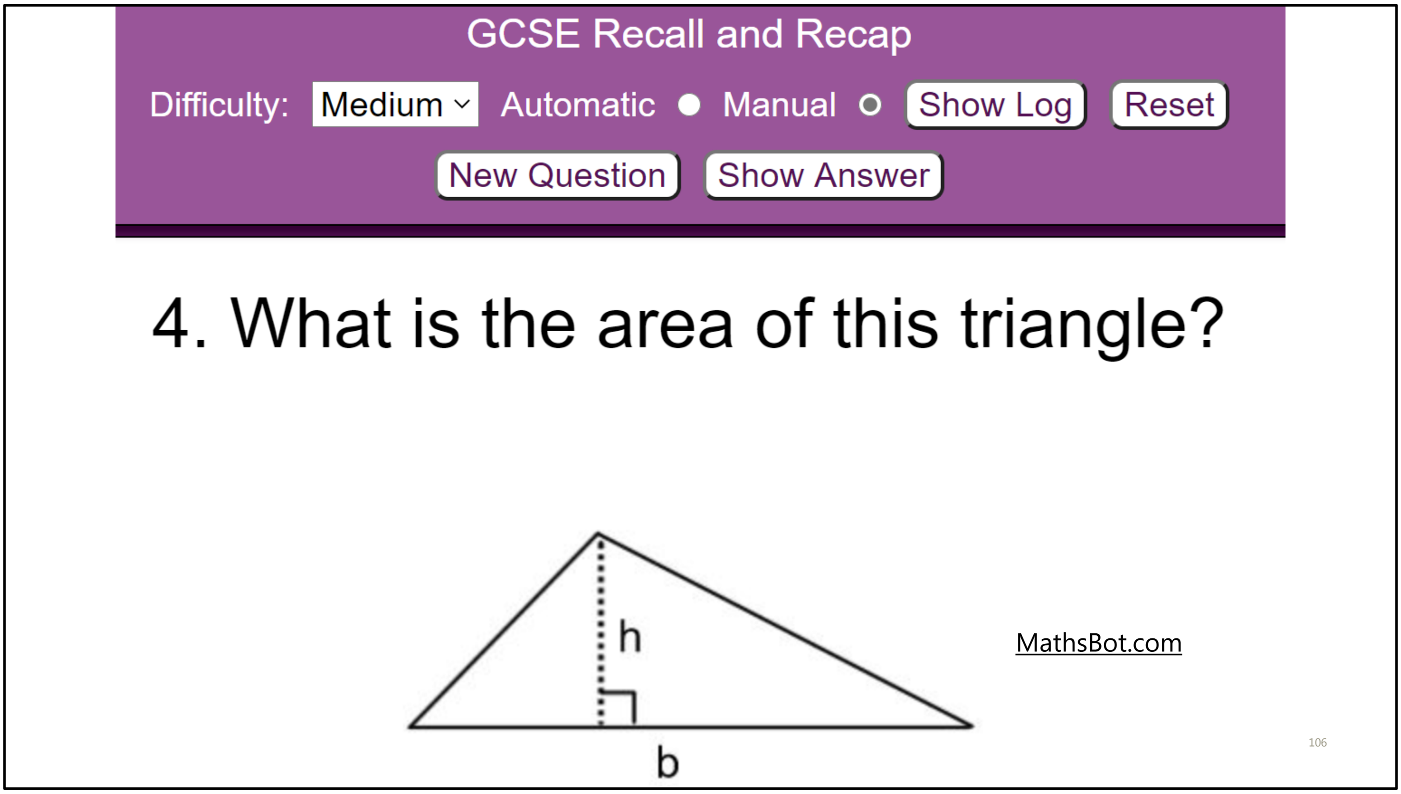
- Ask them any questions – directed number practice, indices, cubes, cube roots, whatever you know they need practice at. All chorus the answer. A way of all of them responding.

No-Quiz Retrieval Strategy: "Two Things"

Here's the scoop: At any point during a lesson, stop and have students write down Two Things about a specific prompt.

For example:
What are two things you learned so far today?
What are two things you learned yesterday (or last week)?
What are your two takeaways from today?
What are two things you'd like to learn more about?
What are two ways today's topic relates to previous topics?

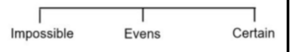
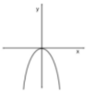
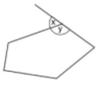
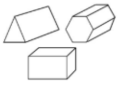
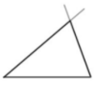
And then what? You move on with your lesson. That's it!



- So many good resources for retrieval practice in Maths

Retrieval Facts

Facts: 10 Difficulty: Medium New Facts Print

1.	What probability is associated with an event that is evens chance to occur?	
2.	What type of graph is shown?	
3.	What do you call an angle between the side of a polygon, and a line extended from the next side?	
4.	What do you call a polyhedron with the same cross section along its length?	
5.	How many factors does a prime number have?	19 2 7 13 101
6.	What does the acronym ASA stand for when contructing a triangle?	

GCSE Revision Grid

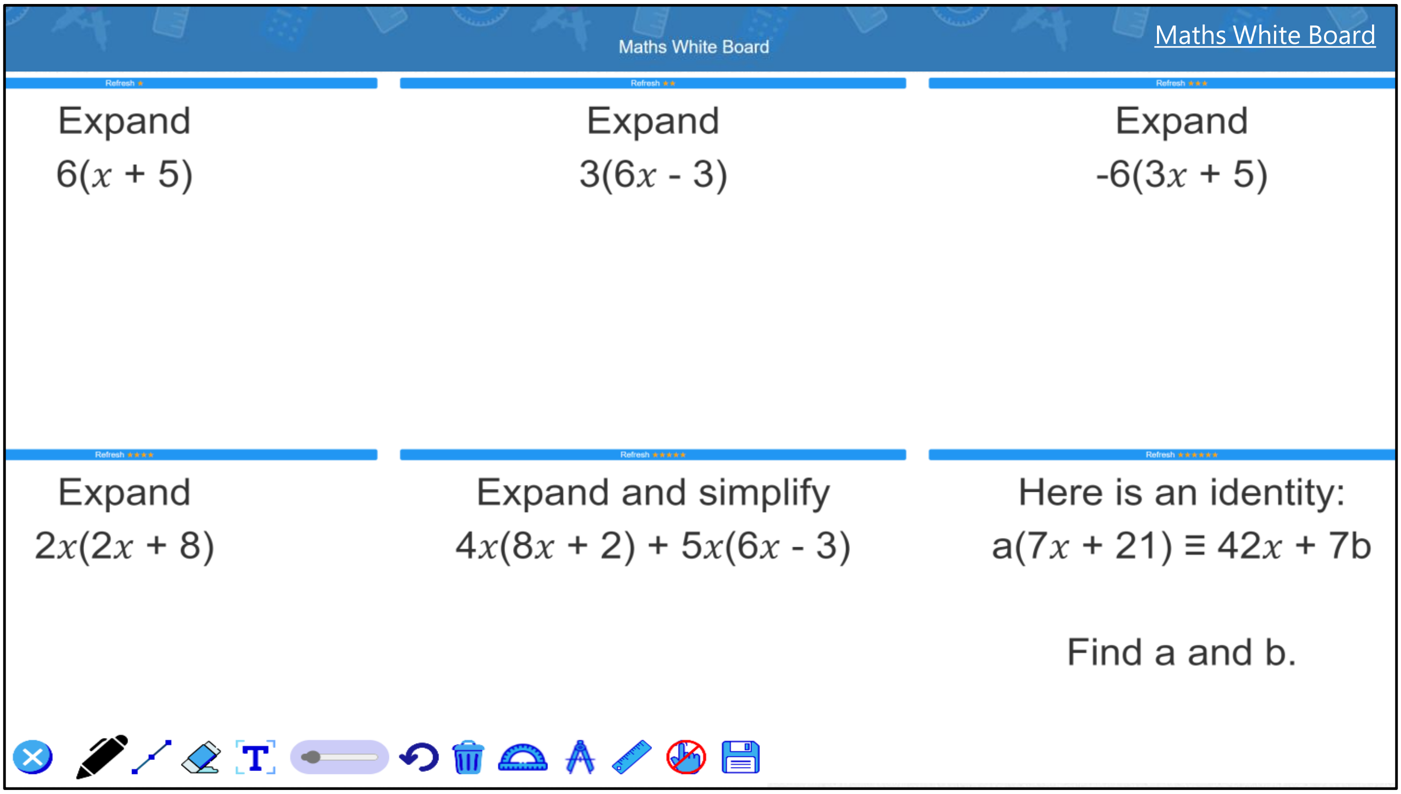
Question: 35. Factor sum problem (F, 2 m

Search: Keyword

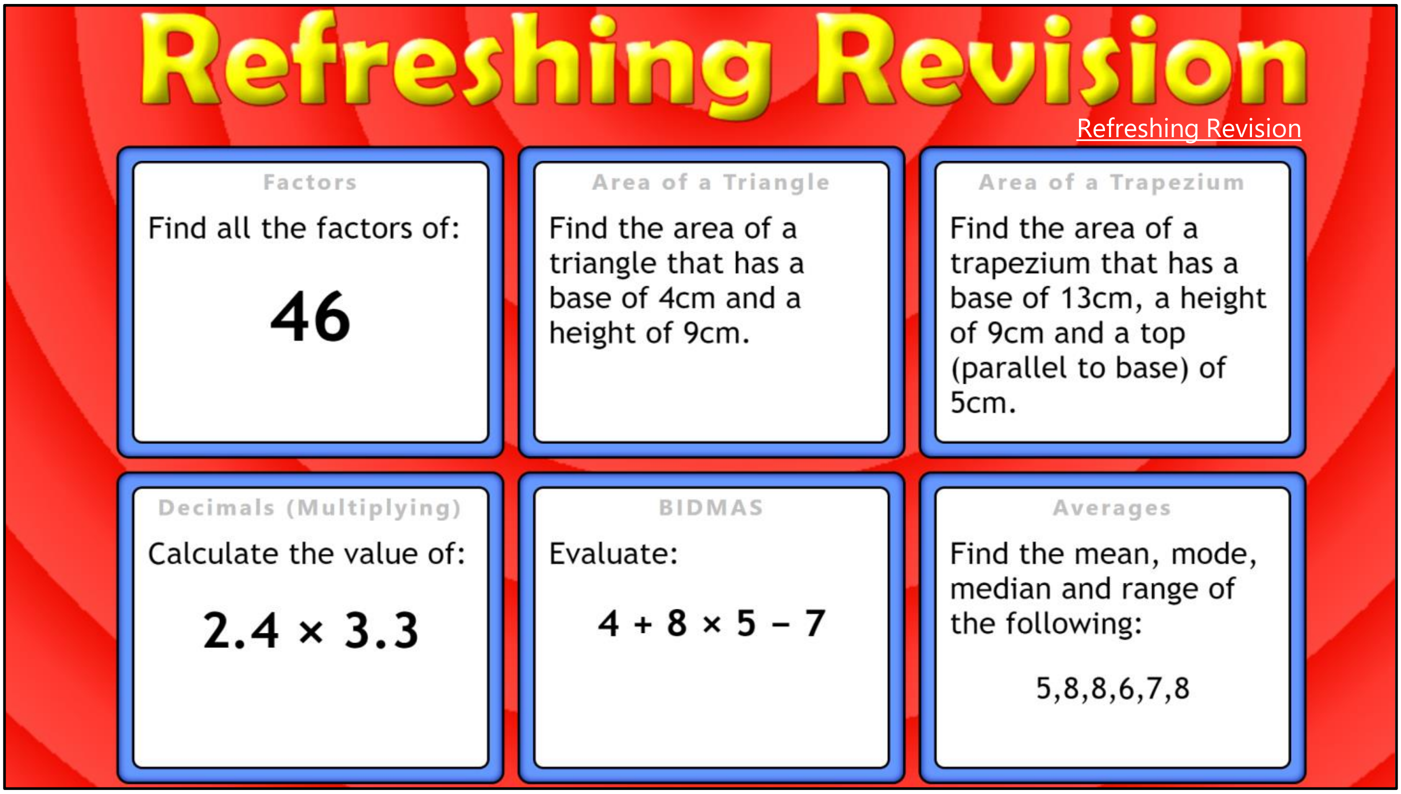
Grid Size: 2 x 2 Background:

Create Grid | Print Grid | Show Answers

1.↻ Two numbers are added together to give 8. Both of the numbers are factors of 30. Both numbers are greater than 2. What are the two numbers?	**2.**↻ Two numbers are added together to give 9. Both of the numbers are factors of 60. Both numbers are greater than 2. What are the two numbers?
3.↻ Two numbers are added together to give 10. Both of the numbers are factors of 48. Both numbers are greater than 2. What are the two numbers?	**4.**↻ Two numbers are added together to give 11. Both of the numbers are factors of 72. Both numbers are greater than 2. What are the two numbers?



- Back to Maths White Board. Fantastic collection of retrieval boards
- (Can also make calendars now with your choice of questions)



- Transum again – a real favourite – this is lovely because you can customise it.

Concept Selection

Teachers can select which concepts are included in this Mathematics Lesson Starter:

- [x] Area of a Trapezium
- [x] Area of a Triangle
- [x] Averages
- [x] BIDMAS
- [ ] Basic Addition
- [ ] Basic Division 1
- [ ] Basic Division 2
- [ ] Basic Multiplication
- [ ] Basic Subtraction
- [ ] Bearings
- [ ] Brackets (Linear)
- [ ] Brackets (Quadratic)
- [ ] Change The Subject
- [ ] Circle (Vocabulary)
- [ ] Circle Area
- [ ] Circle Circumference
- [ ] Circle Theorems
- [ ] Coordinates (Midpoint)
- [ ] Coordinates (Square)
- [ ] Currency Exchange
- [ ] Decimal to Fraction
- [ ] Equations (Type 2)
- [ ] Equations (Type 3)
- [ ] Equations (Type 4)
- [ ] Equations (Type 5)
- [ ] Factorise (Linear)
- [ ] Factorise (Quadratic 1)
- [ ] Factorise (Quadratic 2)
- [x] Factors
- [ ] Formulas (Advanced)
- [ ] Fraction to Decimal
- [ ] Fraction to Percentage
- [ ] Fractions (Adding)
- [ ] Fractions (Dividing)
- [ ] Fractions (Equivalent)
- [ ] Fractions (Mixed)
- [ ] Fractions (Multiplying)
- [ ] Gradient
- [ ] Graph (Linear)
- [ ] Highest Common Factor
- [ ] Indices (Advanced)
- [ ] Indices (Simple)
- [ ] Interest (Compound)
- [ ] Interest (Simple)
- [ ] Last Lesson
- [ ] Last Week
- [ ] Lowest Common Multiple
- [ ] Multiples
- [ ] Probability
- [ ] Pythagoras
- [ ] Ratio
- [ ] Roman Numerals (1-12)
- [ ] Roman Numerals (60-100)
- [ ] Roman Numerals (Large)
- [ ] Rounding
- [ ] Sequence (Arithmetic)
- [ ] Sequence (Geometric)
- [ ] Sequence (Quadratic)
- [ ] Sets (Intersection)
- [ ] Sets (Union)
- [ ] Shape Formulas
- [ ] Simplify
- [ ] Square Numbers
- [ ] Standard Form 1
- [ ] Standard Form 2
- [ ] Standard Form 3
- [ ] Standard Form 4
- [ ] Standard Form 5
- [ ] Substitution
- [ ] Time (Analogue)
- [ ] Time (Digital)
- [ ] Times Tables (12)
- [ ] Times Tables (2)
- [ ] Times Tables (2-12)
- [ ] Times Tables (2-5)

Refreshing Revision

Negative Numbers

a) 12 − 18
b) 12 × (-5)
c) (8−18)(6−12)
d) 60 ÷ (-5)
e) $(-6)^2$

Equations (Type 2)

Solve:

$$5x - 6 = 4$$

BIDMAS

Evaluate:

$$8^2 - 6 \times 7 + 7$$

Simplify

Simplify the following by collecting like terms:

$$3b + 5c + 8b + 4c$$

Brackets (Linear)

Expand:

$$7(9x - 7)$$

Square Numbers

What is the square root of

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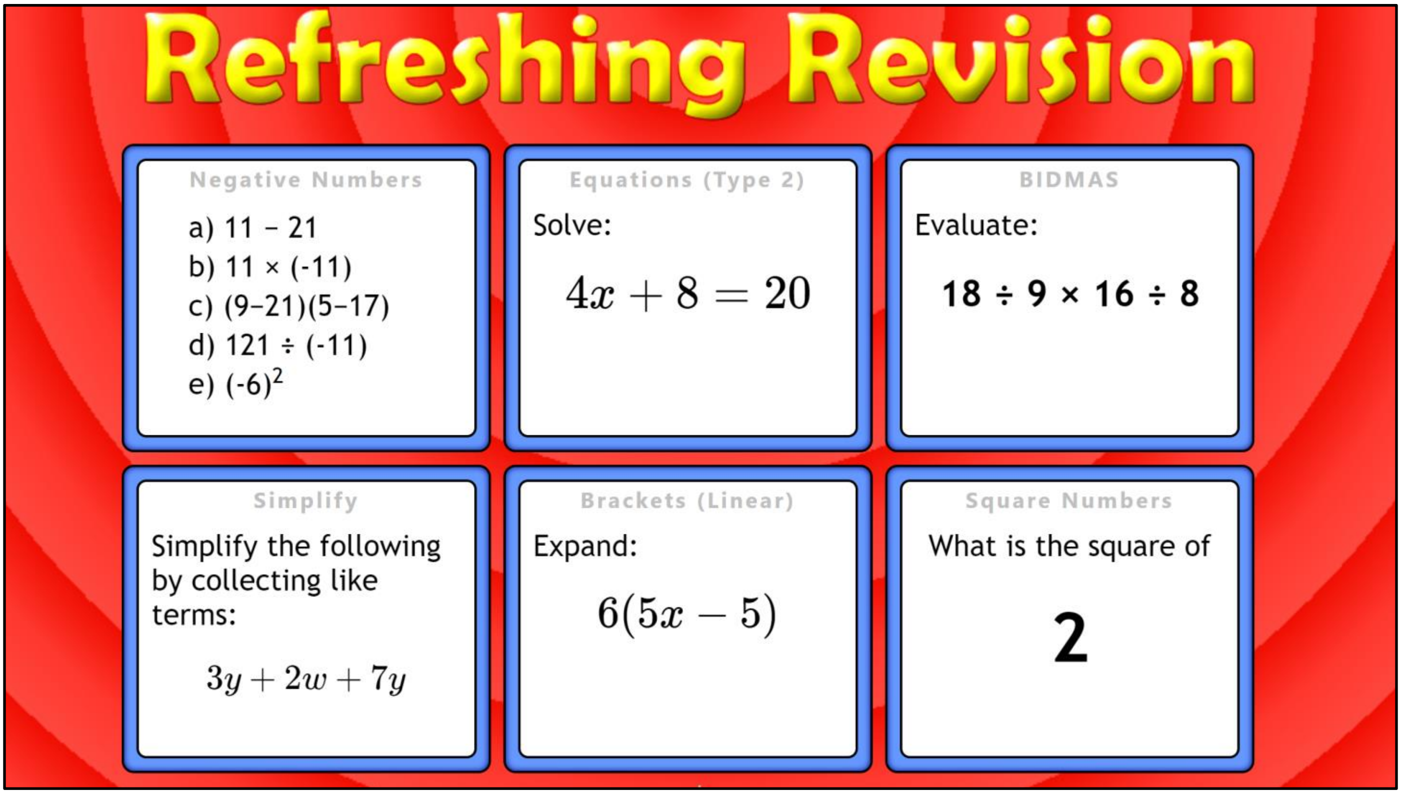


- Refresh for new questions.
- Can save the url of your selection so can build up a collection.

Quiz 1 for shape and space

Complete this statement:

5 litres = ___________ cm³

A 5

B 500

C 5000

D 50

Given that 1 inch is approximately 2.5cm, which of the following is the most accurate answer for the length of a 20 inch snake?

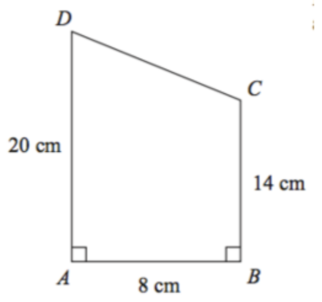
A $60cm$

B $40.5cm$

C $22.5m$

D $50cm$

1) Calculate the area of the trapezium ABCD.



(2)

$0.5 \times 8 \times (14 + 20) = 136cm^2$

BerwickMaths Low stakes quizzes

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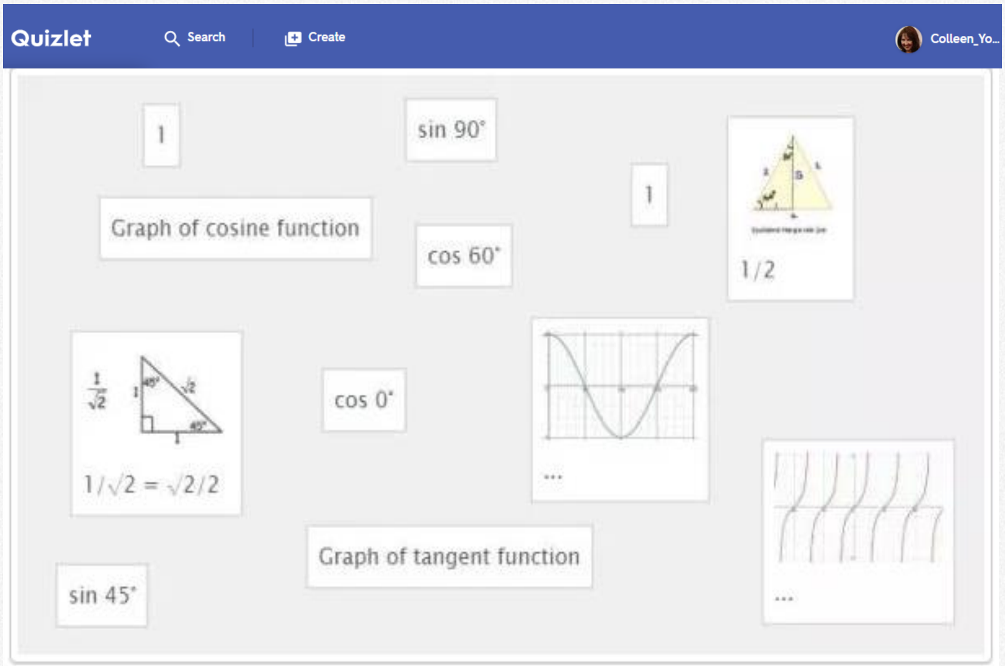
- On Berwickmaths retrieval quizzes – Diagnostic Questions and exam type question

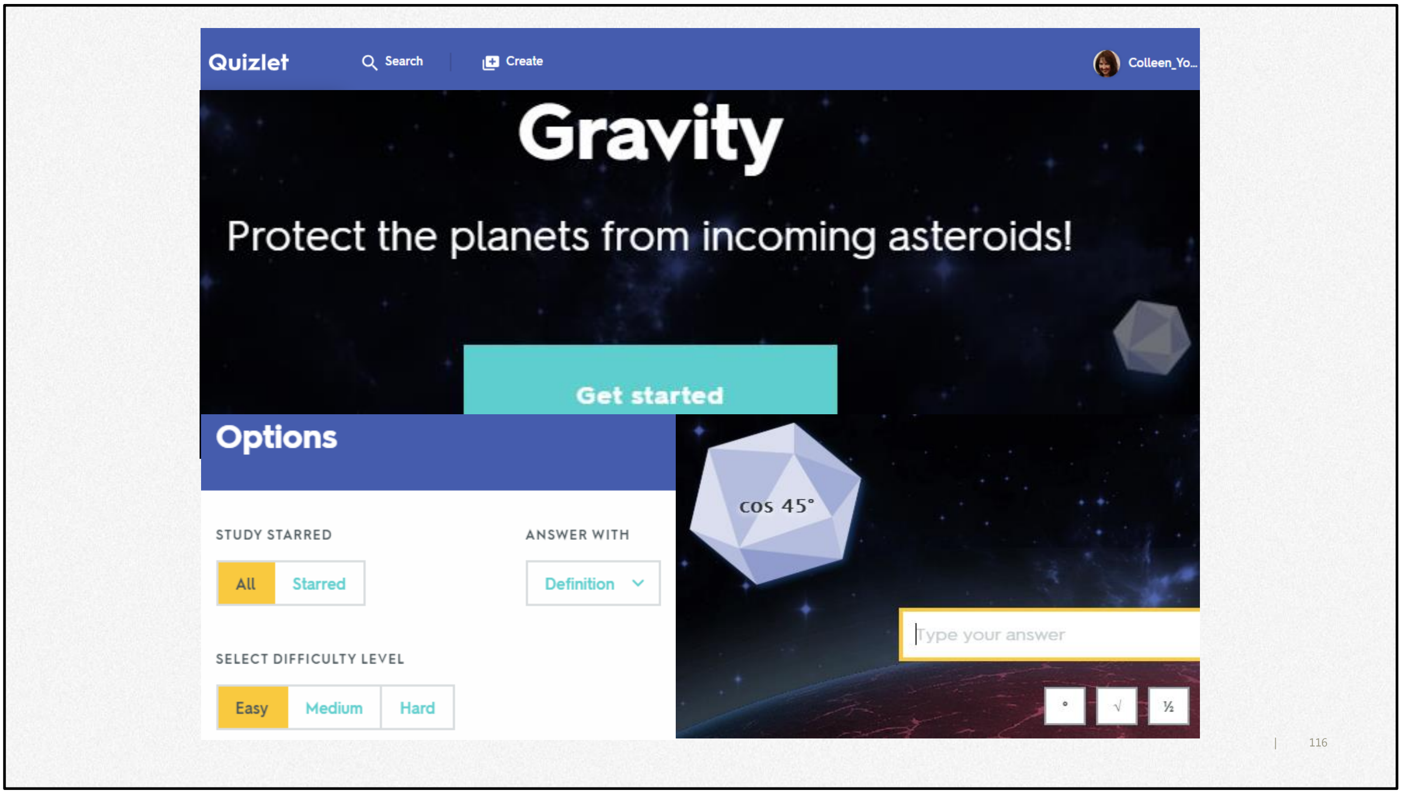
Quizlet GCSE Maths Revision



Quizlet Match Game

115

- Quizlet



- Games versions

RETRIEVAL PRACTICE

Focus on getting information out rather than just always in. Through the act of retrieval our memory is strengthened and forgetting is less likely to occur. Retrieval practice is a learning strategy, not an assessment tool, designed for improving academic performance. Encourage retrieval during learning to improve children's understanding and retention of classroom material.

The more difficult the retrieval practice, the better it is for long-term learning. It also helps to identify gaps in learning and aids their metacognition.

For maximum effect, use frequent and varied low-stakes or no-stakes testing and practice with feedback on how the children have done.

Dunlosky, J., et al. (2013).
Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. Psychological Science in the Public Interest, 14, 4-58.

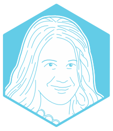
Roediger, H. L., Agarwal, P. K., McDaniel, M. A., & McDermott, K. B. (2011).
Test-enhanced learning in the classroom: Long-term improvements from quizzing. Journal of Experimental Psychology: Applied, 17, 382-395.

- Out not in!

- Tell the students about the benefits of Retrieval Practice – supported by much research
- Resources available from The Learning Scientists

Six Strategies for Effective Learning

www.learningscientists.org



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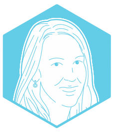

CREATOR

Megan Smith Rhode Island College

ILLUSTRATOR

Oliver Caviglioli www.teachinghow2s.com/cogsci

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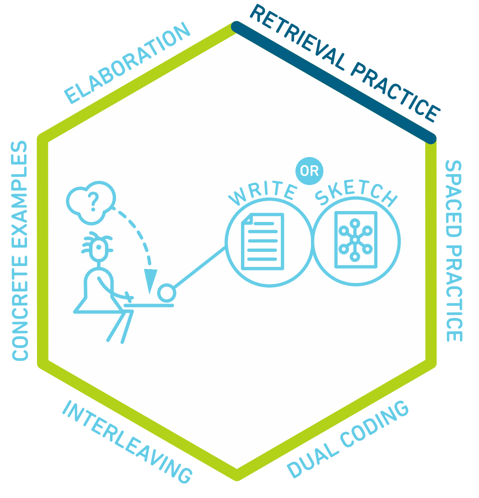
LEARN TO STUDY USING...

Retrieval Practice

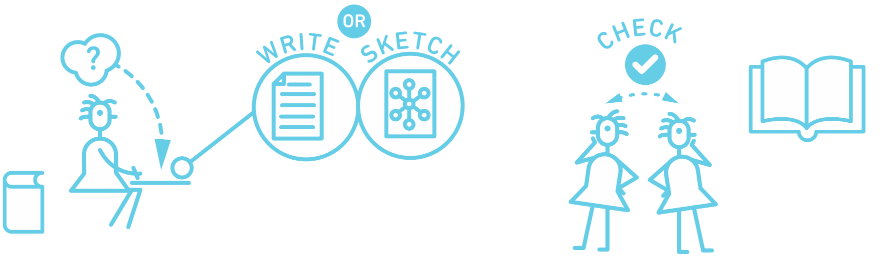
PRACTICE BRINGING INFORMATION TO MIND



Retrieval Practice

HOW TO DO IT

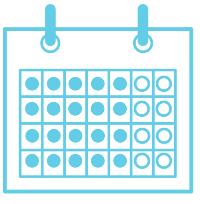
Put away your class materials, and write or sketch everything you know. Be as thorough as possible. Then, check your class materials for accuracy and important points you missed.



Retrieval Practice

HOW TO DO IT

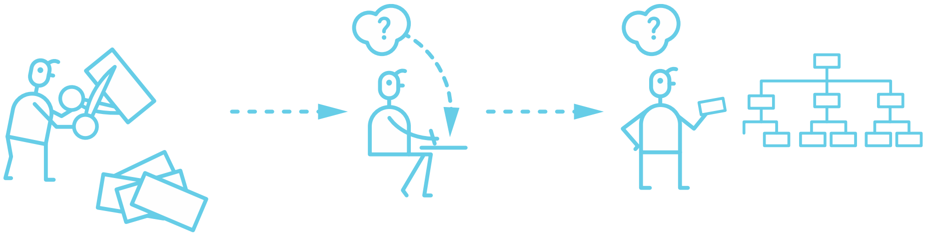
Take as many practice tests as you can get your hands on. If you don't have ready-made tests, try making your own and trading with a friend who has done the same.



Retrieval Practice

HOW TO DO IT

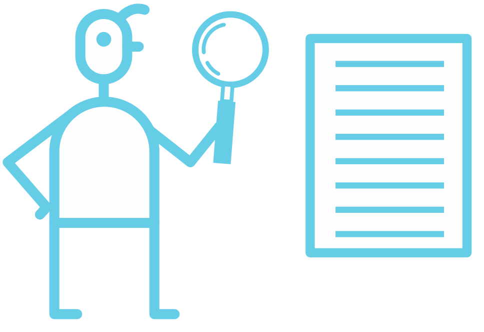
You can also make flashcards. Just make sure you practice recalling the information on them, and go beyond definitions by thinking of links between ideas.



Retrieval Practice

HOLD ON!

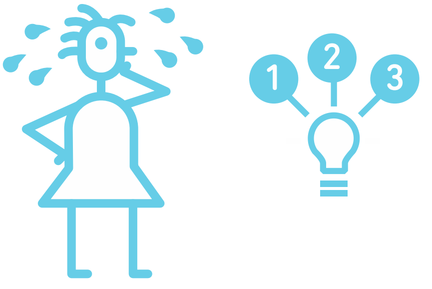
Retrieval practice works best when you go back to check your class materials for accuracy afterward.



Retrieval Practice

HOLD ON!

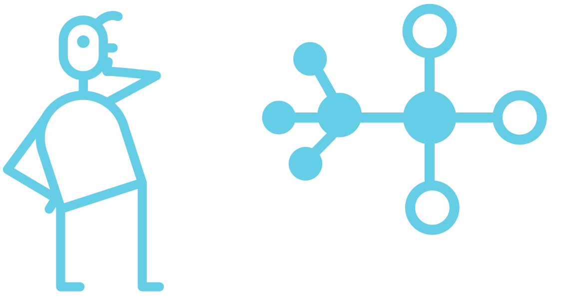
Retrieval is hard! If you're struggling, identify the things you've missed from your class materials, and work your way up to recalling it on your own with the class materials closed.



Retrieval Practice

HOLD ON!

Don’t only recall words and definitions. Make sure to recall main ideas, how things are related or different from one another, and new examples.



Retrieval Practice

RESEARCH

Read more about retrieval practice as a study strategy

- Learning how to Learn: Practicing Retrieval
  http://www.learningscientists.org/blog/2016/6/23-1
- Concept Map: What Does Retrieval Practice Do?
  http://www.learningscientists.org/blog/2016/4/1-1
- How to Study with Flashcards
  http://www.learningscientists.org/blog/2016/2/20-1
- Roediger, H. L., Putnam, A. L., & Smith, M. A. (2011). Ten benefits of testing and their applications to educational practice. In J. Mestre & B. Ross (Eds.), *Psychology of learning and motivation: Cognition in Education* (pp. 1-36). Oxford: Elsevier.

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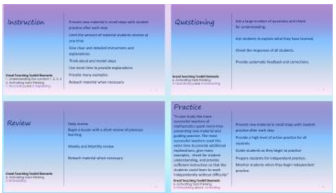

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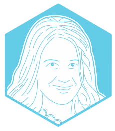

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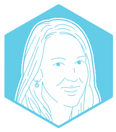

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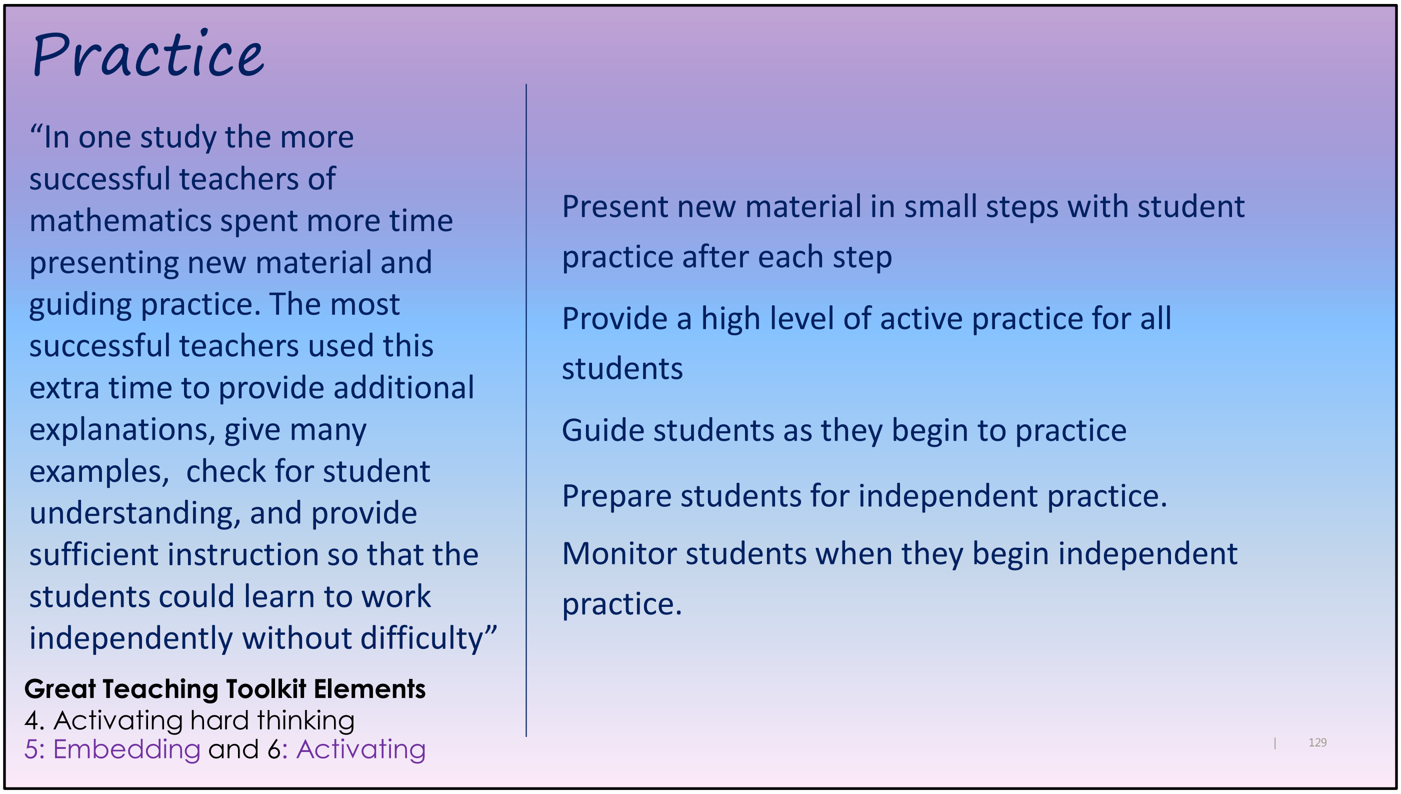
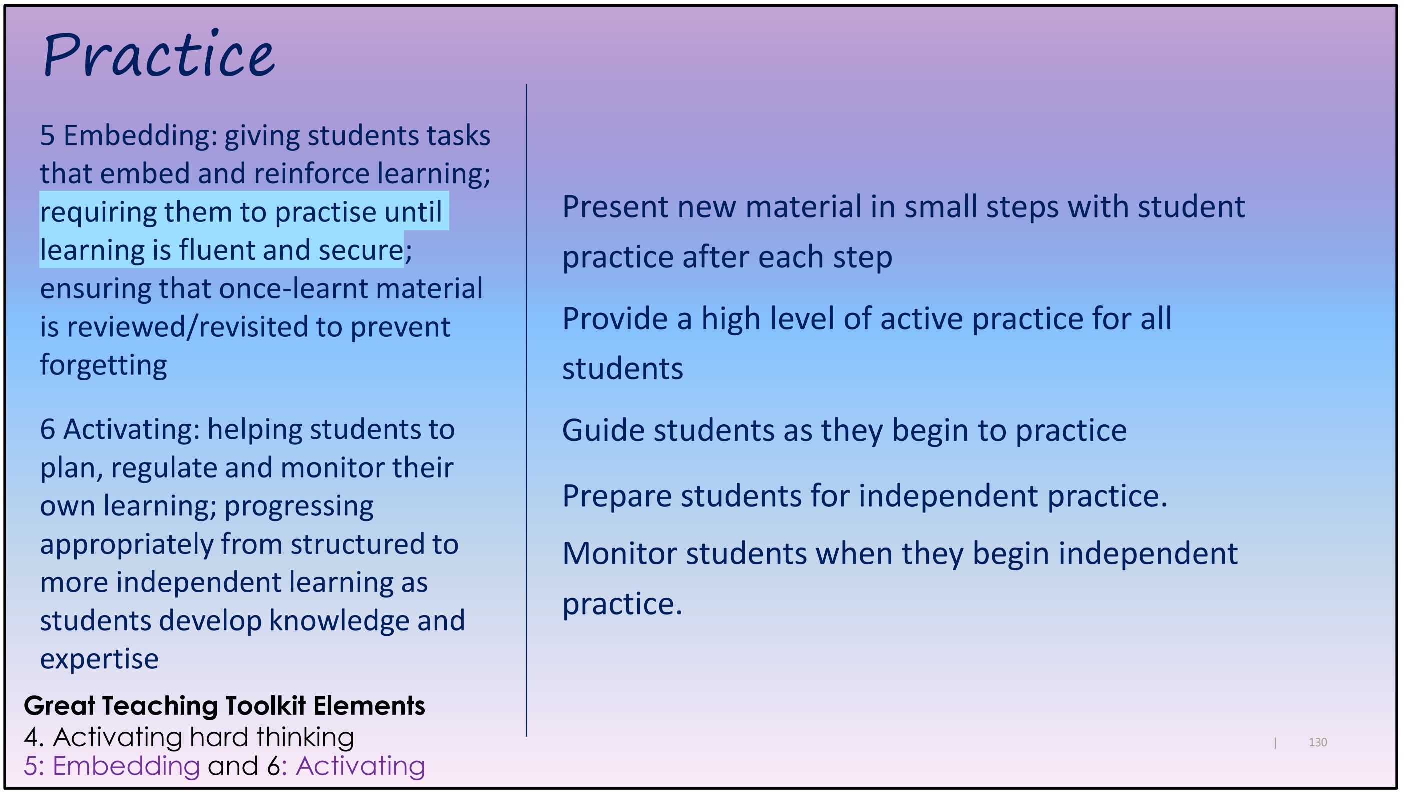
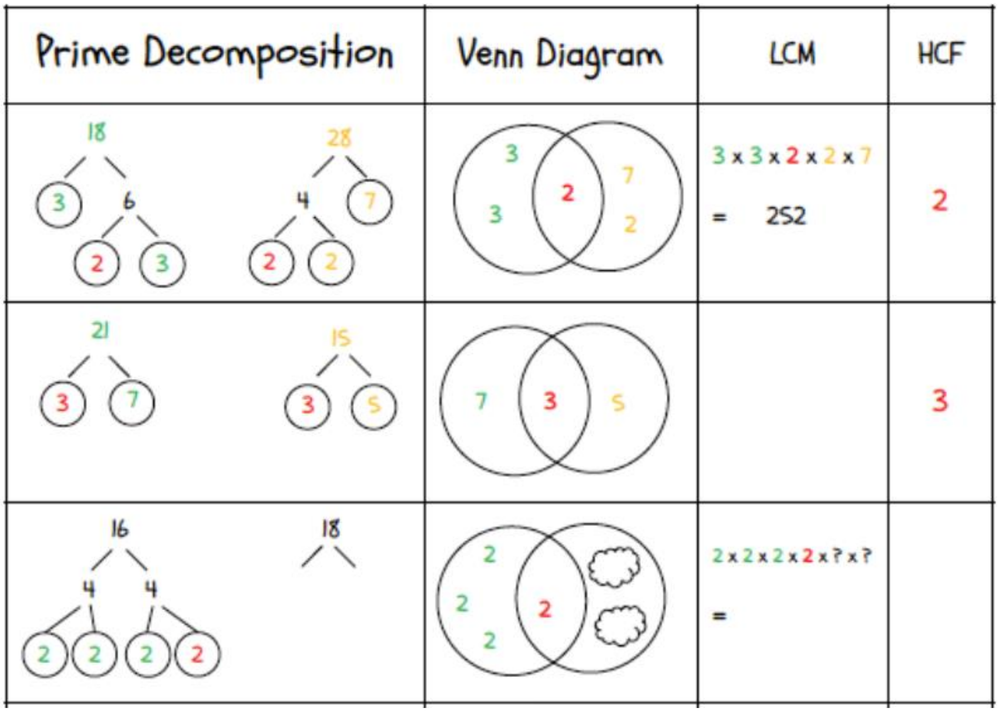


- Practice essential and a large part of what we do.
- But we can’t just leave them to it, need to make sure they have had sufficient instruction and clear guidance.
- Already mentioned that students can practice as you are showing them worked examples.
- Rosenshine 8: Provide scaffolds for difficult tasks
- Rosenshine paper: (on the slide)
  “in one study the more successful teachers of mathematics spent more time presenting new material and guiding practice. The most successful teachers used this extra time to provide additional explanations, give many examples, check for student understanding, and provide sufficient instruction so that the students could learn to work independently without difficulty”



- Rosenshine discusses obtaining a high success rate. Research suggests that 'A high success rate during guided practice also leads to a higher success rate when students are working on problems on their own.' You see figures such as 80% - perhaps not that helpful – just take the message that you want all students to be successful with most of the work.
- Research findings: In a typical teacher-led classroom, guided practice is followed by independent practice. This is necessary because a good deal of practice (or overlearning) is needed to become fluent and automatic in a skill. When material is overlearned, it can be recalled automatically and doesn't take up space in working memory.



Starting Points Maths

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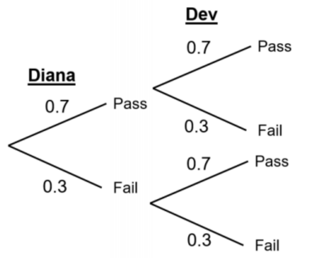
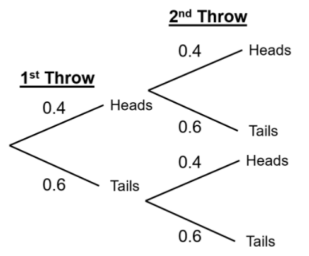
- This task from Chris McGrane's Starting Points Maths
- Completion tasks can be ideal – gradually ask students to do more. Chris McGrane’s site has many such tasks.

- Note the use of colour here…

[Dr Austin Maths](#)

Fill In The Blanks...

Tree Diagrams for Independent Events

<table>
<tr><th>Question</th><th>Tree Diagram</th><th colspan="2">Probability</th></tr>
<tr><td rowspan="4">The probability of passing a music exam is 0.7. Diana and Dev both sit the music exam. Complete the tree diagram and calculate the probability of each outcome.</td><td rowspan="4"></td><td>$P(PF) = 0.7 \times 0.7 =$</td><td>0.49</td></tr>
<tr><td>$P(PF) = 0.7 \times 0.3 =$</td><td></td></tr>
<tr><td>$P(FP) = 0.3 \times 0.7 =$</td><td></td></tr>
<tr><td>$P(FF) = 0.3 \times 0.3 =$</td><td></td></tr>
<tr><td rowspan="4">The probability of a biased coin landing on tails is 0.4. The coin is tossed twice. Complete the tree diagram and calculate the probability of each outcome.</td><td rowspan="4"></td><td>$P(HH) = 0.4 \times 0.4 =$</td><td></td></tr>
<tr><td>$P(HT) = \quad \times \quad =$</td><td></td></tr>
<tr><td>$P(TH) = \quad \times \quad =$</td><td></td></tr>
<tr><td>$P(TT) = \quad \times \quad =$</td><td></td></tr>
</table>

132

- Completion problem. Effective teachers provide many worked examples, gradually reduce the level of completion.
- Dr Austin Maths – fill in the blanks type activity

Examples to complete

10.4 **Simple Equations**

To solve simple equations you must carry out the *same* operation (addition, subtraction, multiplication or division) on *both* sides of the equation so that the new equation is still balanced.

Worked Example 1

Solve each of the following equations.

(a) $x + 3 = 8$ (b) $x - 8 = 11$ (c) $4x = 32$ (d) $\frac{x}{6} = 7$

Solution

(a) To solve this equation, subtract 3 from both sides.

$$x + 3 = 8$$
$$x + 3 - 3 = 8 - 3$$

(b) To solve this equation, add 8 to both sides.

$$x - 8 = 11$$

2

Explaining: presenting and communicating new ideas clearly, with concise, appropriate, engaging explanations; connecting new ideas to what has previously been learnt (and re-activating/checking that prior knowledge); using examples (and non-examples) appropriately to help learners understand and build connections; modelling/demonstrating new skills or procedures with appropriate scaffolding and challenge; using worked/part-worked examples

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- Partially completed examples.

- Something I have done a lot of.
- Easy to prepare – take a worked example and hide bits!

- CIMT here – full of worked examples.

Examples to complete

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(a) $x + 3 = 8$ (b) $x - 8 = 11$ (c) $4x = 32$ (d) $\frac{x}{6} = 7$

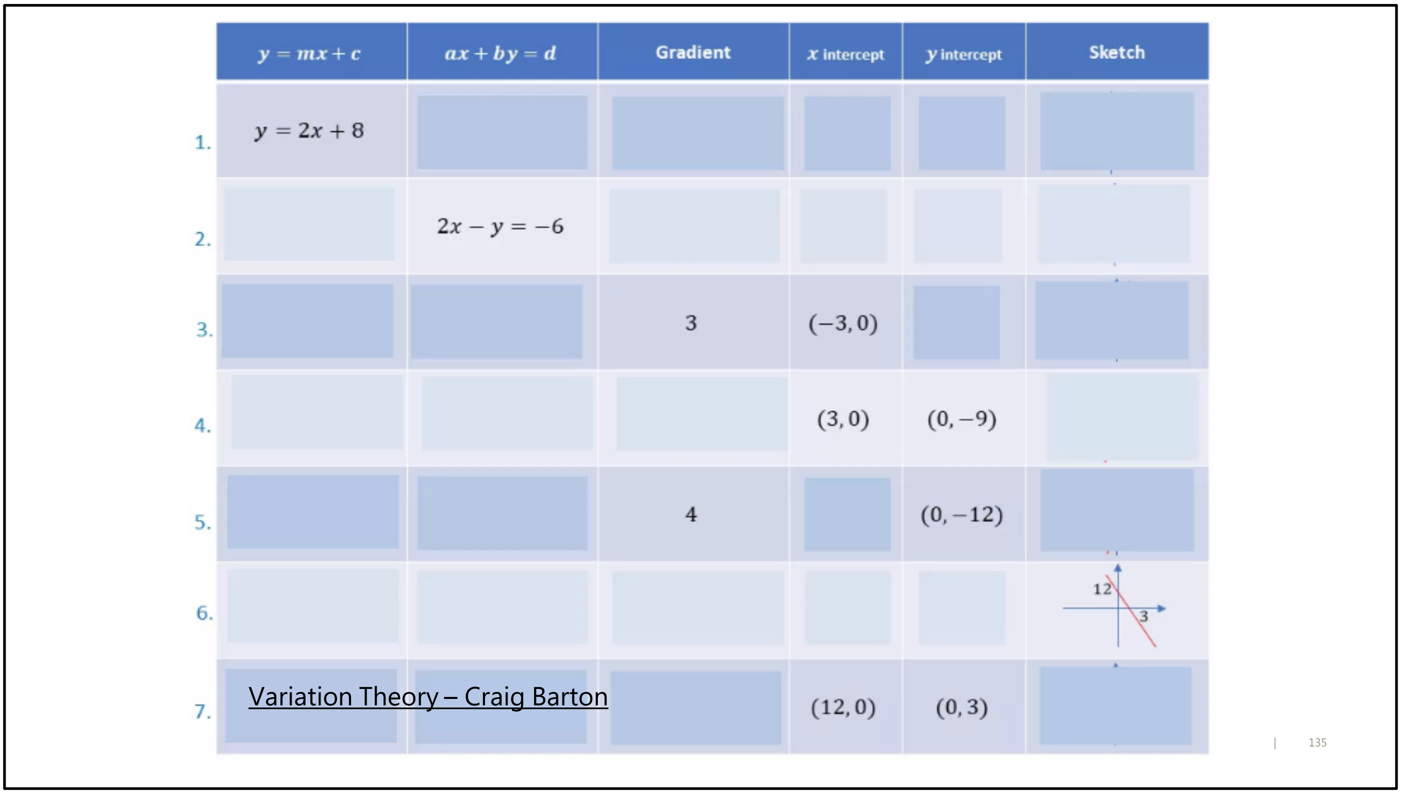
Solution

(a) To solve this equation, subtract 3 from both sides.

$$x + 3 = 8$$
$$x + 3 - 3 = 8 - 3$$
$$x = 5.$$

(b) To solve this equation, add 8 to both sides.

$$x - 8 = 11$$
$$x - 8 + 8 = 11 + 8$$
$$x = 19.$$



	$y = mx + c$	$ax + by = d$	Gradient	x intercept	y intercept	Sketch
1.	$y = 2x + 8$					
2.		$2x - y = -6$				
3.			3	$(-3, 0)$		
4.				$(3, 0)$	$(0, -9)$	
5.			4		$(0, -12)$	
6.						12, 3
7.				$(12, 0)$	$(0, 3)$	

- From Craig Barton – on his variation theory site.
- Perhaps use this when teaching – later come back to just part of this as a starter or plenary.
- And we are showing multiple representations.
- Such an important idea here – show the graph for each,
- Take every opportunity to illustrate graphically.
- Have Desmos or your chosen graphing software to hand – always.
- Suppose we are solving a pair of simultaneous equations – solve.
- Visualise what the graphs look like / display it.

This is how the scores in a quiz are worked out.

Correct answer	3 points
No answer	–1 point
Incorrect answer	–2 points

A team answers 10 questions. How many points could they have received?

<u>Here's the diagram...</u>

- Goal free problems (Pete Matlock site) can provide great practice
- Accessible – question stripped of all but essentials.
- Could get students to work out all the possible scores and then ask them what questions could be asked.

10 Questions						
Correct	Points from correct	Incorrect or no answer	Worst Points	Score	Best Points	Score
0	0	10	-20	-20	-10	-10
1	3	9	-18	-15	-9	-6
2	6	8	-16	-10	-8	-2
3	9	7	-14	-5	-7	2
4	12	6	-12	0	-6	6
5	15	5	-10	5	-5	10
6	18	4	-8	10	-4	14
7	21	3	-6	15	-3	18
8	24	2	-4	20	-2	22
9	27	1	-2	25	-1	26
10	30	0	0	30	0	30

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5 This is how the scores in a quiz are worked out.

Correct answer	3 points
No answer	–1 point
Incorrect answer	–2 points

5 (a) Team A answer 7 of their first 10 questions.
They give 5 correct answers and 2 incorrect answers.

How many points do they score on the 10 questions?

[2 marks]

5×3 (+) 3×-1 (+) 2×-2 or $15 - 3 - 4$	M1	oe
8	A1	

- I particularly like the mixed topic section where exam questions have been used and we can also see the original question.

Correct answer	3 points
No answer	–1 point
Incorrect answer	–2 points

5 (b) Team B score 17 points on the first 10 questions.

Complete the table.

[3 marks]

	Number of questions	**Total points**
Correct answer	7	21
No attempt	2	–2
Incorrect answer	1	–2
	Total = 10	Total = 17

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Correct answer	3 points
No answer	–1 point
Incorrect answer	–2 points

5 (b) Team B score 17 points on the first 10 questions.

Complete the table.

[3 marks]

5(b)	One correctly evaluated trial of 10 questions different from part (a)	M1	oe eg $10 \times 3 = 30$ $9 \times 3 + 1 \times -2 = 25$
	Another correctly evaluated trial of 10 questions different from part (a) or $7 \times 3 + 2 \times -1 + 1 \times -2 = 17$	M1dep	eg $8 \times 3 + 2 \times -1 = 22$
	7 21 2 –2 1 –2	A1	

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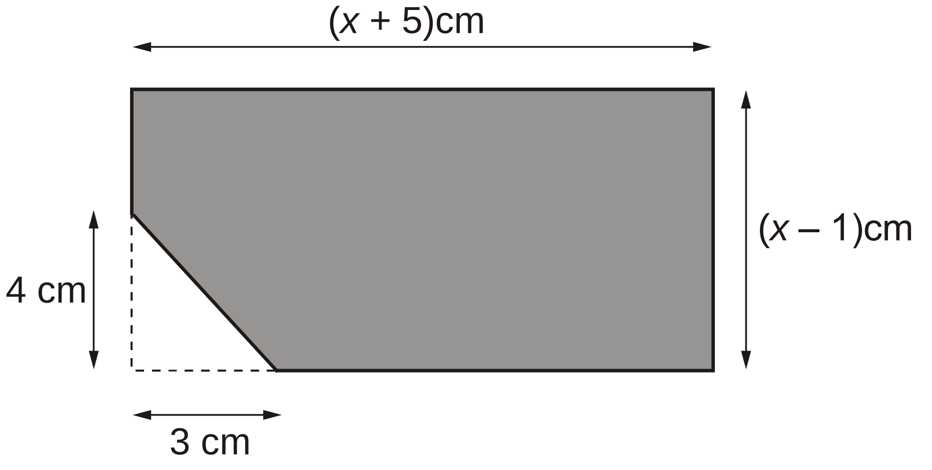
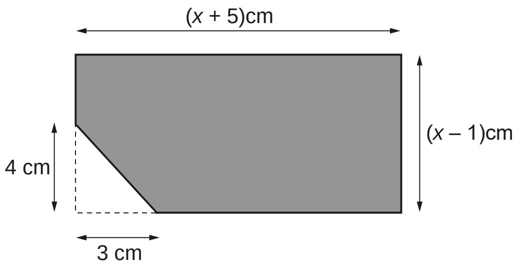
Problem 1



- Work on this diagram
- What do you think the question is?
- How would you use this in class?

Question 1

A rectangle has length $(x + 5)$ cm and width $(x - 1)$ cm.
A corner is removed from the rectangle as shown.



(a) Show that the shaded area is given by $x^2 + 4x - 11$.

(b) The shaded area is 59 cm^2.

(i) Show that $x^2 + 4x - 70 = 0$.

(ii) Calculate the value of x.

- Another source – from Mark Greenaway

Simplifying Expressions

Increasingly Difficult Exercises

a) $3a + 2a + a$	b) $5x - 2x$	c) $6p + 3p - 7p$
d) $3m - 8m$	e) $3p \times 2$	f) $18n \div 6$
g) $3x + 2y + x + 4y$	h) $5m + 4n + 2m - 3n$	i) $2a - 3b - a - b$
j) $2a^2 + 3a^2$	k) $2a + 3b + 3a + 4b$	l) $7x - 2y - 5x - 3y$
m) $3x^2 + 2x + 4x^2 - 5x$	n) $5s^2 + 3t - 4s^2 - 8t$	o) $3ab - 2a - 5ba - a$
j) $2(3x + 1) + 2(1 + 2x)$	k) $5(2p - 3) + 3(2p - 1)$	l) $3(2b - 1) - 5(4 - 3b)$

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<u>Increasingly Difficult Questions – Dave Taylor</u>

- Dave Taylor's Increasingly Difficult questions does what it says on the tin.
- As students are working themselves in class we need to monitor them carefully.
- You may find common problems in which case stop the class and work through any examples causing difficulty – or restate instructions. I have always found that it helps to have timings – allow 10 or 15 minutes for students to work on problems then provide feedback. Something I have always made a fuss about is their marking and corrections, I tell students that when I see their books I am just as interested in their marking and corrections. Train them to be examiners!

MATHEMATICAL **etudes**

Colin Foster - Etudes

The **Mathematical Etudes Project** aims to find creative, imaginative and thought-provoking ways to help learners of mathematics develop their fluency in important mathematical procedures.

The **Mathematical Etudes Project** aims to find practical classroom tasks which embed extensive practice of important mathematical procedures within more stimulating, rich problem-solving contexts (Foster, 2011, 2013, 2014, 2017a, 2017b). Recent research (Foster, 2017a) suggests that etudes are as good as exercises in terms of developing procedural fluency – and it seems likely that they have many other benefits in addition.

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- A great way to practice – have a look at Colin Foster's etudes.
- Lots of practice but in a rich problem.

Primary Students | Secondary Students | Early Years | Primary Teachers | Secondary Teachers | Topics | Search NRICH | Go

NRICH | Events | Donate

Mathematical Etudes

Age 11 to 18
Article by Colin Foster
Published November 2017.

Tedious Exercises	Lovely Rich Tasks
What are the factors of 6?	Find some numbers with exactly 4 factors

Mathematical Etudes Article

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- Read this Nrich article..

Hide Menu

Problem
Getting Started
Solution

Teachers' Resources
Secondary Curriculum Linked

Maths at Home

The Simple Life

Age 11 to 14 ★★

When Colin simplified the expressions below, he was surprised to find that they all gave the same solution! Try it for yourself.

$$3(x+6y)+2(x-5y)$$
$$4(2x-y)-3(x-4y)$$
$$-2(5x-y)+3(5x+2y)$$

Here is a set of five expressions:

$$(x+y) \quad (x+2y) \quad (x-2y) \quad (x+4y) \quad (2x+3y)$$

Choose any pair of expressions and add together multiples of each (like Colin did).

Can you find a way to get an answer of $5x+8y$ in each case?

You may also like

Summing Consecutive Numbers

15 = 7 + 8 and 10 = 1 + 2 + 3 + 4. Can you say which numbers can be expressed as the sum of two or more consecutive integers?

Always the Same

Arrange the numbers 1 to 16 into a 4 by 4 array.

Straight lines

Problem

(1) Which of the following describe or determine a single straight line?

(a) $4x - 2y = 6$

(b) $y = 2$

(c) The points $(1, 2)$ and $(0, -1)$

(d) $y = \frac{3}{2}x$

(e) The points $(-1, -4)$, $(3, 7)$, and $(8, 8)$

(f) $y = 3 - 2x$

(g) The point $(0, -1)$ and the constant gradient 3

(h) $x = -2$

(i) $y = x^2 + 2$

(j) $x = 7y + 5$

(k) $y - 8 = 3(x - 3)$

(l) The points $\left(\frac{1}{2}, 2\right)$, $(1, 1)$, and $\left(\frac{3}{2}, 0\right)$

(m) $y^2 = x^2$

(n) The point $(3, 3)$ and the direction specified by the vector $\binom{1}{2}$

(o) $\frac{1}{3}y - x + \frac{1}{3} = 0$

(p) $xy = 1$

(q) $y^2 - 4xy + 4x^2 = 0$

How did you decide? You might find it helpful to try sketching some of these. You could use graphing software such as Desmos.

Teaching notes

This resource asks students to recognise the shape of a quadratic graph, when given the values of:

- a gives overall shape (positive/negative)
- c gives the y-intercept
- $b^2 - 4ac$ defines the type of roots (hence any x-intercepts).

Some conditions are not possible due to contradicting conditions, and so a graph cannot be drawn. Students should be able to explain why they are not possible.

Students could:

- do a matching activity with all the 'condition' and 'graph' cards
- sketch the possible graphs when only given the 'condition' cards (note that graphs can be reflected in the y-axis and still satisfy the conditions)
- determine the conditions when only given the 'graph' cards.

Condition cards

$a > 0$ $c > 0$ $b^2 - 4ac > 0$ A	$a > 0$ $c > 0$ $b^2 - 4ac < 0$ B	$a > 0$ $c > 0$ $b^2 - 4ac = 0$ C
$a < 0$ $c > 0$ $b^2 - 4ac > 0$ D	$a < 0$ $c > 0$ $b^2 - 4ac < 0$ E	$a < 0$ $c > 0$ $b^2 - 4ac = 0$ F

To log or not to log?

Problem

Some equations involving powers or indices can be solved using logarithms... but not all.

Think about how you could go about solving the following equations. Sort them according to the tools or methods you would use.

Ⓐ $3^x = 81$	Ⓑ $x^5 = 50$	Ⓒ $3^x = 43$
Ⓓ $5^{2x} - 5^x - 6 = 0$	Ⓔ $5^x + 4^x = 8$	Ⓕ $5^x + 2 \times 5^{1-x} = 7$
Ⓖ $3^{2x} - 3 = 24$	Ⓗ $2^{2x} - 9 \times 2^x + 8 = 0$	Ⓘ $\sqrt{2x-3} = 5$
Ⓙ $5^x - x^5 = 3$	Ⓚ $16^{\frac{3}{x}} = 8$	Ⓛ $\left(\frac{13}{16}\right)^{3x} = \frac{3}{4}$

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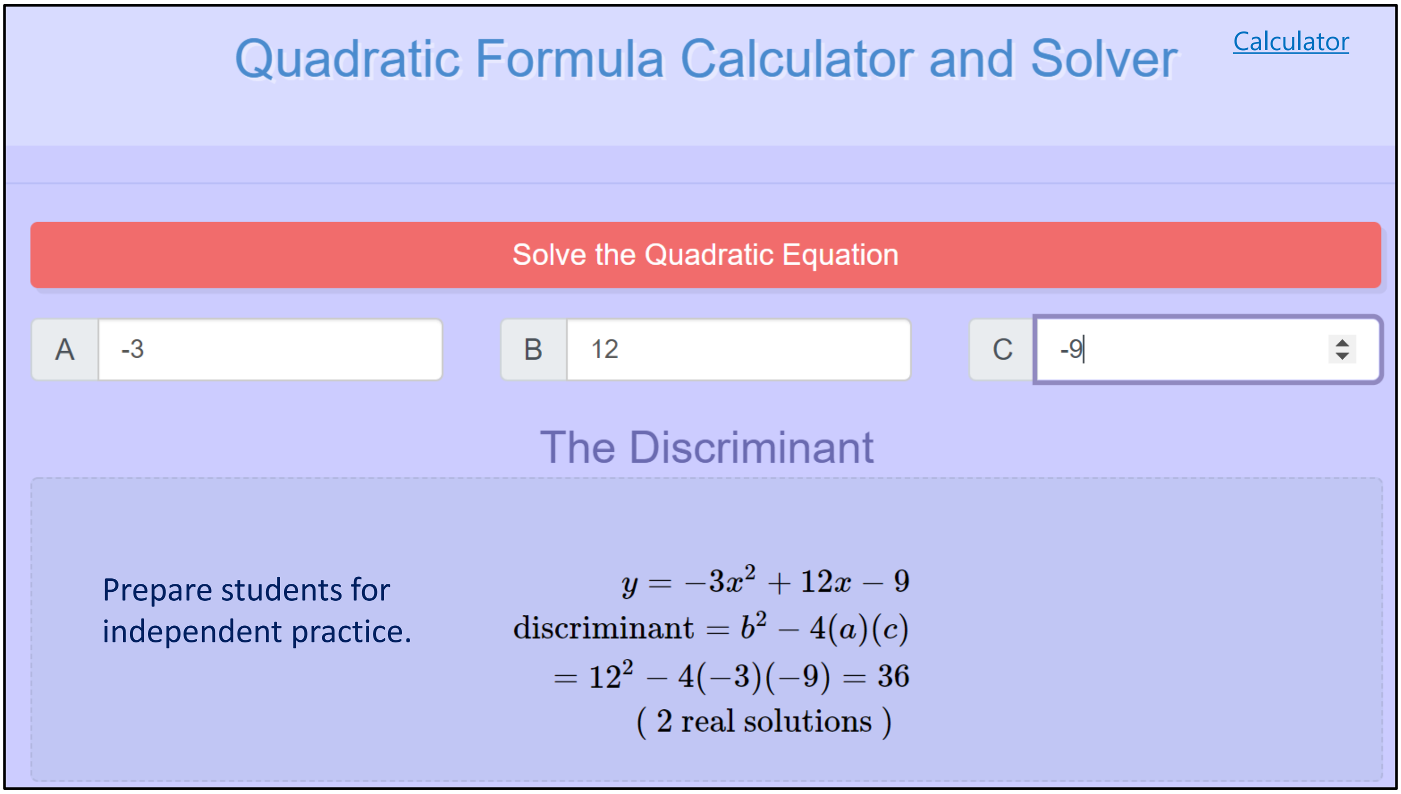
To log or not to log? Student Reponses underground mathematics

I liked this task because it wasn't just focused on logs, so you have to actually question yourself what is needed.

I feel that this helps us not fall into a 'robotic' frame of mind that can sometimes happen when answering questions all totally focused on the same topic.

Difficult in a good way. Enlightening as I've learned what I have been doing wrong all this time!



- Thinking about preparing students for independent practice – show them websites they can use at home.
- It's a habit I have always had – use resources in class the students can use at home.

The Work

$$\frac{-b \pm \sqrt{b^2 - 4(a)(c)}}{2(a)}$$

$$\frac{-12 \pm \sqrt{12^2 - 4(-3)(-9)}}{2(-3)}$$

$$\frac{-12 \pm \sqrt{36}}{-6} = \frac{-12 \pm \sqrt{36 \times 1}}{-6}$$

$$= \frac{-12 \pm 6\sqrt{1}}{-6}$$

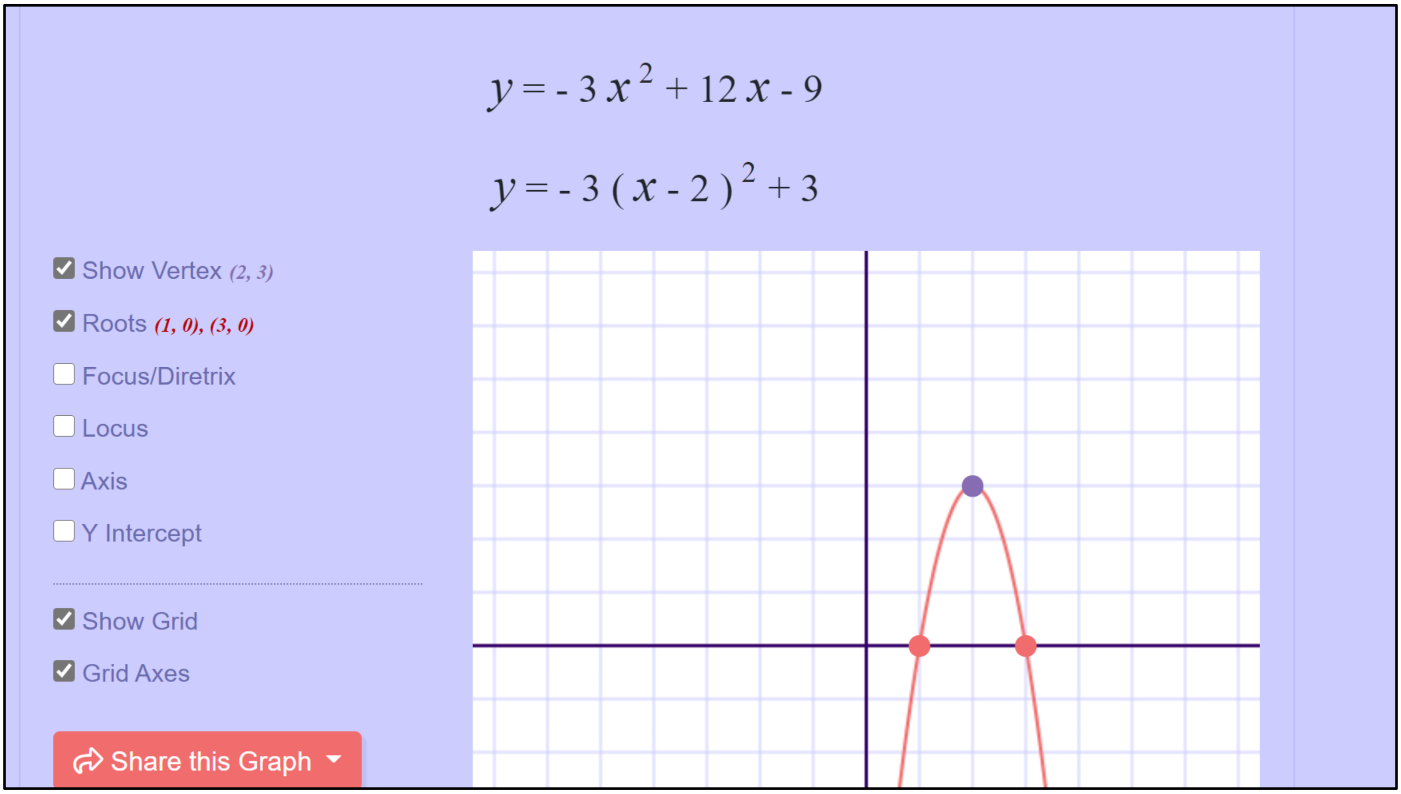
$$= \frac{-2 \pm 1\sqrt{1}}{-1}$$

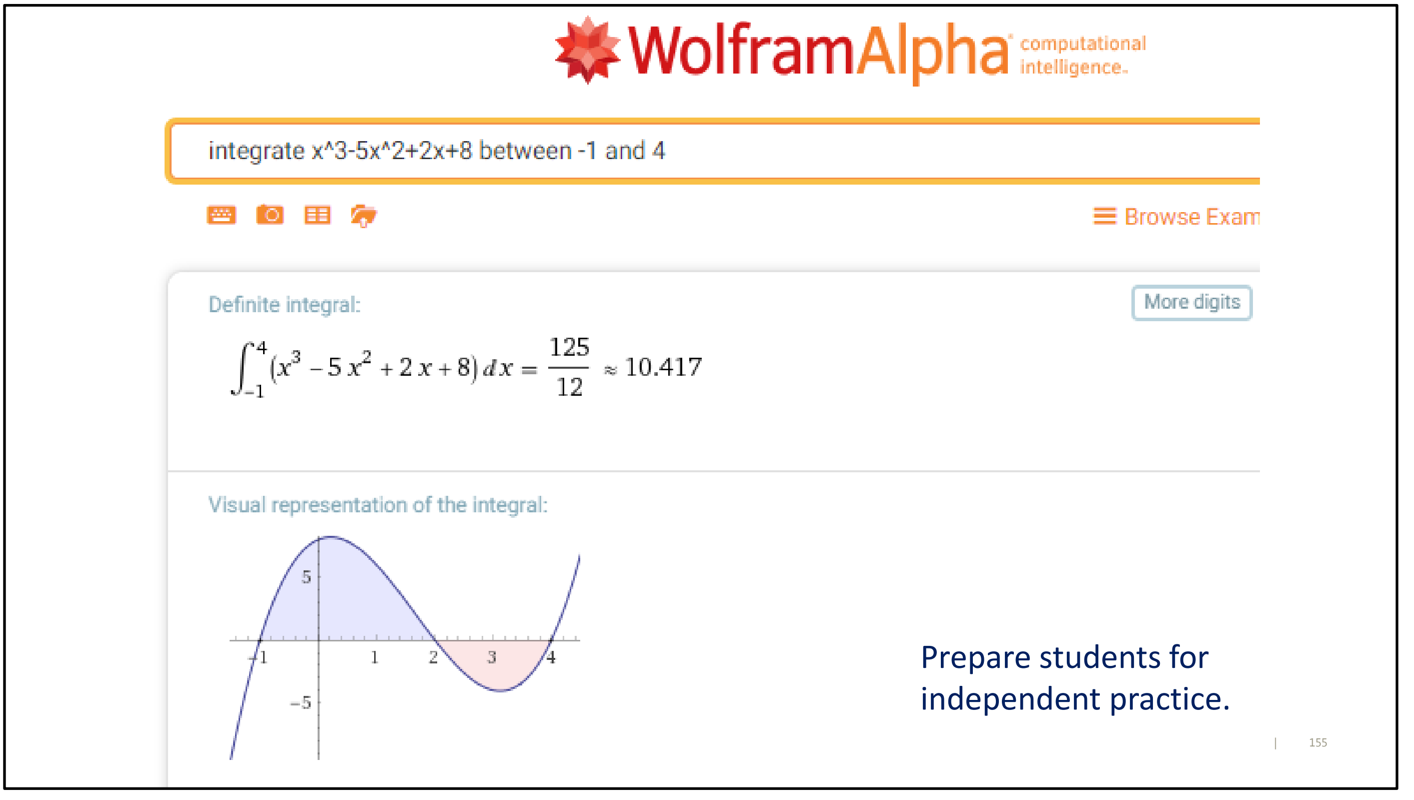
$$= 2 \pm -1\sqrt{1}$$

The Actual Solutions

$$x = 1$$

$$x = 3$$


$y = -3x^2 + 12x - 9$
$y = -3(x-2)^2 + 3$
Show Vertex (2, 3)
Roots (1, 0), (3, 0)
Focus/Diretrix
Locus
Axis
Y Intercept
Show Grid
Grid Axes
Share this Graph



- WolframAlpha can be so useful for students to check work. Free for as many queries as you want a day (ignore pro adverts)

Practice paper | Pearson Edexcel Practice Papers

Common Question Papers
Practice papers of common questions for Nov 2017, June 2018, Nov 2018, June 2019 and Nov 2019
| ZIP 12.8 MB | 18 May 2020

Bronze/Silver/Gold AO3 Papers for November 2019 Series
| ZIP 24.0 MB | 13 May 2020

99 problem-solving questions
| ZIP 17.6 MB | 21 April 2020

One mark questions - Foundation Tier
| ZIP 10.3 MB | 11 February 2020

Bronze/Silver/Gold AO3 papers for June 2017 series
| ZIP 7.7 MB | 12 June 2018

Here are two numbers.

29 37

Nadia says both of these numbers can be written as the **sum** of two square numbers.

(*a*) Write down the first six square numbers:

$1^2 =$ ....

$2^2 =$ ....

$3^2 =$ ....

$4^2 =$ ....

$5^2 =$ ....

$6^2 =$ ....

(1)

2 Explaining: presenting and communicating new ideas clearly, with concise, appropriate, engaging explanations; connecting new ideas to what has previously been learnt (and re-activating/checking that prior knowledge); using examples (and non-examples) appropriately to help learners understand and build connections; modelling/demonstrating new skills or procedures with appropriate scaffolding and challenge; using worked/part-worked examples

Guide students as they begin to practice

- An excellent source of questions with various amounts of scaffolding are the bronze / silver / gold type question.
- Edexcel have numerous examples of these with bronze / silver and gold versions of papers.
- Examine this example.
- Read the question.
- Here we have the bronze version.
- Very much leading students through…

Here are two numbers.

29 37

Nadia says both of these numbers can be written as the **sum** of two square numbers.

(*b*) Can you add two of the square numbers to make 29?
If so, write the number sentence.

(*c*) Can you add two of the square numbers to make 37?
If so, write the number sentence.

(*d*) Is Nadia correct?

2 Explaining: presenting and communicating new ideas clearly, with concise, appropriate, engaging explanations; connecting new ideas to what has previously been learnt (and re-activating/checking that prior knowledge); using examples (and non-examples) appropriately to help learners understand and build connections; modelling/demonstrating new skills or procedures with appropriate scaffolding and challenge; using worked/part-worked examples

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- Bronze continued
- So having written down the first 6 square numbers
- (b) (c) and (d) hopefully follow.

Here are two numbers.

29 37

Nadia says both of these numbers can be written as the **sum** of two square numbers.

(*a*) Write down the first six square numbers.

(*b*) Is Nadia correct?
If she is, write each of the numbers 29 and 37 as the sum of two square numbers.

2 Explaining: presenting and communicating new ideas clearly, with concise, appropriate, engaging explanations; connecting new ideas to what has previously been learnt (and re-activating/checking that prior knowledge); using examples (and non-examples) appropriately to help learners understand and build connections; modelling/demonstrating new skills or procedures with appropriate scaffolding and challenge; using worked/part-worked examples

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- Silver version….
- Still instructing students to write down the first 6 square numbers
- ….you can guess gold!

Here are two numbers.

29 37

Nadia says both of these numbers can be written as the **sum** of two square numbers.

Is Nadia correct?
You must show how you get your answer.

2 Explaining: presenting and communicating new ideas clearly, with concise, appropriate, engaging explanations; connecting new ideas to what has previously been learnt (and re-activating/checking that prior knowledge); using examples (and non-examples) appropriately to help learners understand and build connections; modelling/demonstrating new skills or procedures with appropriate scaffolding and challenge; using worked/part-worked examples

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- Can be very instructive to study examples like this and think about the kind of bronze level – the scaffolding to support students through problems.

1 Having deep and fluent knowledge and flexible understanding of the content you are teaching

Student comments

Good at explanations and lecturing.

Someone who can explain in different ways.

Someone who won't just tell you how to do something, but will explain how and why it works.

Helpful Maths websites for students.

Lets us be independent.

Provokes your mind to think beyond the syllabus.

- I have a habit of asking students what they think, so asked them to talk about their ideal Maths teacher. This was not inviting comments on any individuals.
- Build a Maths Teacher (Build a bear!)
- I was struck by how their comments fitted with the paper on Great Teaching – also in fact with Rosenshine's Principles.

Student comments

2 Explaining: presenting and communicating new ideas clearly, with concise, appropriate, engaging explanations; connecting new ideas to what has previously been learnt (and re-activating/checking that prior knowledge); using examples (and non-examples) appropriately to help learners understand and build connections; modelling/demonstrating new skills or procedures with appropriate scaffolding and challenge; using worked/part-worked examples

Hard working.
Puts a lot of time into lesson planning.
Doesn't mind repeating things.
Speaks at a suitable pace.
Gives us notes which are helpful like worked examples.
Make sure we can write good notes.
Go through examples together.
The right amount of homework.
Someone who is willing to answer any question.
Pushes you to work on harder questions to extend your abilities.
Helpful individually AND generally.
Does practical work.
Gives detailed and constructive feedback.
Someone willing to help outside class

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- And here's what the students said.
- They like their worked examples and clear explanations …and a lot of patience!

Student comments

Here's a comment to make you smile!

Maths teachers are different from other teachers, because Maths can be very different to other subjects.

...and an appropriate final comment:

What makes a good Maths teacher is someone who is passionate about Maths and explains everything REALLY well.

I think being passionate is really important as we students can tell if a teacher is enjoying a subject and sometimes the explanations of topics are better when a teacher loves a subject.

I think it is also important that the teacher can challenge the most able students whilst making sure that the least able are keeping up.

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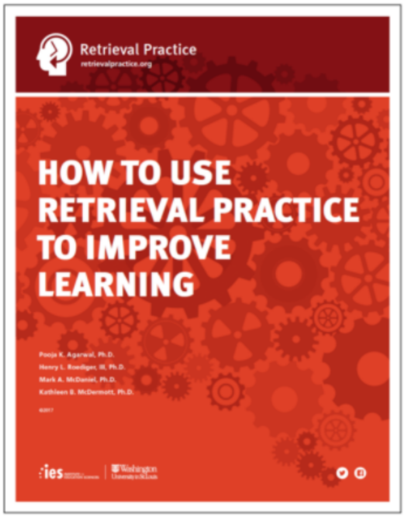
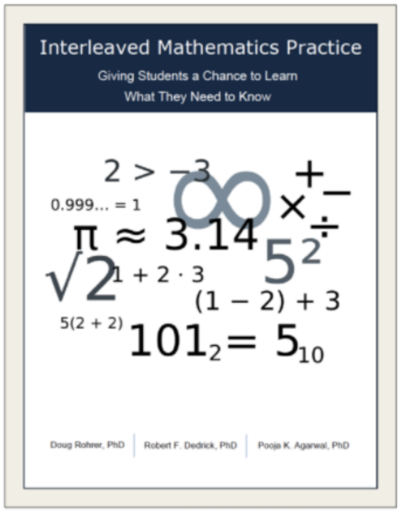
- Had to show you this one – we're different from other teachers! Maths can be the scariest subject for many I think.
- ...and Rosenshine again – explain it REALLY well.

https://www.retrievalpractice.org/library

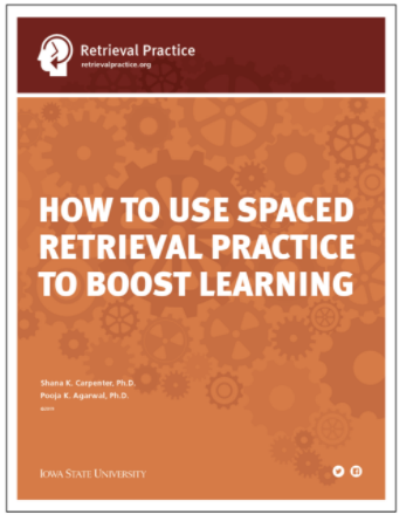
Practice Guides by Cognitive Scientists



RETRIEVAL PRACTICE



INTERLEAVING



SPACING

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No-Quiz Retrieval Strategy: "Two Things"

Here's the scoop: At any point during a lesson, stop and have students write down Two Things about a specific prompt.

For example:
What are two things you learned so far today?
What are your two takeaways from today?
What are two things you'd like to learn more about?