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How to question with IMPaCT!

Jo Denton

While you are waiting…

Find 15% of £300 in as many ways as you can.

Write each one on a Post-it note.

Find 15% of £300 in as many ways as you can…

- Which is the most efficient method if you have a calculator?
- Which is the most efficient without a calculator?
- Which is the most sophisticated/elegant? Why?
- Which are truly different and which are variations of another?
- What's 300% of £15? Does this always work? Why?
- Do your answers change if I was asking 6.5% of £43.82?
- If you used the % button on your calculator, when might this method come unstuck?

Why write this thesis?

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How to question with IMPaCT!

Dr Jo Denton

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Why was this research needed?

- My own questioning was identified as an area for development by my head teacher at the time.
- According to Ofsted (2012), questioning *was* not being used effectively to check learners' understanding in the mathematics classroom .
- Furthermore, teachers' questioning *was* "not always well judged or productive for learning" (DfES, 2004, p.4) and research highlighted the need to use "open, higher-level questions to develop pupils' higher-order thinking skills" (ibid, p.18).
- But what constitutes higher-level questions and higher-order thinking and how can these be established in the mathematics classroom?

The Literature

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Developing a Climate for Effective Classroom Discourse

Classroom Social Norms

Social norms are expectations established by the teacher in the classroom. Social norms relating to effective classroom discourse are characterised by developing the following:

- **explanation**
- **justification**
- **argumentation**
- **a climate where it is acceptable to make mistakes**

These characteristics are not specific to mathematics lessons, as learners should be expected to justify their own thinking and challenge the thinking of others across the curriculum, not just in mathematics.

Developing a Climate for Effective Classroom Discourse

Sociomathematical Norms (Yackel & Cobb, 1996)

To develop learners' mathematical thinking, norms which are unique to the learning of mathematics need to be established. A sociomathematical norm is intended to "set an expectation in the classroom that encourages strong mathematical activity in the form of justification" (Gerson & Bateman, 2011, p. 115) e.g.

- **understanding of what constitutes an *acceptable mathematical explanation and justification***
- **developing an understanding of *mathematical difference***
- **developing an understanding of *mathematical sophistication*, *mathematical efficiency* and *mathematical elegance***

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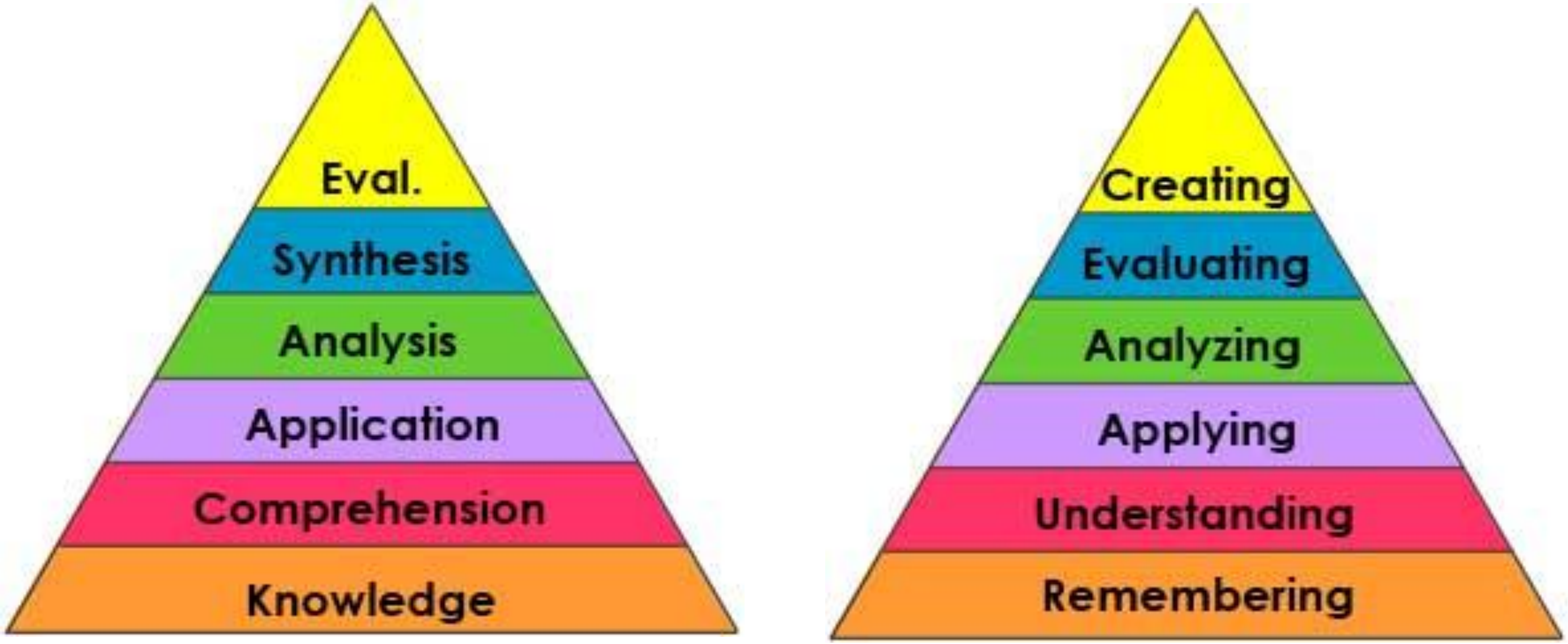
Bloom's Taxonomy



Bloom's Original and Revised Taxonomies (Image from GURO21, 2012)

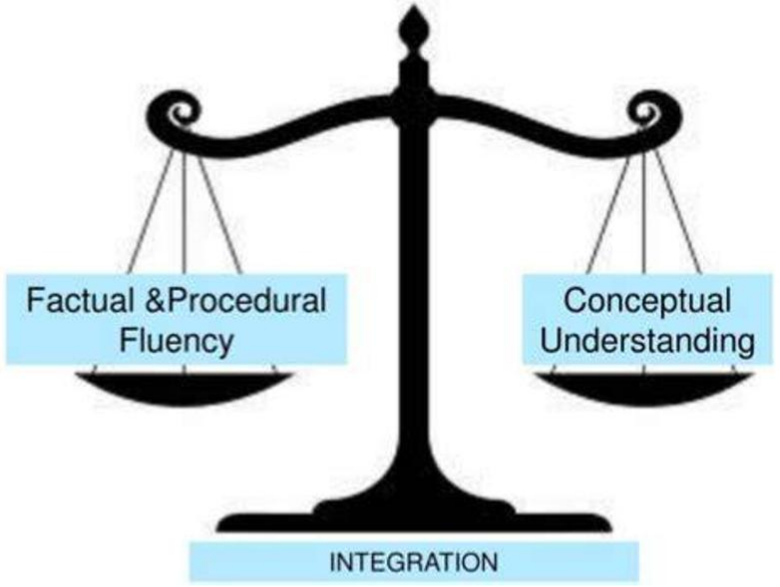
- Bloom's Taxonomy "underplays knowledge and comprehension in mathematics" (Watson, 2007, p.114)
- Could be argued that mathematical understanding is not necessarily a linear progression (Sfard, 1991; Gray & Tall, 1991)

Process-Object Theory

Or …Instrumental-Relational (Skemp)

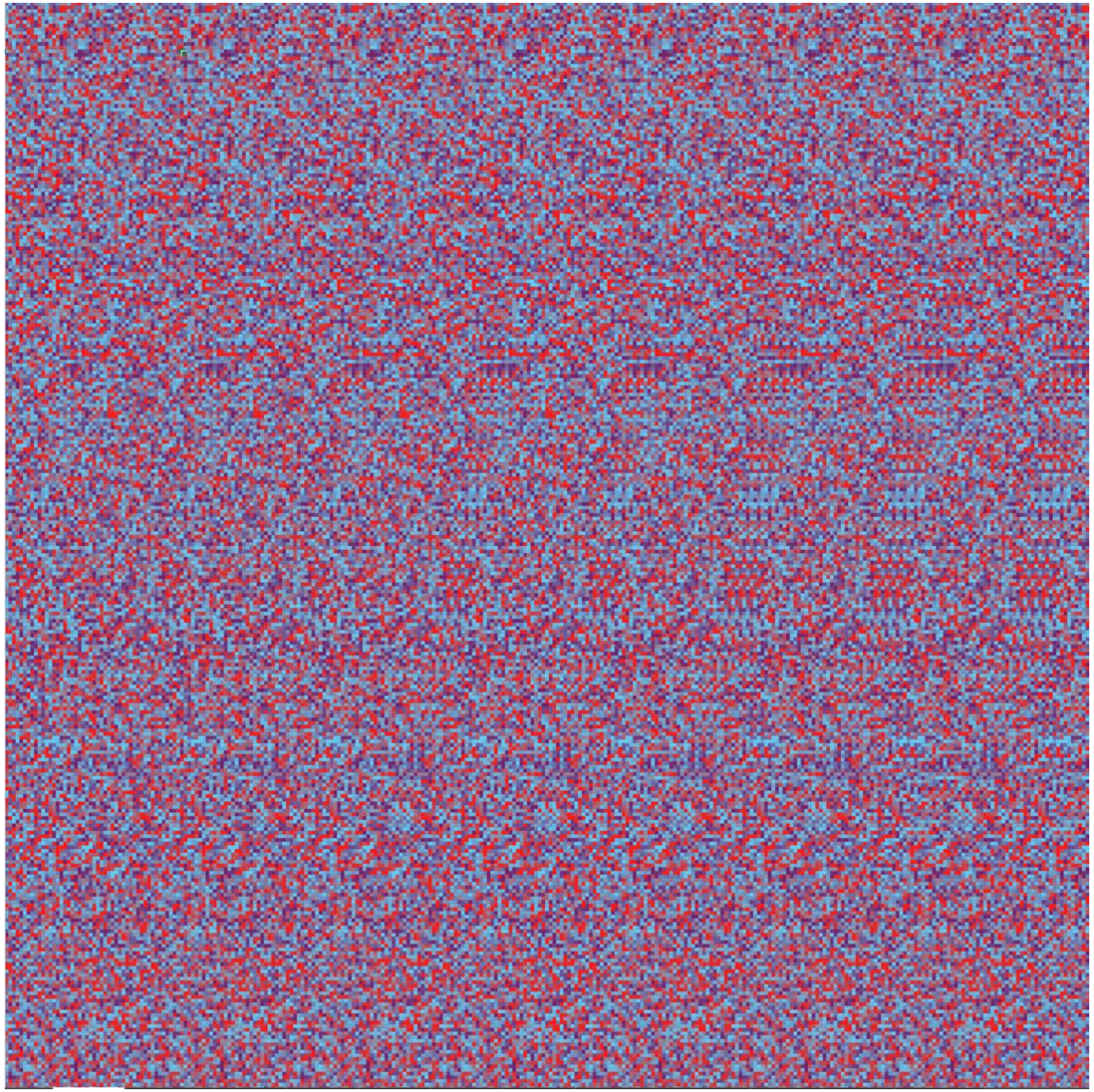
…Procedural-Conceptional

(Links to Mastery)



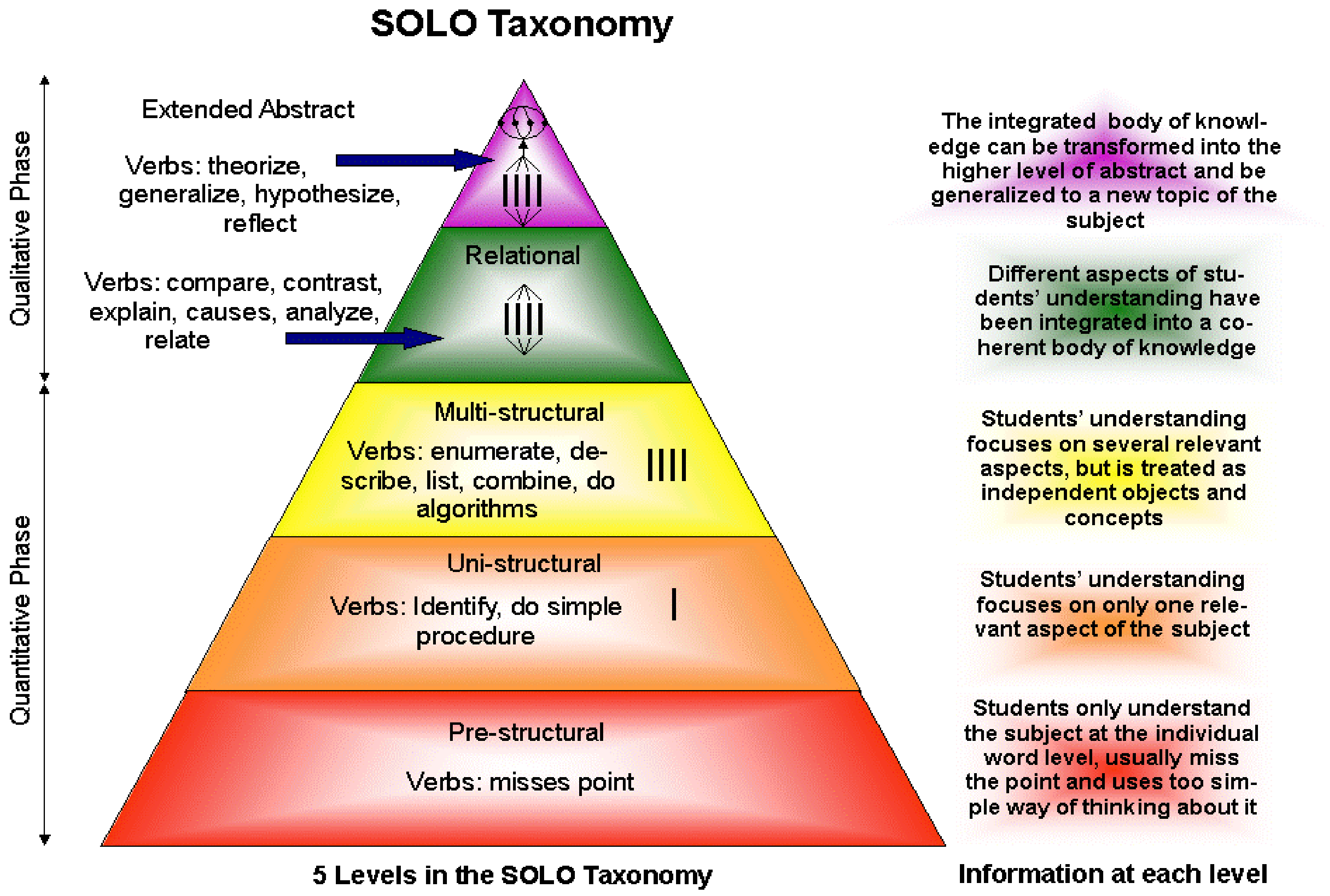
- Not as simple as a linear progression of understanding
- Algorithm not the problem if understand how/why algorithm works
- Bloom devalues process, but in maths process is only way to achieve object – “encapsulation”
- Encapsulation often requires a leap in understanding (see Sfard, 1991; Gray & Tall, 1992; Dubinsky & McDonald, 2001).
- A bit like 3D magic eye puzzles…

A process before the object emerges…



David Richeson (2024) Make a “Magic Eye” image using Excel, Divisbyzero.com

Taxonomies for Mathematical Thinking

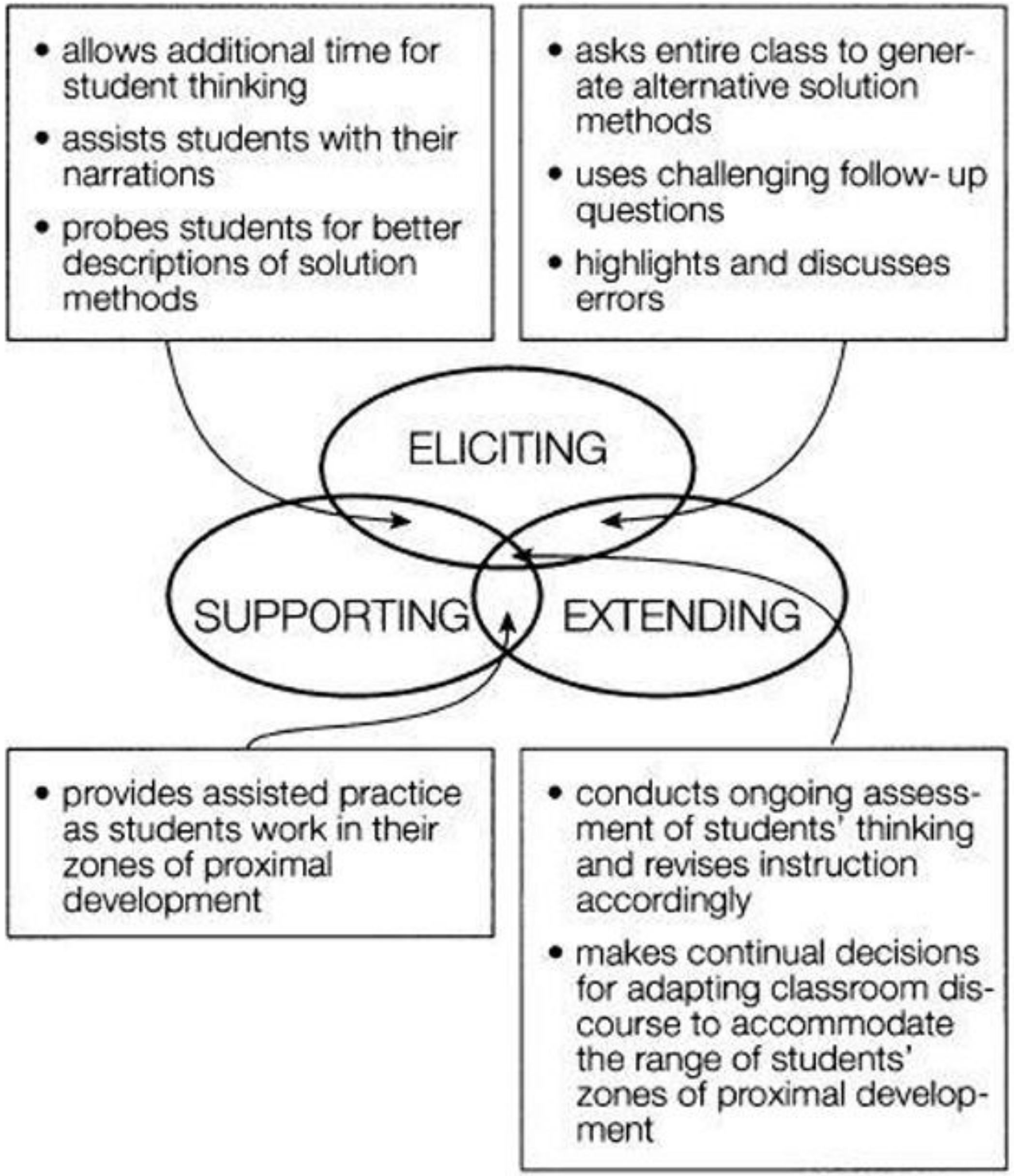


Biggs and Collis (1980)

ACT Framework *(Advancing Children's Thinking in Mathematics)*

Three-tiered structure to examine the purpose behind the question:

- Eliciting Children's Solution Methods
- Supporting Children's Conceptual Understanding
- Extending Children's Mathematical Thinking



Fraivillig et al. (1999)

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Asking better questions – Morgan & Saxton (2006)

Also classify questioning in three ways:

- **probing what the learner already knows;**
- **building a context for shared understanding between teacher and learners;**
- **challenging learners to think both critically and creatively.**

However, the classifications are very broad, particularly the second category which could contain a large array of types of mathematical understanding as well as a wide range of level of complexity in the questioning associated with the category.

How usable as a lesson planning tool?

MATH Taxonomy
(Mathematical Assessment Task Hierarchy)

Group A	Group B	Group C
Factual knowledge	*Information transfer*	*Justifying and interpreting*
Comprehension	Application in new situations	Implications, conjectures and comparisons
Routine use of procedures		Evaluation

(Smith et al., 1996, p.67)

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Mathematical Foci

Conceptual	The teacher emphasises or encourages the conceptual development of his or her students.
Derivational	The teacher emphasises or encourages the process of developing new mathematical entities from existing knowledge.
Structural	The teacher emphasises or encourages the links or connections between different mathematical entities; concepts, properties etc.
Procedural	The teacher emphasises or encourages the acquisition of skills, procedures, techniques or algorithms.
Efficiency	The teacher emphasises or encourages learners' understanding or acquisition of processes or techniques that develop flexibility, elegance or critical comparison of working.
Problem solving	The teacher emphasises or encourages learners' engagement with the solution of non-trivial or non-routine tasks.
Reasoning	The teacher emphasises or encourages learners' development and articulation of justification and argumentation.

(Andrews et al., 2005, p.11)

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Literature – A Summary

- Notion of open or closed questions is simplistic in mathematics (Watson, 2003).
- More helpful to distinguish between a surface and deep approach (Smith et al, 1996)
- Understanding mathematics can be interpreted at different levels of mathematical thought (Watson, 2007) so hierarchy not helpful.
- Learning is constructed through social interaction (Vygotsky, 1978)
- Questioning needs to be specific to mathematics, with sociomathematical norms in place, to elicit mathematical thinking (Yackel & Cobb, 1996).

The Pilot Study

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QUESTION TYPE *Adapted from Smith et al. (1996) and Andrews et al. (2005)*	PROMPTS *Adapted from Watson's analytical instrument (2007, p.119)*	FORMATIVE QUESTION STEMS *From Wiliam (2006)*	SURFACE APPROACH QUESTION CODING	DEEPER APPROACH QUESTION CODING
Factual	• Name • Recall facts • Give definitions • Define terms		SUR-FAC	
Procedural	• Imitate method • Copy object • Follow routine procedure • Find answer using procedure • Give answer		SUR-PRO	
Reasoning	• Justify • Interpret • Visualise • Explain • Exemplify • Informal induction • Informal deduction	Can you explain/ improve/add to that explanation? How do you know that . . . ? Can you justify . . .?	SUR-REA	DP-REA
Reflective	• Summarise • Express in own words • Evaluate • Consider advantages/ disadvantages	What was easy/difficult about this problem . . . this mathematics? What have you found out? What advice would you give to someone else about . . . ?	SUR-REF	DP-REF
Structural	• Show me… • Analyse • Compare • Classify • Conjecture • Generalise • Identify variables • Explore variation • Look for patterns • Identify relationships	Tell me about the problem. What do you know about the problem? Can you describe the problem to someone else? What is similar . . . ? What is different . . . ? Do you have a hunch? . . . a conjecture? What would happen if . . . ? Is it always true that . . . ? Have you found all the solutions?		DP-STR
Derivational	• Prove • Create • Design • Associate ideas • Apply prior knowledge (in new situations) • Adapt procedures • Find answer without known procedure	Have you seen a problem like this before? What mathematics do you think you will use? Can you find a different method? Can you prove that . . . ?		DP-DER

QUESTIONING TECHNIQUE	CODE
Use random methods to choose a student to answer (e.g. names from hat)	RAN
Hands up	HU
No hands up	NHU
‘Wait time’	WT
Discuss answer for a set time in pairs/groups first	DPG
Use mini-whiteboards to write answers	MWB
Generate discussion from mini-whiteboards	MWB-D
Choose from a few answers (e.g. Using voting fans)	VOT
Ask a student to explain their answer	EXP
Ask a student to explain another student’s answer	EXPA
Ask if a student agrees with another	AG
Identify the error	ERR
Writing up selection of responses on board then discuss	SRB-D
Odd one out	OOO
Always/Sometimes/Never True (or equivalent)	ASN
Problems with more (or less) than one correct solution	PMA

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Pilot Study

- Previous micro-research study for the award of Master of Science formed the pilot study for this action research
- The following research questions were investigated in the pilot study:
  - A larger proportion of questions requiring a ‘surface approach’ are used in mathematics lessons than those requiring deeper thinking.
  - The use of formative questioning techniques supports a wider range of intended mathematical thinking.
- Four lessons with four different teachers observed and questions transcribed and coded
- Semi-structured interview with teachers after the lesson observations
- Learner questionnaires

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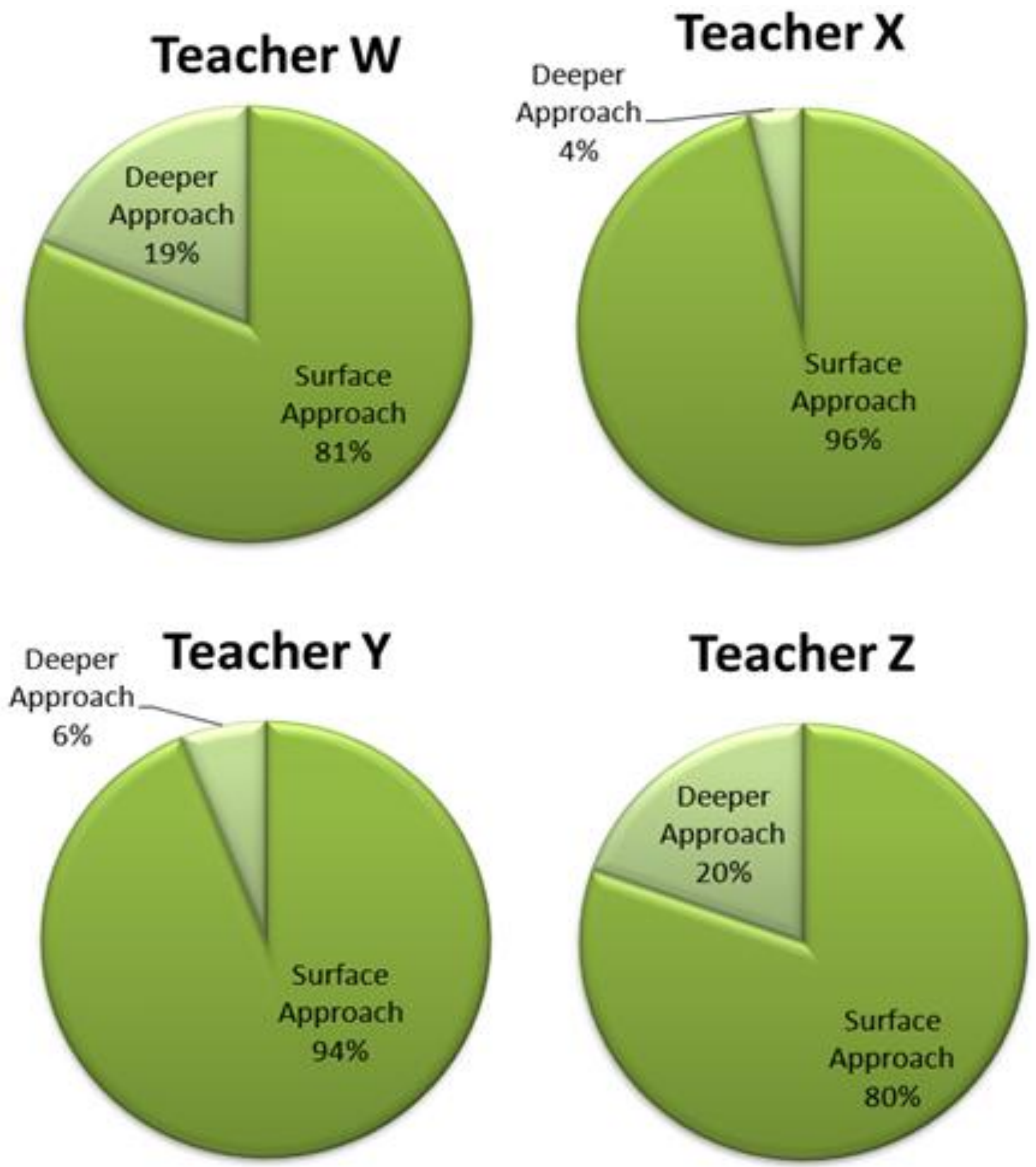
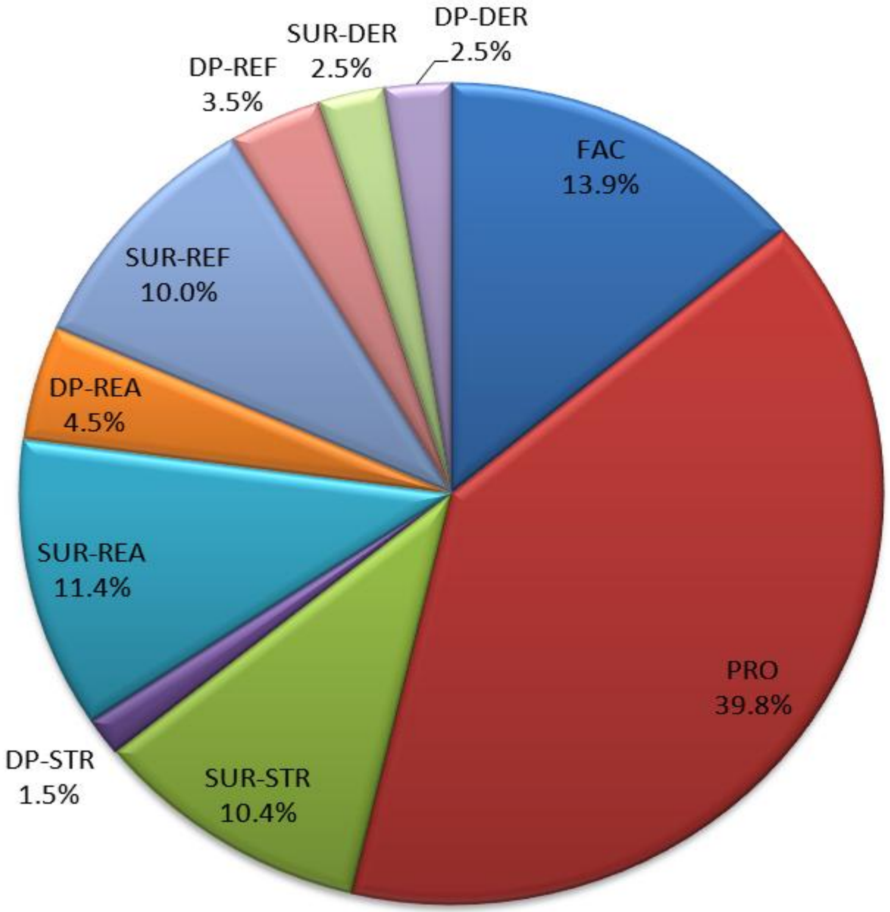
Pilot Study Results

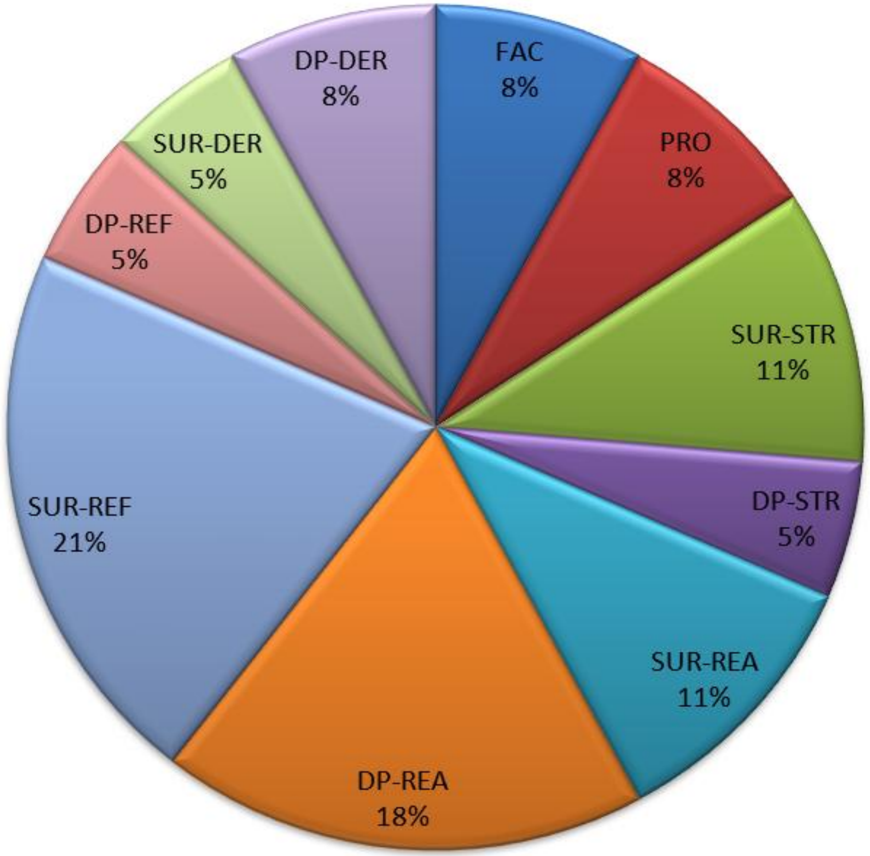
Larger proportion of questions requiring a ‘surface approach’ were used in the mathematics lessons observed than those requiring deeper thinking.



Formative questioning techniques varied questioning type



Overall proportions for each category



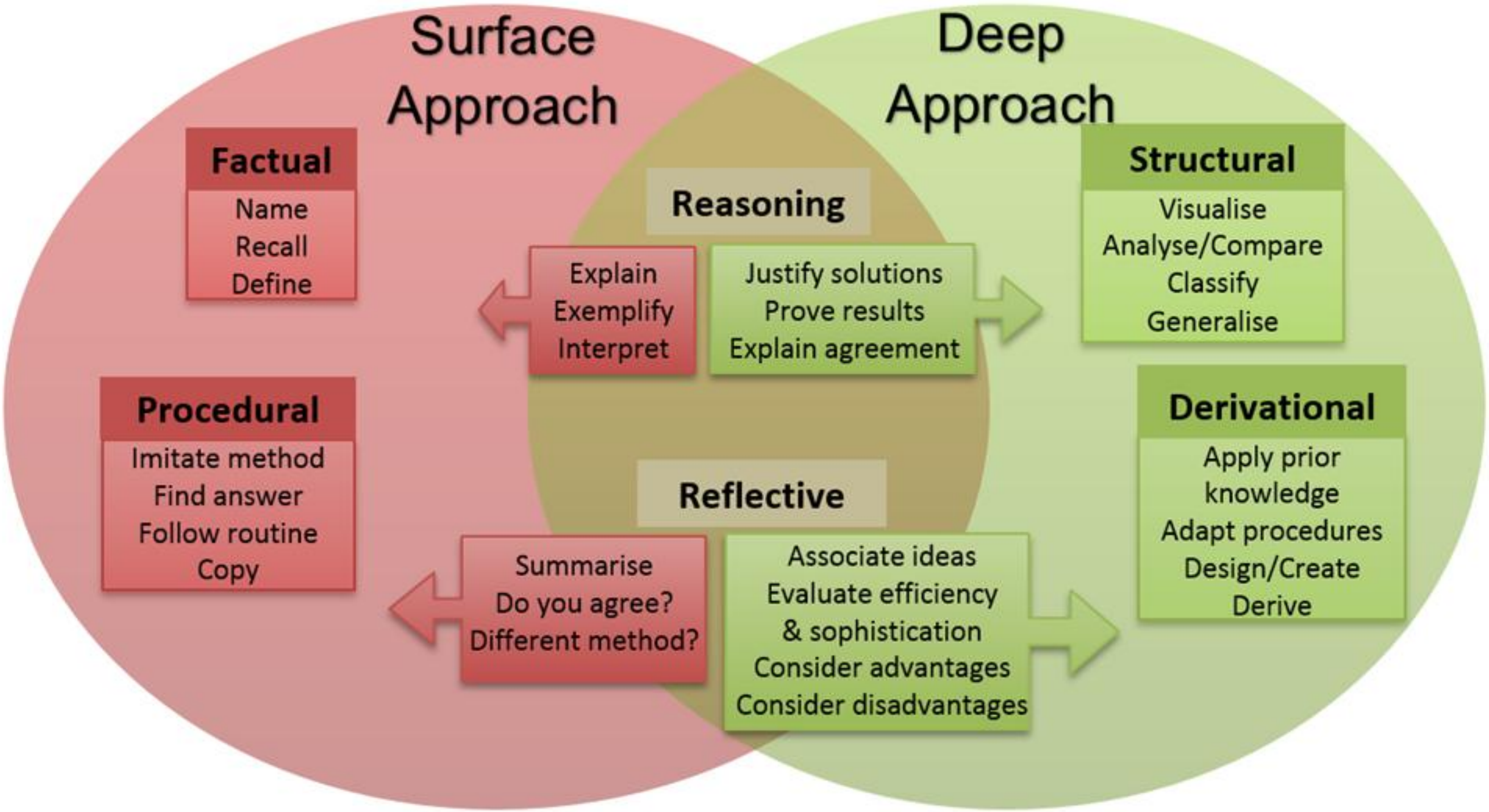
Proportions for each category when "AfL" techniques are employed

Conclusions from the Pilot Study

- Surface questioning significantly outnumbered a deeper approach.
- Variation in the proportion for different teachers.
- Teachers attribute a variation in the proportion of surface level questions to the level of attainment of the class and the topic or concept they are learning.
- The findings suggest that it is in fact the teachers' planning which influences the depth and type of questioning employed.
- The variety of question type increases and the depth of questioning is improved when formative techniques are employed.

The IMPaCT Taxonomy

The IMPaCT Taxonomy



Intended Mathematical Processes and Cognitive Thought

Research Objectives

The aim of this research was to investigate the following questions:

1. **What factors affect the type and depth of questioning used by mathematics teachers?**
2. **Does working with the IMPaCT Taxonomy affect the type and depth of questioning used in mathematics lessons?**
3. **Does the IMPaCT Taxonomy affect mathematics teachers' understanding of how their questioning impacts on their learners' mathematical thinking?**

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Research Methodology

- Action research strategy
- Four teachers and five classes from Year 10-11
- Cycle 1 - Three baseline observations per class (Summer/Autumn 2015)
- Semi-structured teacher interviews (Summer/Autumn 2015)

Intervention

- Cycle 2 – One observation per class (February 2016)

Intervention

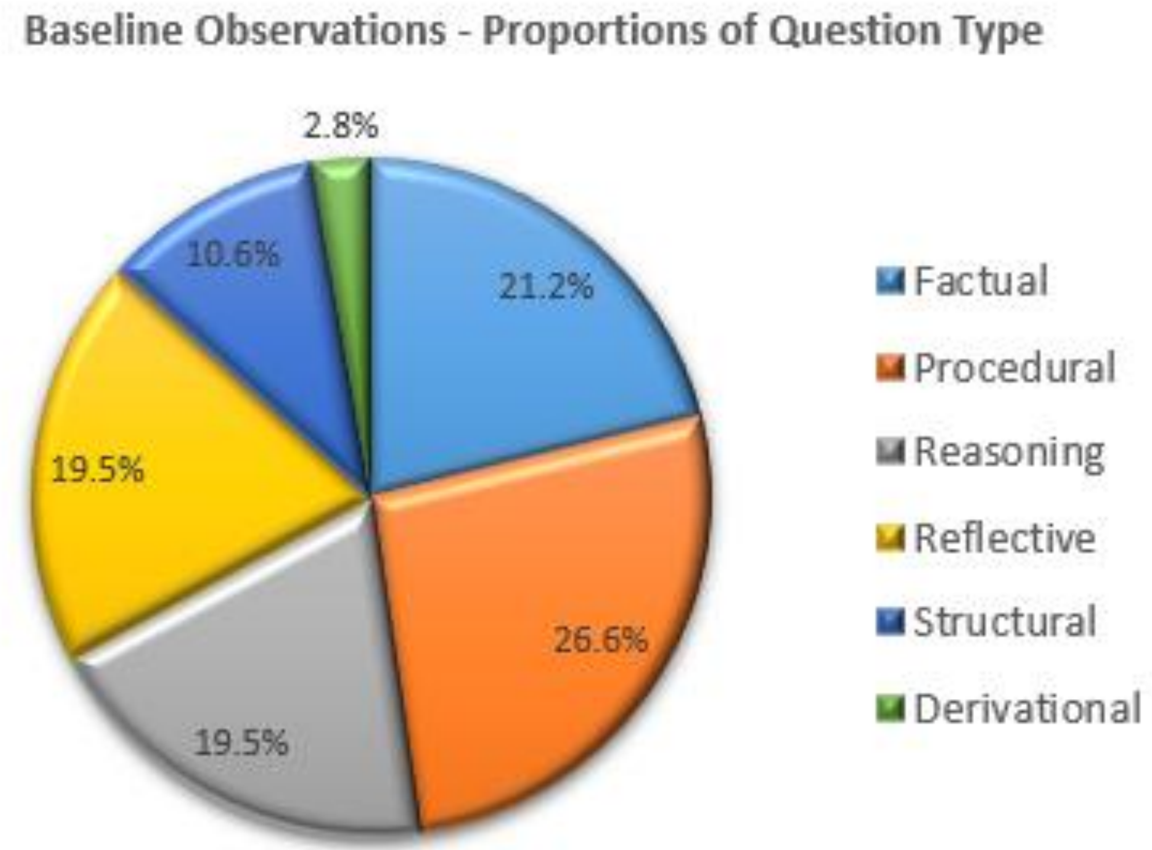
- Cycle 3 – Two observations per class (May 2016)
- Semi-structured teacher interviews (Summer 2016)

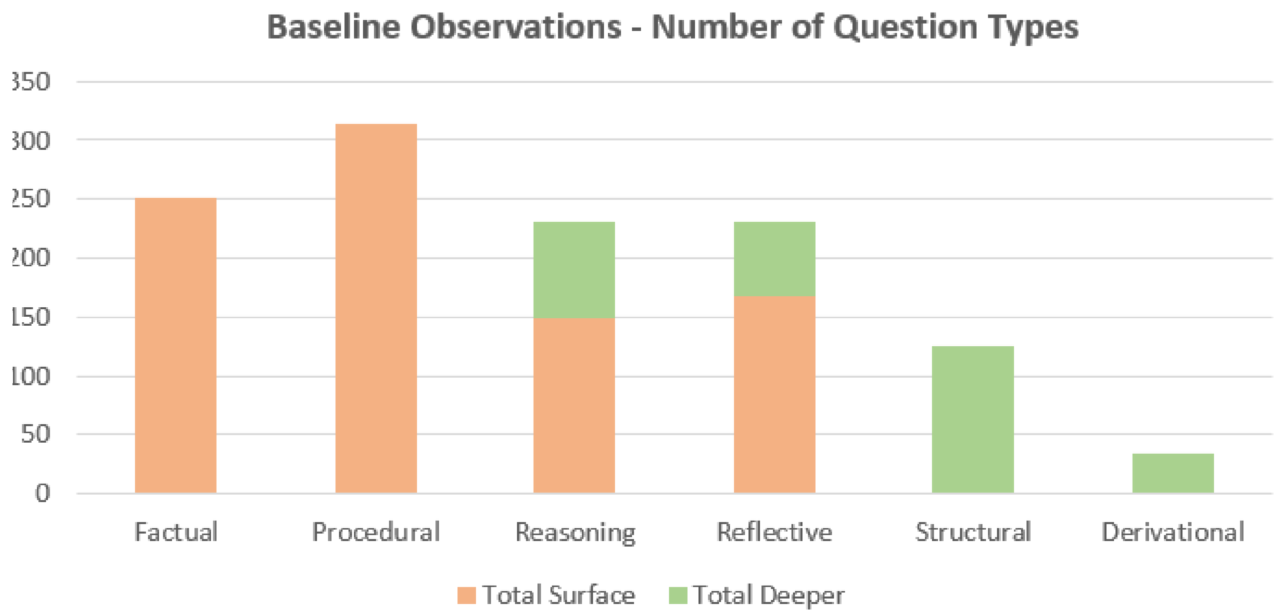
Maximising Validity and Reliability

- Inter-observer reliability will be tested using a non-participant colleague to code a lesson and compare results.
- Teachers observed several times to test internal consistency reliability.
- Internal validity also addressed by observing multiple lessons - differences could be attributable to class, topic, teacher etc.
- Classifying the level of complexity cannot be done in isolation of the context in which it was posed (Yang, 2006), so all coding was made in relation to the class and topic being taught.
- Triangulation of methods - If the outcomes from the qualitative post-intervention teacher interviews correspond with the quantitative data from observations, then greater confidence in the validity of the findings.

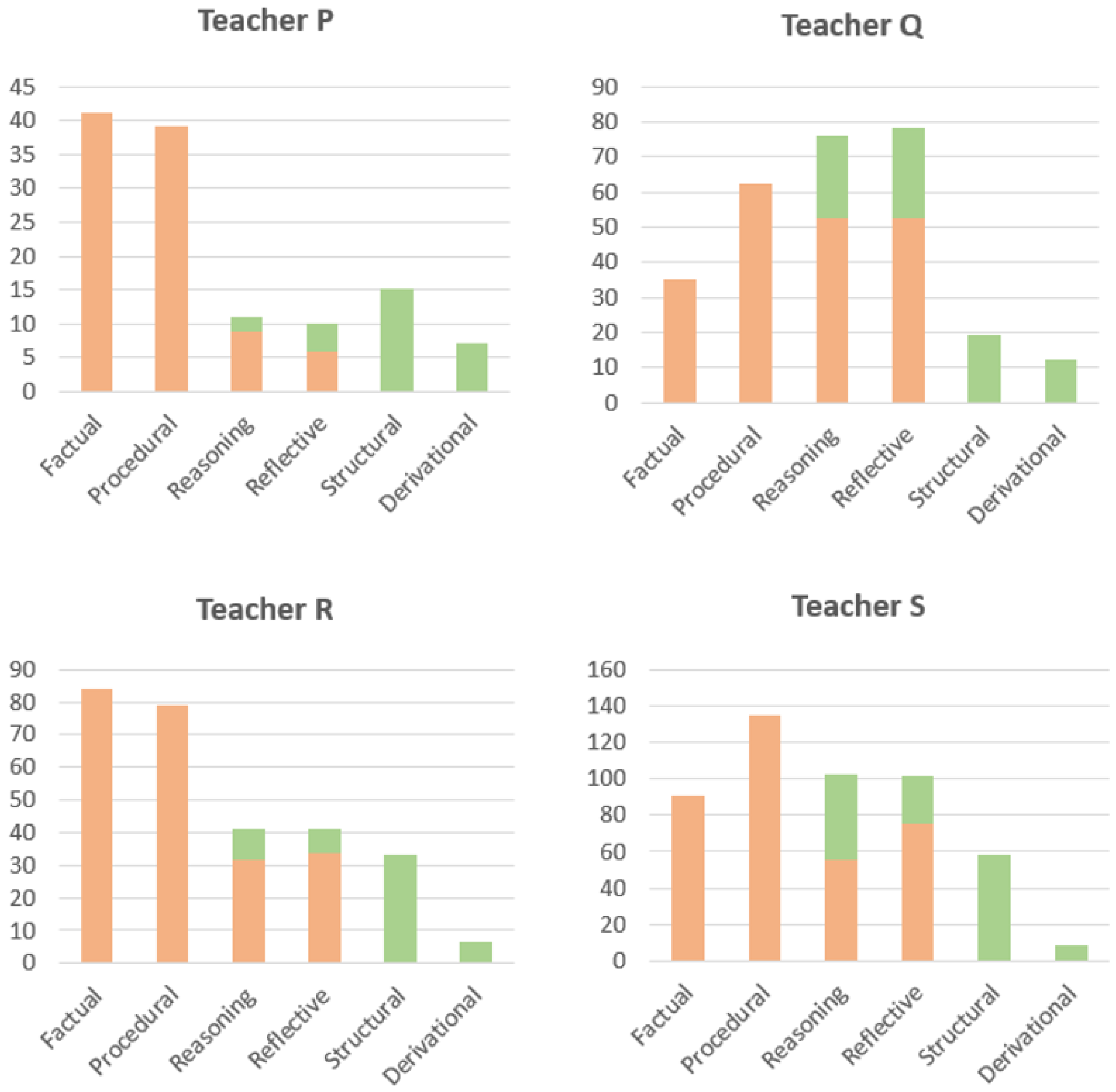
The Pre-Intervention Headline Statistics

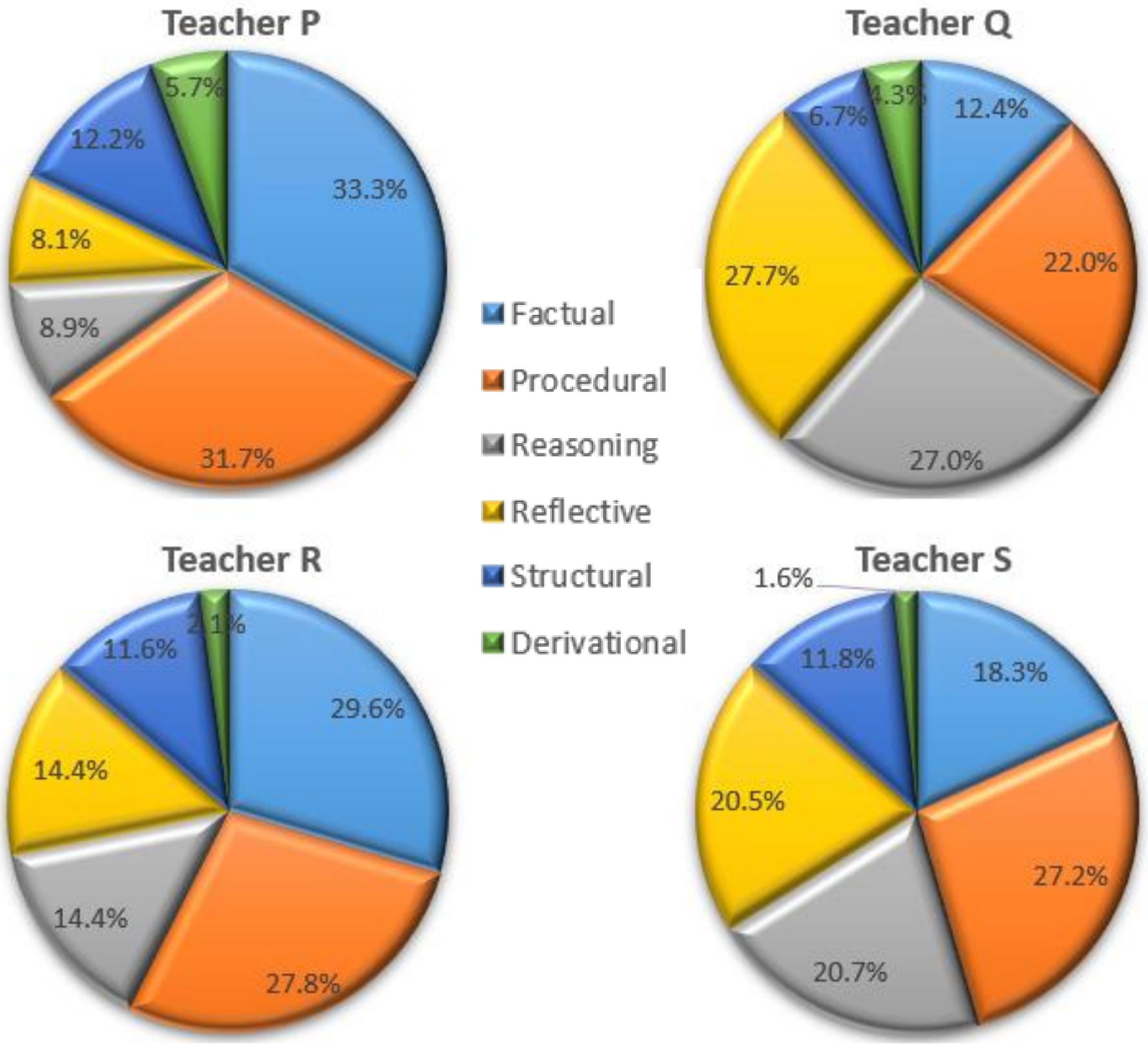
- In the 15 observed or recorded lessons, a total of 1182 questions were transcribed and coded, a mean average of 78.8 questions per lesson.
- 25.3% of questions were coded as a deeper approach.



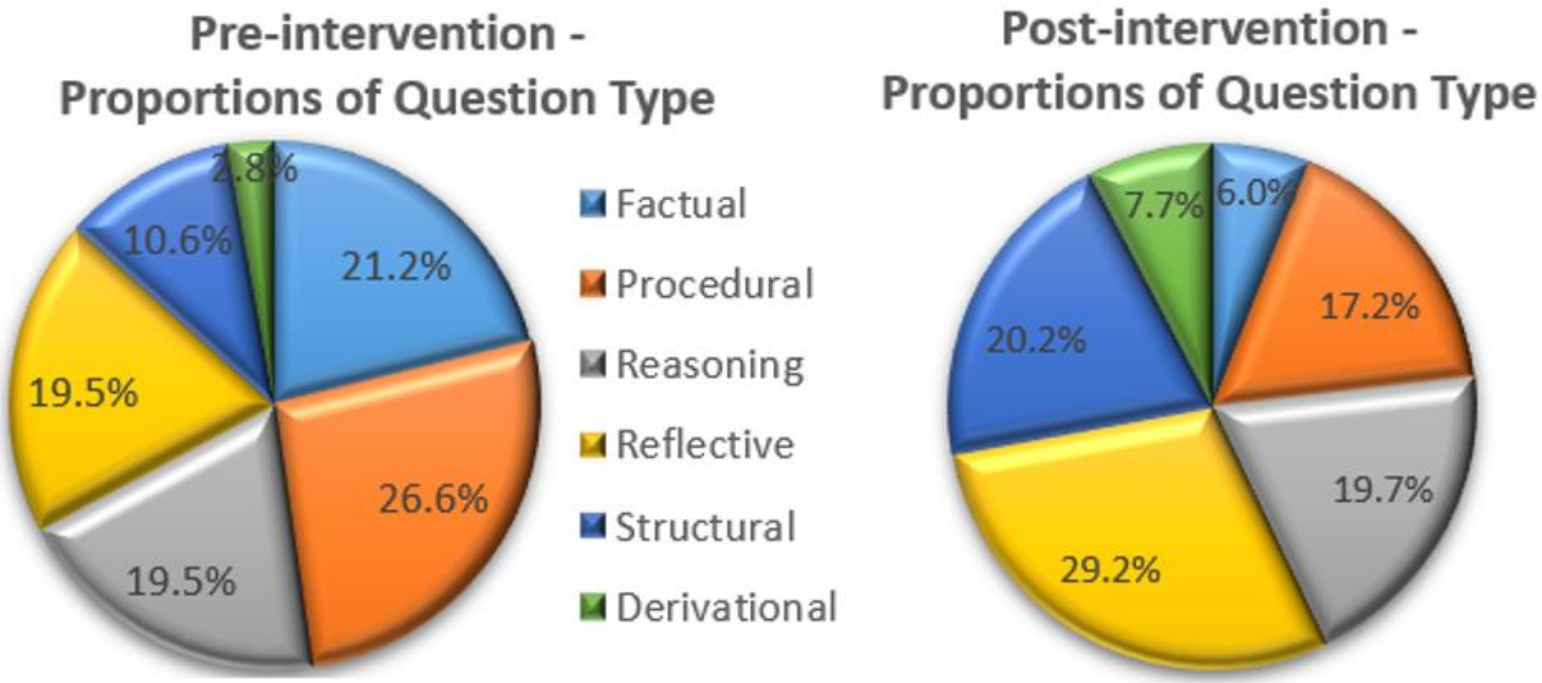


Individual Teacher Analysis





The Post-Intervention Headline Statistics



- Proportion of deeper level questions rose from 25.3% to 51.7% *($p<0.001$)*
- Reasoning category had 63.2% deeper level questions post-intervention, compared to 34.8% pre-intervention *($p<0.001$)*
- Reflective category rose from 26.5% deeper level to more than double this figure at 60.2% post-intervention *($p<0.001$)*

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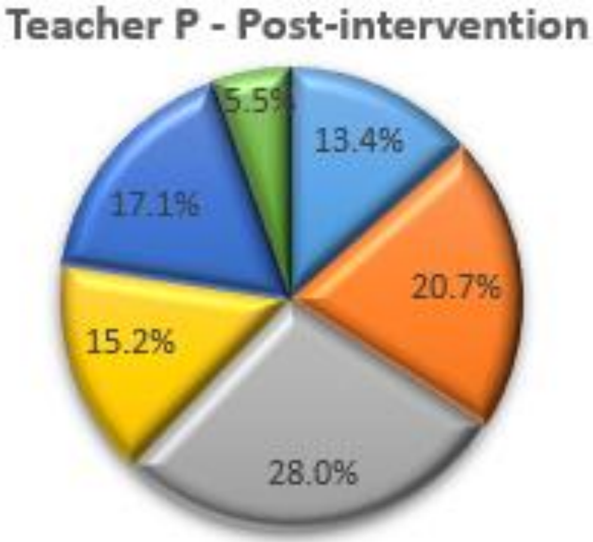
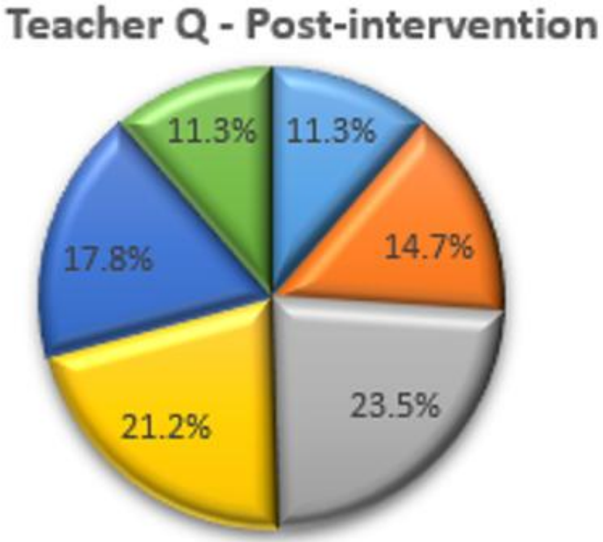
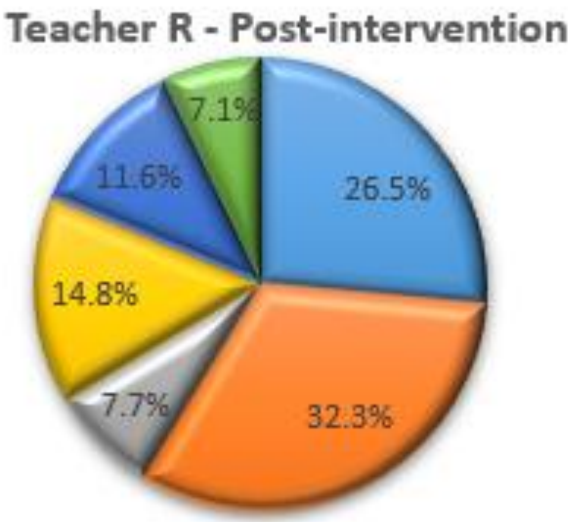
Effect on individual teachers

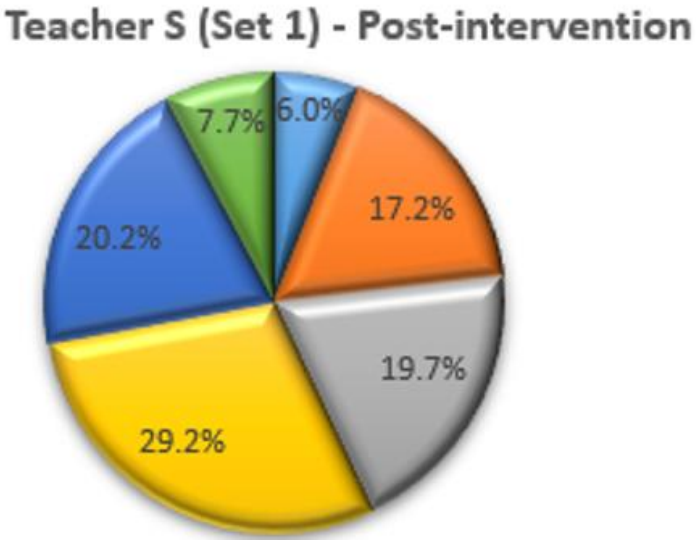
Teacher	% Deeper Pre-intervention	% Deeper Post-intervention	Actual Difference	Percentage Increase
P	22.8	48.2	25.4	111.4
Q	28.0	60.6	32.6	116.4
R	19.4	29	9.6	49.5
S (Set 1)	32.8	55.8	23	70.1

($p<0.05$)



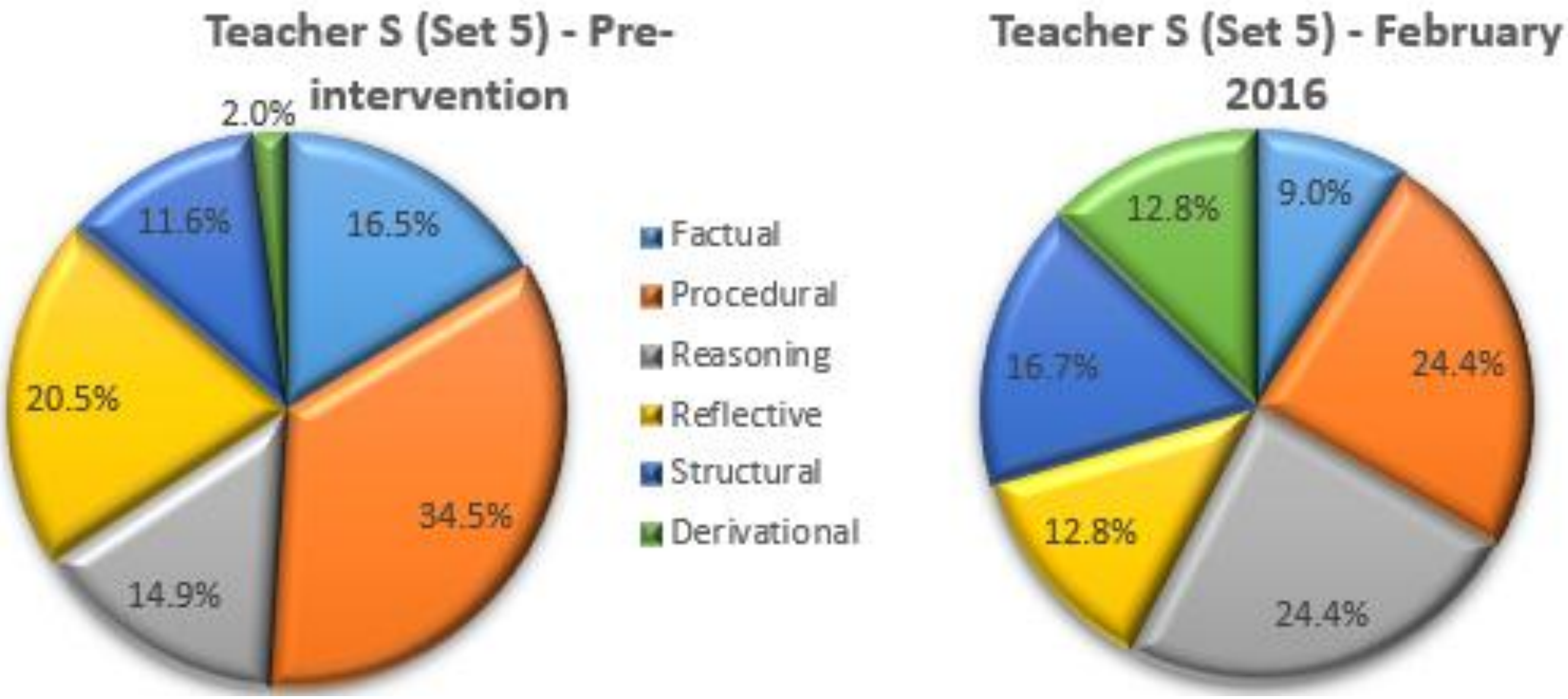






Effect of level of attainment

- Limited data as only one lesson recorded post-intervention
- Biggest percentage increase seen in the proportion of derivational questioning and a substantial decrease in the proportions of factual and procedural.
- Z-test on these differences, indicates that the proportions are significantly greater than in baseline ($p<0.001$)



Effect of Topic

Geometry – Pre-intervention
(based on 6 lessons)

Question Type	Surface	Deeper	Total
Factual	17.8%		17.8%
Procedural	24.1%		24.1%
Reasoning	13.1%	10.5%	23.6%
Reflective	13.3%	6.4%	19.7%
Structural		12.1%	12.1%
Derivational		2.7%	2.7%
Total	68.2%	31.8%	100.0%

Geometry – Post-intervention
(based on 3 lessons)

Question Type	Surface	Deeper	Total
Factual	10.6%		10.6%
Procedural	18.2%		18.2%
Reasoning	9.0%	16.0%	25.0%
Reflective	4.7%	13.5%	18.2%
Structural		17.0%	17.0%
Derivational		11.0%	11.0%
Total	42.5%	57.5%	100.0%

Number – Pre-intervention
(based on 1 lesson)

Question Type	Surface	Deeper	Total
Factual	46.2%		46.2%
Procedural	15.4%		15.4%
Reasoning	15.4%	3.8%	19.2%
Reflective	3.8%	0.0%	3.8%
Structural		0.0%	0.0%
Derivational		15.4%	15.4%
Total	80.8%	19.2%	100.0%

Number – Post-intervention
(based on 2 lessons)

Question Type	Surface	Deeper	Total
Factual	10.5%		10.5%
Procedural	24.3%		24.3%
Reasoning	15.9%	12.9%	28.8%
Reflective	7.6%	7.1%	14.7%
Structural		12.1%	12.1%
Derivational		9.4%	9.4%
Total	58.4%	41.6%	100.0%

Algebra – Pre-intervention
(based on 5 lessons)

Question Type	Surface	Deeper	Total
Factual	27.7%		27.7%
Procedural	29.7%		29.7%
Reasoning	11.4%	3.6%	15.0%
Reflective	12.0%	2.2%	14.2%
Structural		11.0%	11.0%
Derivational		2.4%	2.4%
Total	80.7%	19.3%	100.0%

Algebra – Post-intervention
(based on 6 lessons)

Question Type	Surface	Deeper	Total
Factual	11.9%		11.9%
Procedural	21.5%		21.5%
Reasoning	5.5%	9.3%	14.9%
Reflective	11.4%	12.3%	23.7%
Structural		19.1%	19.1%
Derivational		9.0%	9.0%
Total	50.4%	49.6%	100.0%

Statistics – Pre-intervention

No data

Statistics – Post-intervention
(based on 1 lesson)

Question Type	Surface	Deeper	Total
Factual	13.0%		13.0%
Procedural	13.0%		13.0%
Reasoning	6.5%	17.4%	23.9%
Reflective	4.3%	8.7%	13.0%
Structural		32.6%	32.6%
Derivational		4.3%	4.3%
Total	37.0%	63.0%	100.0%

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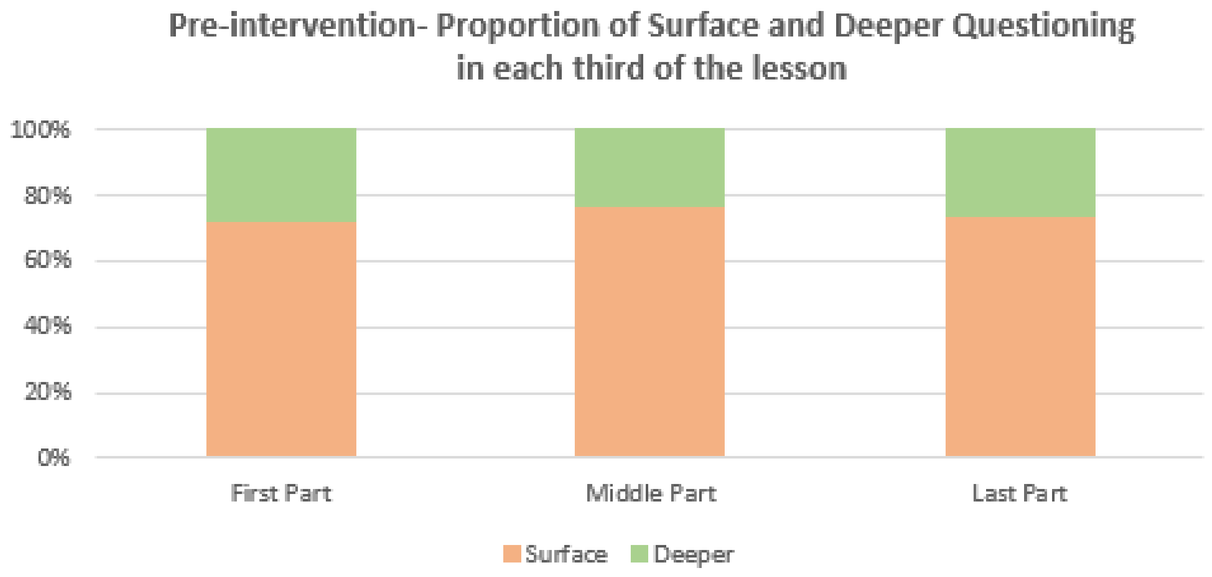
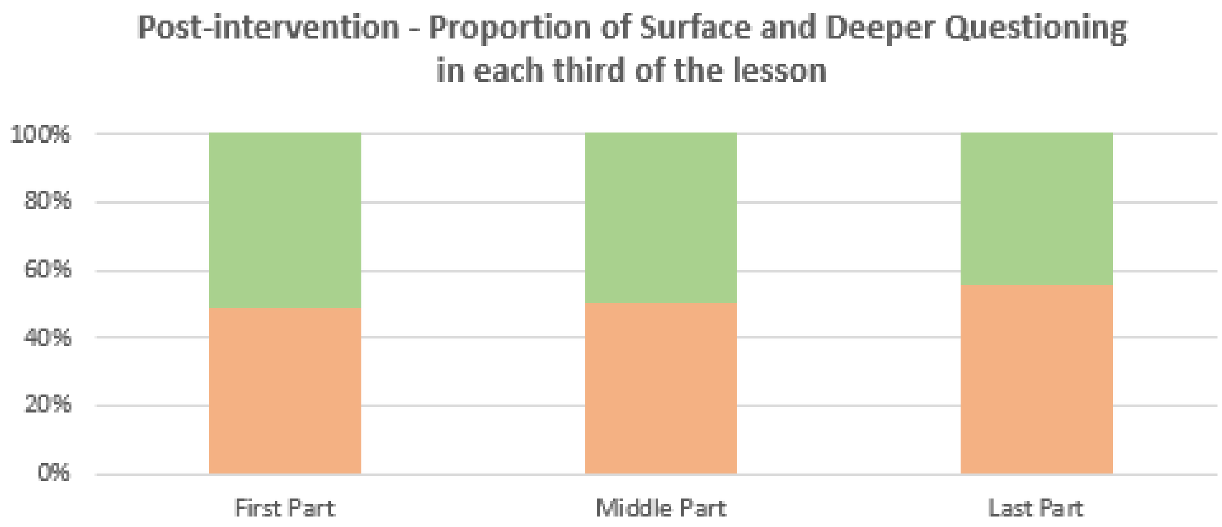
Effect on stage of lesson

- A higher proportion of deeper questioning was observed in every stage of the lesson compared to the baseline observations.
- The largest increase in the depth of questioning can be seen in the middle part of the lesson.
- All three stages of the lesson had very similar proportions of surface and deeper questioning.





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Evidence of sociomathematical norms

Mathematical explanation and **mathematical justification**:

- *What is Student X trying to do there?*
- *Why has he created that first line?*
- *How does Student X know to say that 3x + 5 is the same as 5 – x?*
- *What about this (method) from Student Y and Student Z? What are they trying to do?*

Mathematical difference:

- *Do you get the same if you draw it?*
- *If we look at the four cases here, is there something similar about all of them?*

Mathematical efficiency:

- *Is it easy to see your solutions from that graph?*
- *Which method do you prefer and why?*
- *Tell me why this method might be more useful?*

Mathematical elegance/sophistication:

- *Could you express it in a nice way with integer values?*

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Evidence of sociomathematical norms

- Teacher P encountered a learner giving a particularly procedural response post-intervention:

  Teacher P: How do I do 500 divided by 0.2?

  Student Z: Put the zero from the bottom on the top

- Teacher P dealt with this by stressing the mathematical justification of multiplying top and bottom by the same value (in this case 10) to achieve mathematical equivalence.

- Teacher P made clear to the class what constituted an acceptable **mathematical explanation** and **justification**.

Teacher view of the importance of questioning

- **Teacher P:** It gets them more to explain their findings and justify their answers […] It gives them a bit of a deeper understanding.
- **Teacher Q:** It has made me focus a little bit more on this, the actual making sure that you were asking a question that relates to the deeper part of the understanding not just a superficial one.
- **Teacher R:** It made me consciously think about what questions I would have to ask.
- **Teacher S:** It's all to do with questioning. It's not to do with the resource. You can get the most whizz bang resource but if you can't question students correctly then they don't understand.

Putting it into practice

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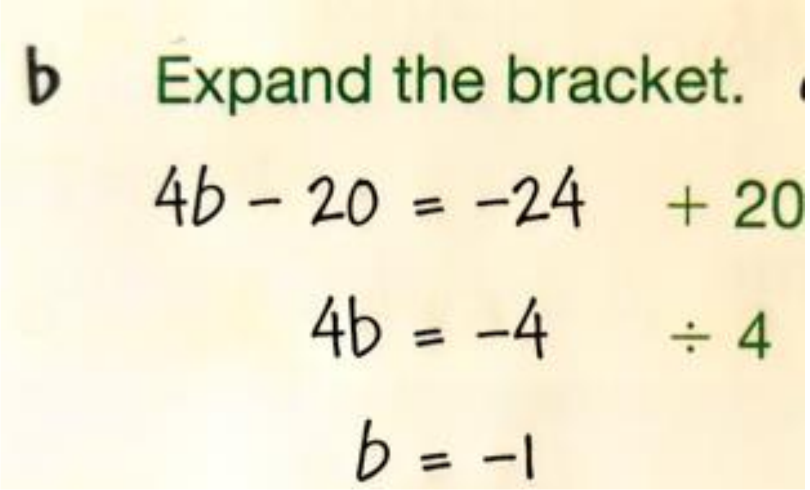
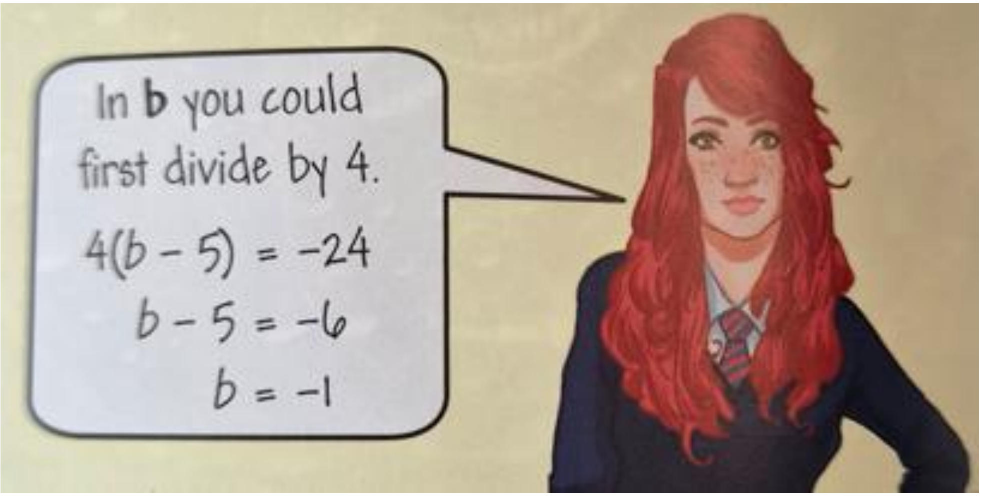
Procedural vs Structural

b $\quad 4(b - 5) = -24$

1. Expand any brackets and collect like terms
2. Collect unknowns on the side of the equation where there are most of them
3. Collect constants on the other side
4. Multiply or divide to find the unknown





Fearnley, S. et al. (2015) AQA GCSE Maths Higher, Oxford University Press

What questions could you ask?

$$4(b-5)=-24$$

Method 1

$$4(b-5)=-24$$
$$4b-20=-24$$
$$4b=-4$$
$$b=-1$$

Method 2

$$4(b-5)=-24$$
$$b-5=-6$$
$$b=-1$$

- What are the advantages of using Method 1?
- What are the advantages of using Method 2?
- Which is most efficient in this question?
- Write an equation where Method 1 might be “better”

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Solve $(3x+5)^2-(x+1)^2=0$

Student X

$$(3x+5)^2-(x+1)^2=0$$
$$(3x+5)(3x+5)-(x+1)(x+1)=0$$
$$(9x^2+15x+15x+25)-(x^2+x+x+1)=0$$
$$(9x^2+30x+25)-(x^2+2x+1)=0$$
$$9x^2+30x+25-x^2-2x-1=0$$
$$8x^2+28x+24=0$$
$$2x^2+7x+6=0$$
$$(2x+3)(x+2)=0$$
$$2x+3=0 \quad \text{or} \quad x+2=0$$
$$2x=-3 \quad \text{or} \quad x=-2$$
$$x=-3/2$$

Student Y

$$\text{Let } a=(3x+5) \text{ and } b=(x+1)$$
$$a^2-b^2=0$$
$$(a-b)(a+b)=0$$
$$((3x+5)-(x+1))((3x+5)+(x+1))=0$$
$$(3x+5-x-1)(3x+5+x+1)=0$$
$$(2x+4)(4x+6)=0$$
$$2(x+2)\cdot 2(2x+3)=0$$
$$x+2=0 \quad \text{or} \quad 2x+3=0$$
$$x=-2 \quad \text{or} \quad 2x=-3$$
$$x=-3/2$$

- What's the same/different?
- Which method is most efficient?
- Which is most sophisticated?
- When would Student Y's method not work? (What happens if…?)

Mean = median = mode = range = 5

2, 5, 5, 6, 7

- Find another set of five numbers where mean = median = mode = range
- Explain your strategy
- Whose strategy was most efficient?
- Whose strategy was most sophisticated?

How might a Year 7 approach this?
How might a Year 12 approach this?

https://nrich.maths.org/problems/unequal-averages

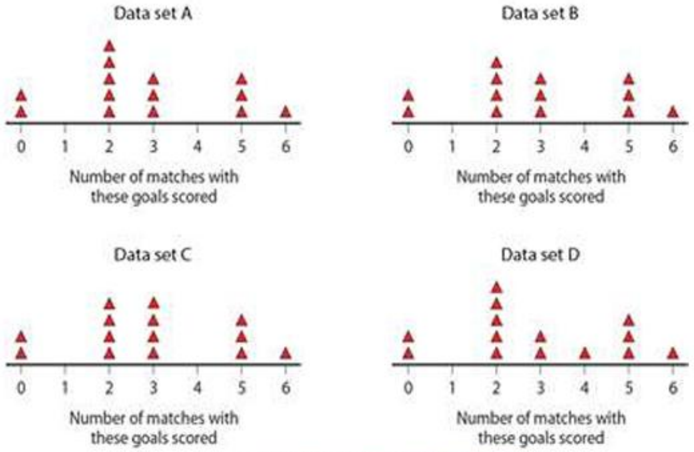
MEI

What question do you think I want to ask?!!

Increase the challenge

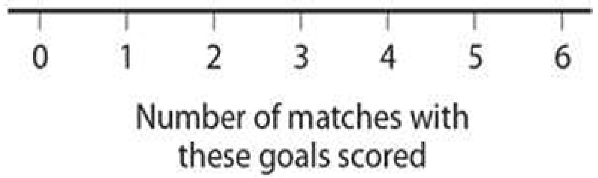
What is the mean, median and mode of each data set?

Sequence the data sets so that they increase in difficulty of calculation.



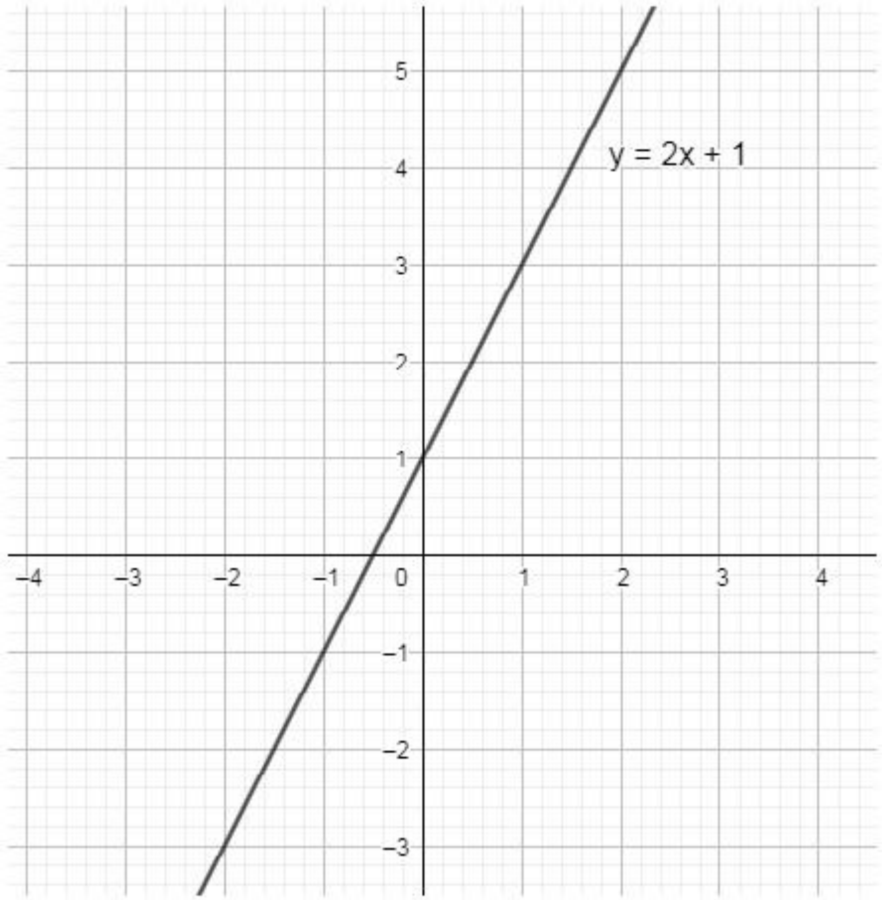
Reverse the problem

Create a data set that has a mode of 3 and a range of 4.



Write down the equation of a line parallel to $y = 2x + 1$

- Can you write down an equation which no one else will think of?
- How many answers to my question are there?
- Can you find an equation which could be seen on this set of axes?
- Would $y = 2x + 8$ be visible?
- Could you find an equation which could be seen on this set of axes which no one else will have?
- Could you write down an equation which will cross $y = 2x + 1$



MEI

Multiplying Fractions

Calculate $\frac{2}{7} \times \frac{1}{4}$

- Did you all do it in the same way?
- Which method is most efficient?
- Can you create a multiplying fractions question where cancelling common factors first would *definitely* be more efficient?
- **What if** you were creating a division calculation?

Explicitly drawing attention to…

Solving Trig Equations

Solve the following for $0° \leq x < 360°$

1. $4\cos x = 3$
2. $2\sin x = -1.6$
3. $\sin^2 x = \frac{1}{4}$
4. $\tan^2 x = 3$

Why did I chose these questions?

What can we learn from these other than just the answers?

…your carefully planned questions!

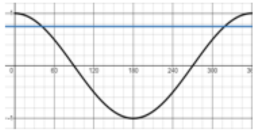
Slide from AMSP SKL AQA L2 FM Topics and Pedagogy: Trigonometry

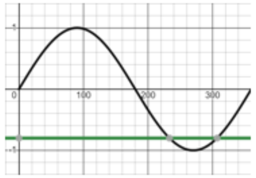
Suggested solutions

Solve the following for $0° \leq x° < 360°$

1. $4\cos x = 3$ — $\cos x = \frac{3}{4}$ — $x = 41.40\ldots, 360 - 41.40\ldots$

   $x = 41.4, 318.6$ (to 1dp)

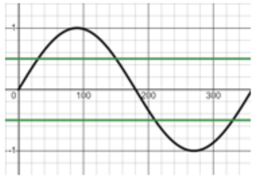




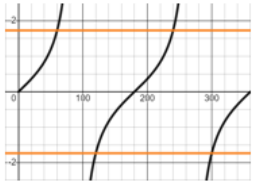
2. $2\sin x = -1.6$ — $\sin x = -0.8$ — Calculator gives $-53.13\ldots$,

   $x = 233.1, 306.9$ (to 1dp)

3. $\sin^2 x = \frac{1}{4}$ — $\sin x = \pm\frac{1}{2}$ — $x = 30, 150, 210, 330$



4. $\tan^2 x = 3$ — $\tan x = \pm\sqrt{3}$ — $x = 60, 120, 240, 300$



1. Standard question, use calculator to get one then symmetry to find next.
2. Calculator answer is less than domain.
3. Four solutions (due to +ve and –ve square root), exact values
4. Has both issues encountered in Q2 and Q3

Explicitly drawing attention to…

Surface level

How do you find the perimeter and area of a sector?

Deeper level

Which do you think learners find harder – finding the area or perimeter of a sector?

Why is finding the perimeter more “work” than finding the area?

What mistake do you think is most common?

…common errors and misconceptions!

MEI

Easy win…turn procedural into derivational

Surface level

Can you use Pythagoras' Theorem to find the height of the cone?

- *Remove the procedural prompt*
- *Allow student to make decision to apply prior knowledge*
- *Demand justification over solution*

Deeper level

How could you find the height of the cone?

Rich tasks that lend to deeper questioning: Sorting activities

Number of decimal places

Number of significant figures		0	1	2	3
	0				
	1				
	2				
	3				

0.0   0.002   43.6   2.867   450   0.604

0.023   0.21   8.70   0.9   0   8 010

MEI

Number of decimal places

Number of significant figures	0	1	2	3
0	0	0·0		
1		0·9		0·002
2	450		0·21	0·023
3	8 010	43·6	8·70	0·604

2·867

1. Which number cannot be placed in the table? Why?

2. Find numbers which could go in the empty cells.

3. What do we normally call rounding to 0 d.p.?

4. What could each number in your table have been before it was rounded?

5. What proportion of cells have a unique answer?

6. What can you say about the number of answers possible in other cells in the table?

MEI

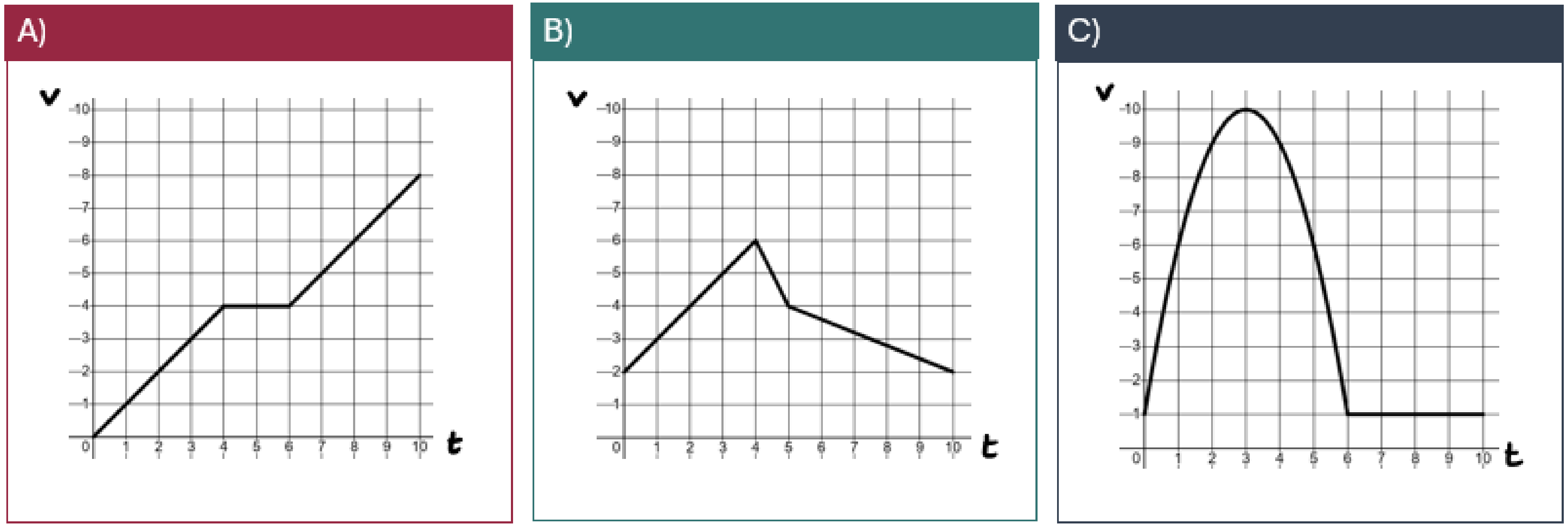
Rich tasks that lend to deeper questioning: Odd One Out

Which one doesn't belong?

Give a reason why each velocity-time graph might be considered the odd one out.

What is the most obvious reason you can give in each case?

What is the least obvious (but still justifiable) reason?



Slide from launch session of Level 3 Maths Leadership Communities

Rich tasks that lend to deeper questioning: Always, Sometimes, Never True

$a \times b = b \times a$ It doesn't matter which way round you multiply, you get the same answer.	$a \div b = b \div a$ It doesn't matter which way round you divide, you get the same answer.
$12 + a > 12$ If you add a number to 12 you get a number greater than 12.	$12 \div a < 12$ If you divide 12 by a number the answer will be less than 12.
$\sqrt{a} < a$ The square root of a number is less than the number.	$a^2 > a$ The square of a number is greater than the number.

Activity from the Standards Unit resources

MEI

Strategies to support deeper questioning

- Setting problems with more (or less) than one correct solution
- Use mini-whiteboards **and** generate discussion from answers
- Ask a student to justify their answer/another student's answer
- Ask if a student agrees with another **and** why/why not?
- Identify the error/common misconception
- Writing up selection of responses on board then discuss – *efficiency, sophistication, elegance, difference*
- Sorting activities (e.g. card sort, two-way table, Venn diagram)
- Odd one out
- Always/Sometimes/Never True

MEI

Always have these questions up your sleeve…

- What if…/What happens if…?
- What's the same/different?
- Which method is most efficient/sophisticated/elegant?

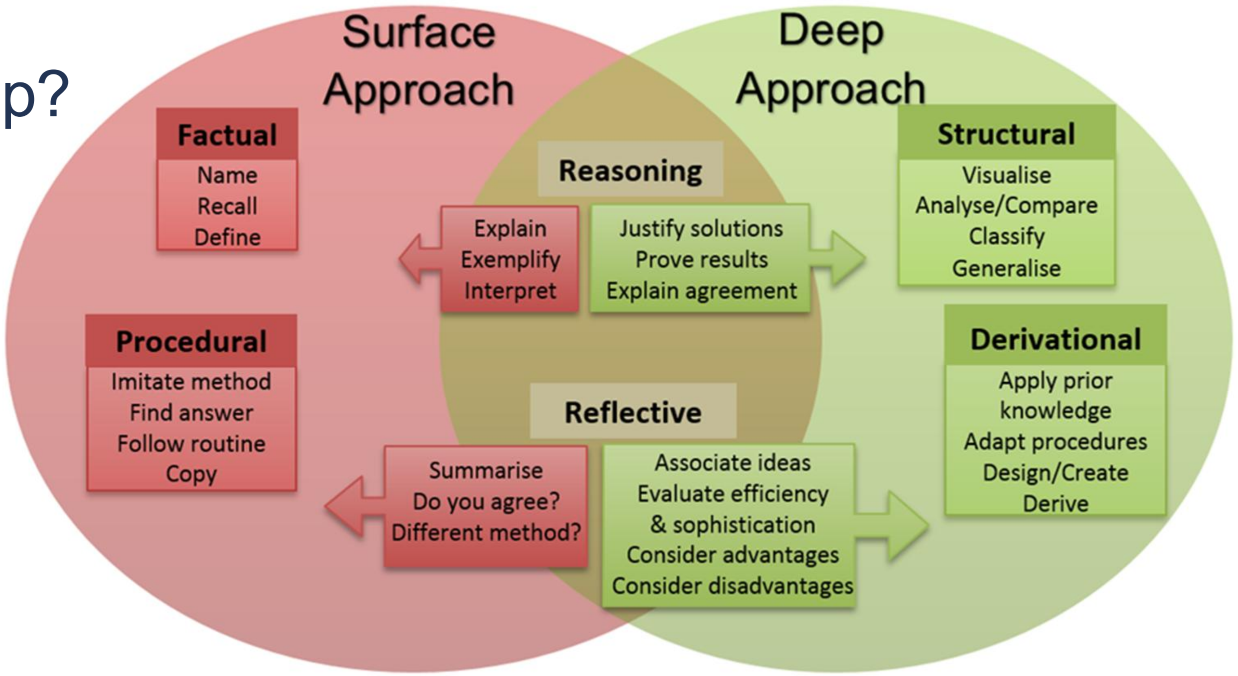
Using the IMPaCT Taxonomy…

- Think of an upcoming lesson/topic and the questions you plan to ask (or usually ask).
- Where would you place them in the IMPaCT Taxonomy?
- How could you tweak your questions to encourage a deeper understanding of the mathematics?
- What questions could you ask to vary the types of intended mathematical thinking for your learners?

MEI

Final Thoughts

- The results of the action research demonstrated how working with the IMPaCT Taxonomy had significantly increased the depth and variety of their questioning in lessons.
- Orrill (2013) stated that further research was required to “identify and characterize more effective questioning strategies” which are accessible to maths teachers.
- Could the IMPaCT Taxonomy fill this gap?



References

Andrews, P., Hatch, G. and Sayers, J. (2005) ‘What do teachers of mathematics teach? An initial episodic analysis of four European traditions’, in Hewitt, D. and Noyes, A. (Eds.) Proceedings of the Sixth British Congress of Mathematics Education held at the University of Warwick, pp. 9-16.

Biggs, J. & Collis, K. F. (1980) SOLO taxonomy, Education News, Vol. 17, No.5, pp. 19-23.

DfES (2004) ‘Unit 7: Questioning’, Pedagogy and Practice: Teaching and Learning in Secondary Schools, Key Stage 3 National Strategy, Crown Copyright.

Dubinsky, E. and McDonald, M.A. (2001) ‘APOS: A Constructivist Theory of Learning in Undergraduate Mathematics Education Research’, in Hoton, D. (Ed.) The Teaching and Learning of Mathematics at University Level, An ICMI Study, New York, Kluwer Academic Publishers, pp. 275-282.

Fraivillig, J., Murphy, L. and Fuson, K. (1999) ‘Advancing children’s mathematical thinking in everyday mathematics classrooms’, Journal for Research in Mathematics Education, Vol. 30, No. 2, pp. 148-170.

Gerson, H. and Bateman E. (2011) ‘Authority in the Negotiation of Sociomathematical Norms’, in Brown, S., Larsen, S., Marrongelle, K. and Oehrtman, M. (Eds.) Proceedings of the 14th Annual Conference on Research in Undergraduate Mathematics Education, Vol. 1, Portland, Oregon, p. 115-127.

Gray, E. and Tall, D. (1991) ‘Duality, Ambiguity and Flexibility in Successful Mathematical Thinking’, Proceedings of PME 15, Vol. 2, pp. 72–79.

Gray, E. and Tall, D. (1992) ‘Success and Failure in Mathematics: The Flexible Meaning of Symbols as Process and Concept’, Mathematics Teaching 142, pp. 6-10.

GURO21 (2012) Gearing Up Responsible and Outstanding Teachers in Southeast Asia for the 21st Century, Course 1, Module 2, SEAMEO INNOTECH. Available at: http://iflex.innotech.org/GURO21/Module2/l2_28.html [Accessed 9 July 2017]

Morgan, N. and Saxton, J. (2006) Asking better questions, Markham, Ontario, Pembroke Publishers.

Ofsted (2012) Mathematics: made to measure, Manchester, Crown Copyright. Available at: www.ofsted.gov.uk/resources/110159 [Accessed 25 May 2013]

Sfard, A. (1991) ‘On the Dual Nature of Mathematical Conceptions: Reflections on Processes and Objects as Different Sides of the Same Coin’, Educational Studies in Mathematics, Vol. 22, No. 1, pp. 1-36.

Smith, G., Wood L., Coupland, M., Stephenson, B., Crawford, K. and Ball, G. (1996) ‘Constructing mathematical examinations to assess a range of knowledge and skills’, International Journal of Mathematical Education in Science and Technology, Vol. 27, No.1, pp. 65-77.

Watson, A. (2003) ‘Opportunities to learn mathematics’, Mathematics education research: Innovation, networking, opportunity, pp. 29-38.

Watson, A. (2007) ‘The nature of participation afforded by tasks, questions and prompts in mathematics classrooms’, Research in Mathematics Education, Vol. 9, No. 1, pp. 111-126.

Yackel, E. and Cobb, P. (1996) ‘Sociomathematical norms, argumentation, and autonomy in mathematics’, Journal for Research in Mathematics Education, Vol. 27, No. 4, pp. 458-477.