What might it look and sound like when a year 6 child meets a barrier to or becomes stuck during mathematical reasoning?

Enjoyment in learning mathematics: its role as a barrier to children's Perseverance in Mathematical Reasoning
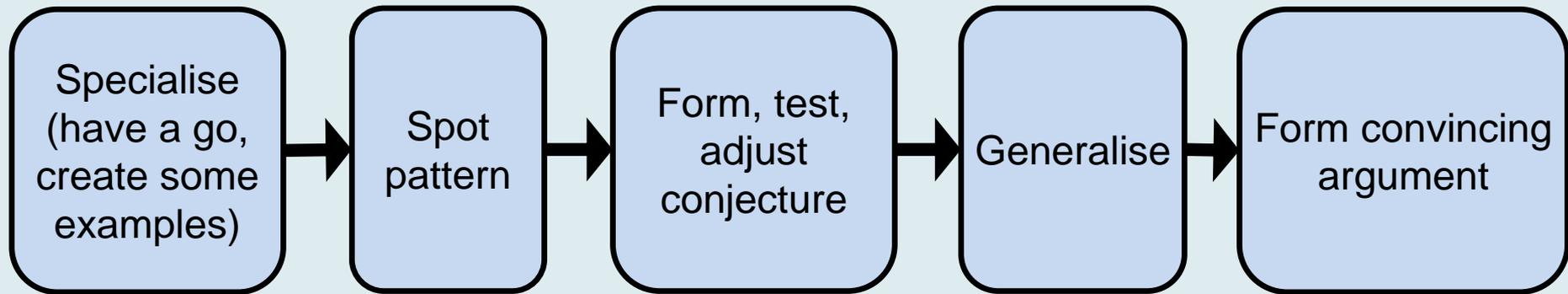
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Mathematical Reasoning

The pursuit of a line of enquiry to produce assertions and develop an argument to reach and justify conclusions.

Specialise (have a go, create some examples) → Spot pattern → Form, test, adjust conjecture → Generalise → Form convincing argument

Perseverance in Mathematical Reasoning (PiMR)

Striving to pursue a line of mathematical reasoning, during a mathematical activity, despite difficulty or delay in achieving success.

Conative aspects of perseverance	Interpreted for PiMR
Focusing attention	Focusing attention on and engaging with the mathematical activity, mathematical concepts and potential lines of reasoning
Striving	Striving to pursue a line of mathematical reasoning to produce assertions and develop an argument to reach and justify conclusions
Self-regulating	Cognitive self regulation Affective self-regulation

DeBellis and Goldin, 2006; Fredricks et al, 2004; Huitt and Cain, 2005; Malmivuori, 2006; Özcan, 2016; Tait-McCutcheon, 2008; Tanner and Jones, 2003;

Known barriers to primary children's PiMR

Cognitive

Utilising patterns as a platform for generalisation

Not expecting to explain reasons why mathematical pattern occurs

Creating convincing arguments about why a generalisation might be true

(Ellis, 2007; Reid, 2002)

Affective

Negative emotional pathway

Feeling apprehensive about mathematics

Mathematics anxiety

(Ashcraft and Moore, 2009; Goldin 2000)

Conative

Development of self-regulatory processes is not easy – it's a "major achievement of the primary years"

(Goswami, 2015, p.17)

Conceptual Framework:
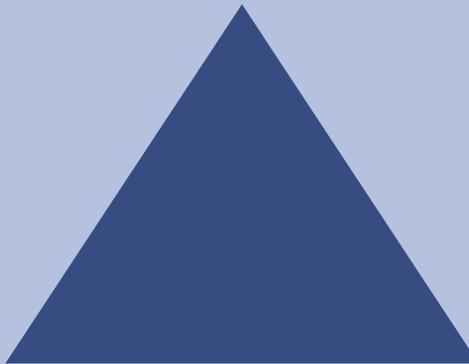# tripartite psychological model

Cognition
Mathematical reasoning
processes

Conation
Perseverance in
mathematical reasoning

Affect
Emotions during
activities involving
mathematical reasoning

Approach, participants, methods

Approach
- Pragmatic stance
- Action research
- Pilot study & main study
- Main study: a baseline lesson, 2 cycles each with 2 research lessons

Data collection methods
- Observations of children during mathematics lesson, audio recordings and photographs
- Interviews with children

Participants
- 2 Y6 teachers in 2 different schools
- 8 children, 4 in each school, purposively selected for their limited PiMR
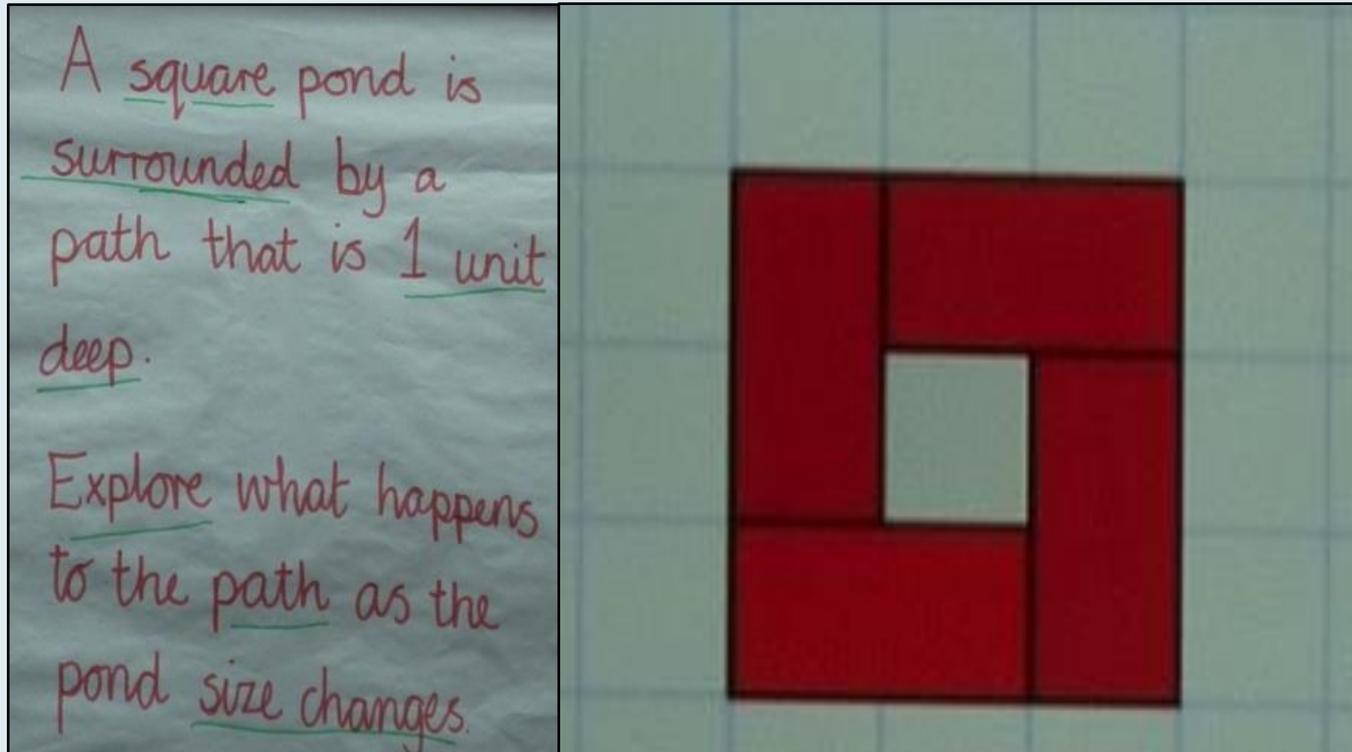
Data analysis methods
- Hypothesis coding (conceptual framework)
- Diagrammatic representation and analysis of cognitive-affective interplay

This presentation focuses on 2 girls in one school

Bradbury, 2015; Delanty and Strydom, 2003; Dewey, 2003 (1938); Gillham, 2008; Grey, 2009; Hammond, 2013; Hobson and Townsend; Saldaña, 2016

Vignette 1

A square pond is surrounded by a path that is 1 unit deep.

Explore what happens to the path as the pond size changes.

Ruby: You could just use the orange ones and then just make it get smaller and smaller
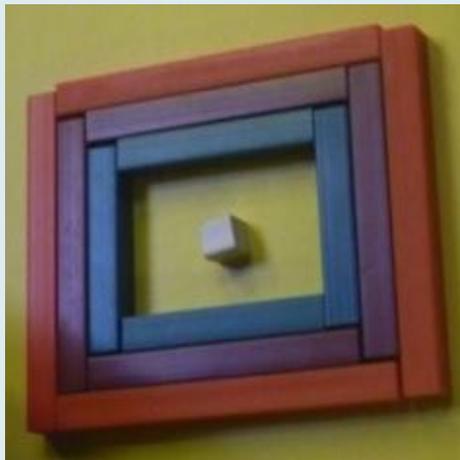
Alice: Then we keep closing in

Ruby: And then it gets really small

Alice: Oh my god, I've figured out a pattern. Cos you have to like do one, leave one of them and then… [said in excited tones]

Ruby: … do another one [said in excited tones]

Ruby: That's really weird

Alice: It doesn't work

Alice: Try this, look get 4 of these [10 cm rods]
           I'm just going to use this – got it

Alice: They go up in steps [said in excited tones]
           Oh my god, I've got a pattern [cheers, claps]
           That's 9, then the next one will be 8, then 7 then 6, then that's 5, 4, 3, then there'll be 2 then 1

Teacher: At this stage, do you need to keep building the ponds or can you just use the numbers? [gives out A3 paper]
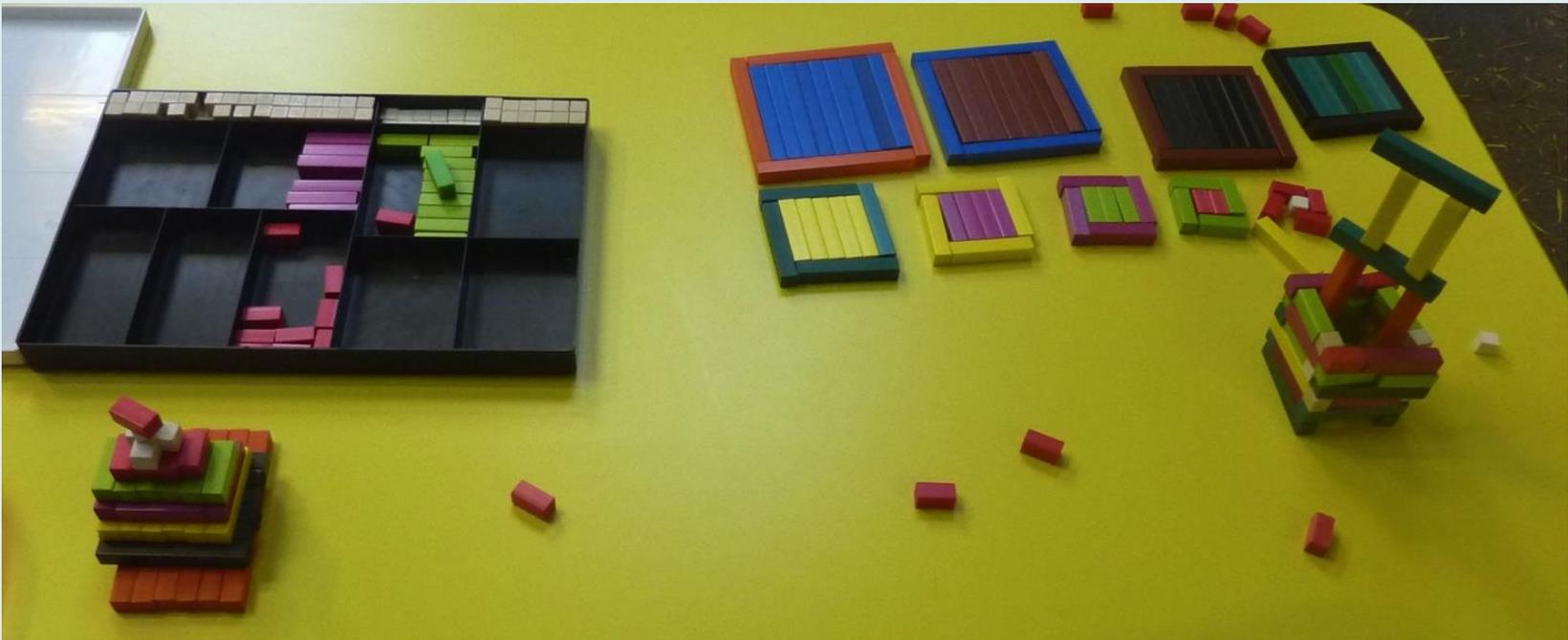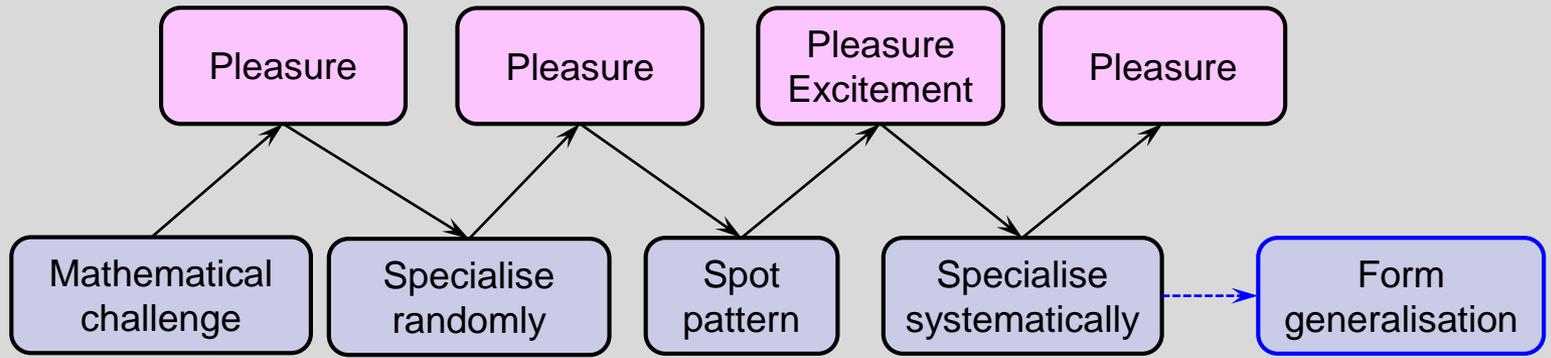

Ruby: I thought we didn't need to do it on the paper because we'd already done it
Alice: It was really fun because it was really challenging
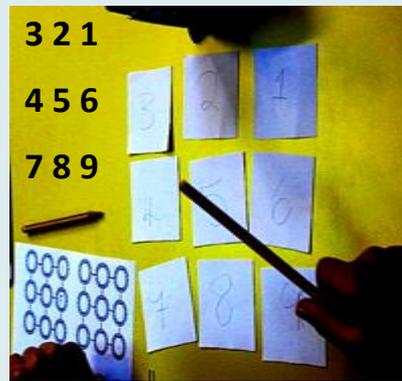
Vignette 2

1 2 3 4 5 6 7 8 9

Arrange the digits 1-9 into the grid so that the differences between linked circles is odd
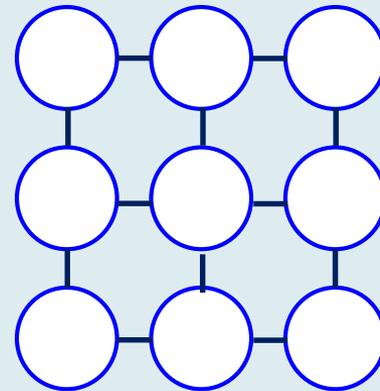
Teacher: Identify and explain a successful pattern, so it's not just about saying those are my numbers, I'm done

Alice: Woo! [clapping and cheering]

Ruby: We've got 10 left, we've done 2

Alice: No we need to do 10 solutions - let's try and do 12 anyway

Ruby: We could just put them in order, 1, 2, 3, 4, 5

Alice: Shall we try 9 in the middle? What number shall we put in the middle? What's odd?

Ruby: We've got 5 [pleased, excited tone of voice]

Alice: I've spotted that you can use the odd number in the middle

Teacher: If you have 10 solutions and a pattern that works, then your job is to explain that pattern and why it works

Alice   We need 3 more [solutions]

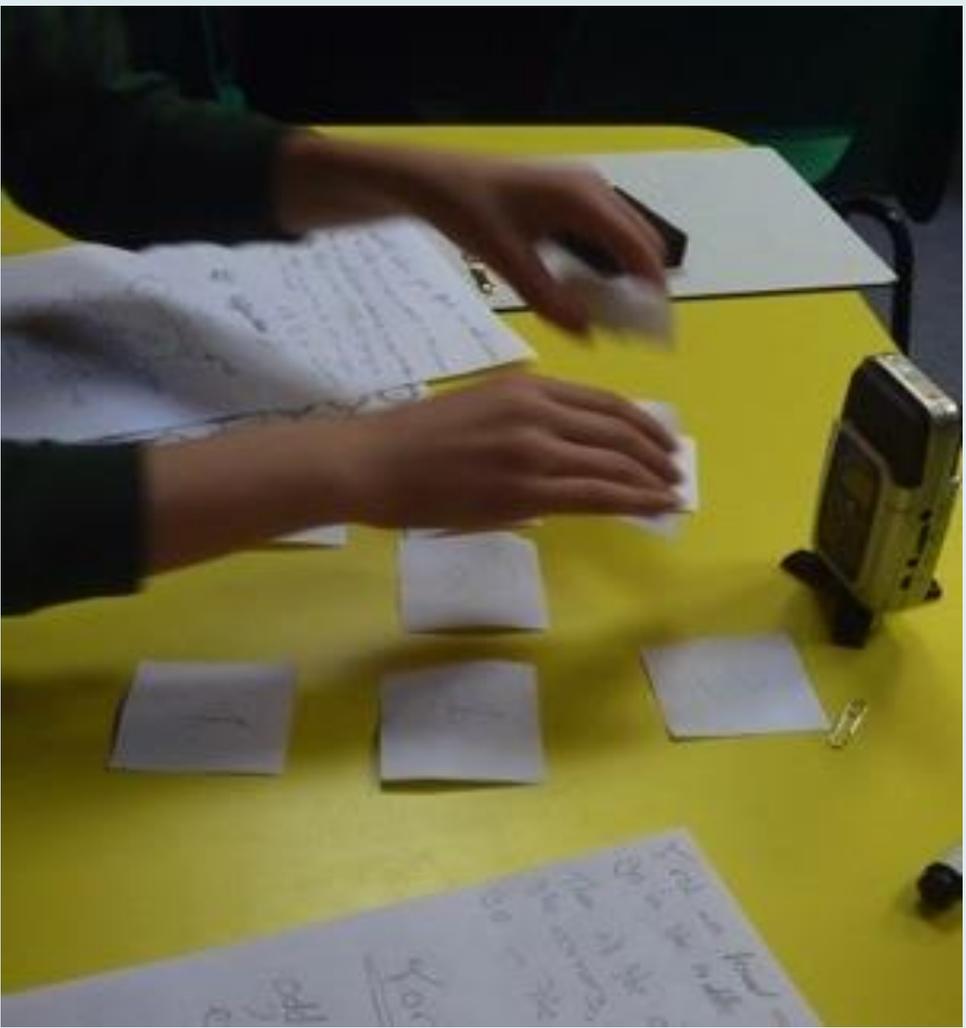Ruby   Yes, come on

Alice   We've done 12 [claps and cheers]

Teacher: If you have 10 solutions and a pattern that works then your job is to explain that pattern and why it works.

Alice

First we found out that the odd numbers go in the middle one by one.

Then all the other odd numbers go in the corners, and the even numbers go in the spaces left.

Ruby

It works when you put a odd number in the middle and odd numbers in the corners because a odd number added to a even number... the space in the middle is going to even=be odd but you have to use the right odd ...ow numbers

hire is a diagram
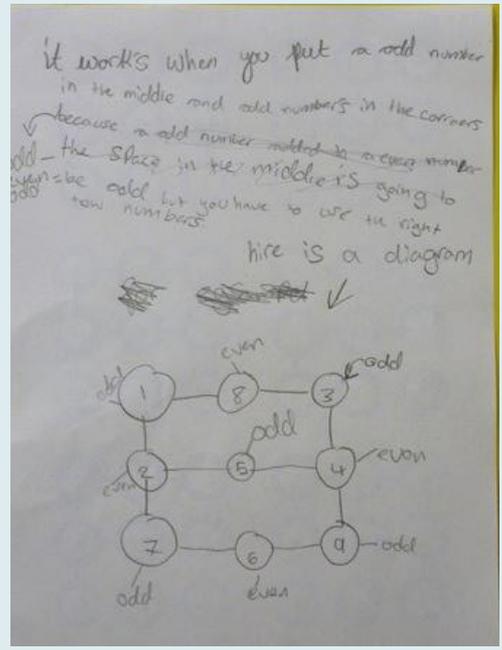
Alice: One more to go and then we've got 23 [solutions]

Emotions expressed

Pleasure | Pleasure | Pleasure Excitement | Pleasure | Pleasure Excitement

Reasoning processes

Mathematical challenge → Specialise → Spot pattern → Form & test conjecture → Form & explain generalisation → Further specialisation

Focus

Creating successful solutions → Explaining generalisation → Creating successful solutions
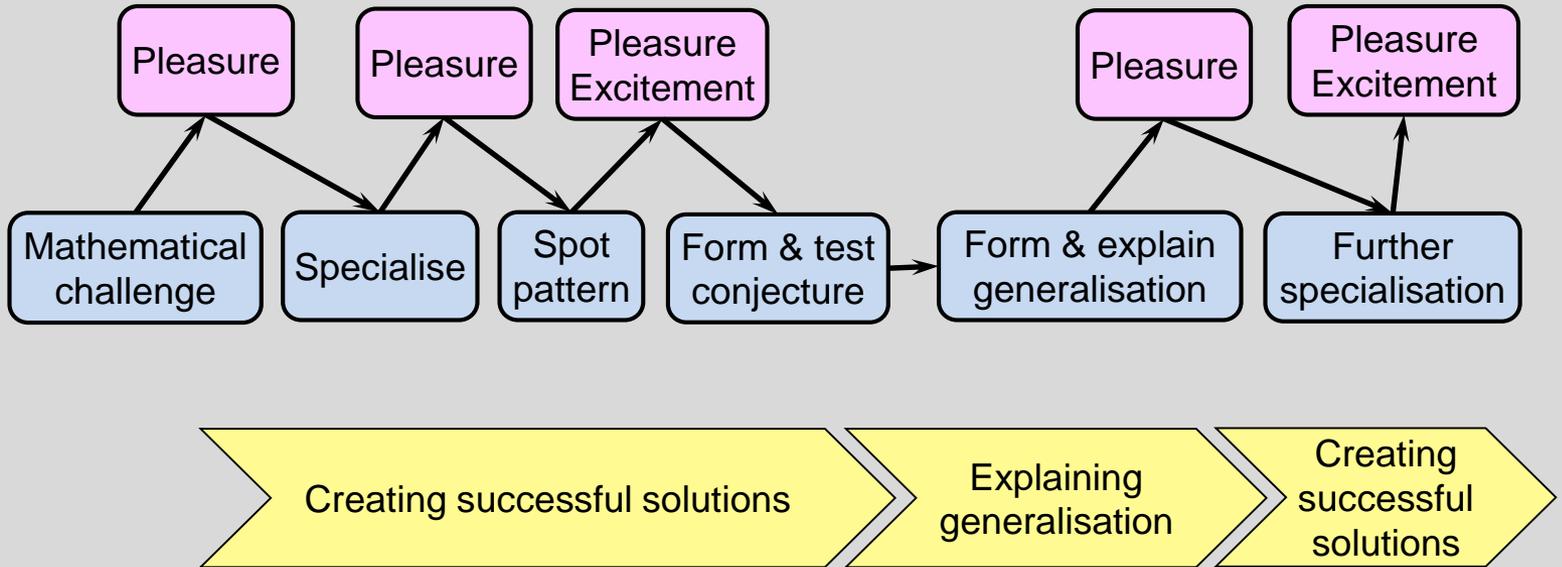
Conclusion: 4 additional barriers to PiMR

Repetitions, habitual behaviours

Cognition
Mathematical reasoning processes

Conation
Perseverance in mathematical reasoning

Affect
Emotions during activities involving mathematical reasoning

Lack of awareness that they had encountered a barrier to mathematical reasoning

Focus on creating solutions

Feelings of pleasure derived from finding solutions

No outward displays of being stuck

Recommendations for primary teachers

Conative and affective cues are insufficient to assess children's PiMR during lessons

- Look at children's cognitive responses as indicators of having met a barrier to PiMR, eg repeated use of finding solutions

Pedagogic strategies such as explaining and modelling the task are insufficient to support children's PiMR

- Set goals for children that focus on generalising findings and explaining why these are true

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