Enjoyment in learning mathematics: its role as a barrier to children’s

Perseverance in Mathematical Reasoning

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June 2018
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.

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

DeBellis and Goldin, 2006; Fredricks et al, 2004; Huit and Cain, 2005; Malmivuori, 2006; Özcan, 2016; Tait-McCutcheon, 2008; Tanner and Jones, 2003;
## Known barriers to primary children’s PiMR

<table>
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<tr>
<th>Cognitive</th>
<th>Utilising patterns as a platform for generalisation</th>
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<td></td>
<td>Not expecting to explain reasons why mathematical pattern occurs</td>
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<td></td>
<td>Creating convincing arguments about why a generalisation might be true</td>
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(Ellis, 2007; Reid, 2002)

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<tr>
<th>Affective</th>
<th>Negative emotional pathway</th>
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<tr>
<td></td>
<td>Feeling apprehensive about mathematics</td>
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<td>Mathematics anxiety</td>
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(Ashcraft and Moore, 2009; Goldin 2000)

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<tr>
<th>Conative</th>
<th>Development of self-regulatory processes is not easy – it’s a “major achievement of the primary years”</th>
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(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

### Participants
- 2 Y6 teachers in 2 different schools
- 8 children, 4 in each school, purposively selected for their limited PiMR

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

### Data analysis methods
- Hypothesis coding (conceptual framework)
- Diagrammatic representation and analysis of cognitive-affective interplay

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This presentation focuses on 2 girls in one school

A square pond is surrounded by a path that is 1 unit deep.
Explore what happens to the path as the pond size changes.

Warning: there is some blaspheming in the following data.....
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
Create all possible solutions from Cuisenaire rods

Mathematical challenge

Specialise randomly

Spot pattern

Specialise systematically

Form generalisation

Actual pathway

Potential pathway
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 an odd number in the middle and odd numbers in the corners because an odd number multiplied by an even number will get a 0 instead of a 1. The shape in the middle is going to give you a 0. Here is a diagram.

Alice: One more to go and then we've got 23 [solutions]
Emotions expressed

Mathematical challenge

Pleasure

Spot pattern

Pleasure

Pleasure Excitement

Form & test conjecture

Form & explain generalisation

Further specialisation

Reasoning processes

Focus

Creating successful solutions

Explaining generalisation

Creating successful solutions
Conclusion: 4 additional barriers to PiMR

- **Cognition**
  - Mathematical reasoning processes

- **Conation**
  - Perseverance in mathematical reasoning

- **Affect**
  - Emotions during activities involving mathematical reasoning

- **Repetitions, habitual behaviours**

- **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
References


