SYMPOSIUM
The Teaching and Learning of Mathematical Modelling In Singapore Schools – Some Perspectives from Research

Secondary School perspective: Opportunities for Learners' Development of Metacognition

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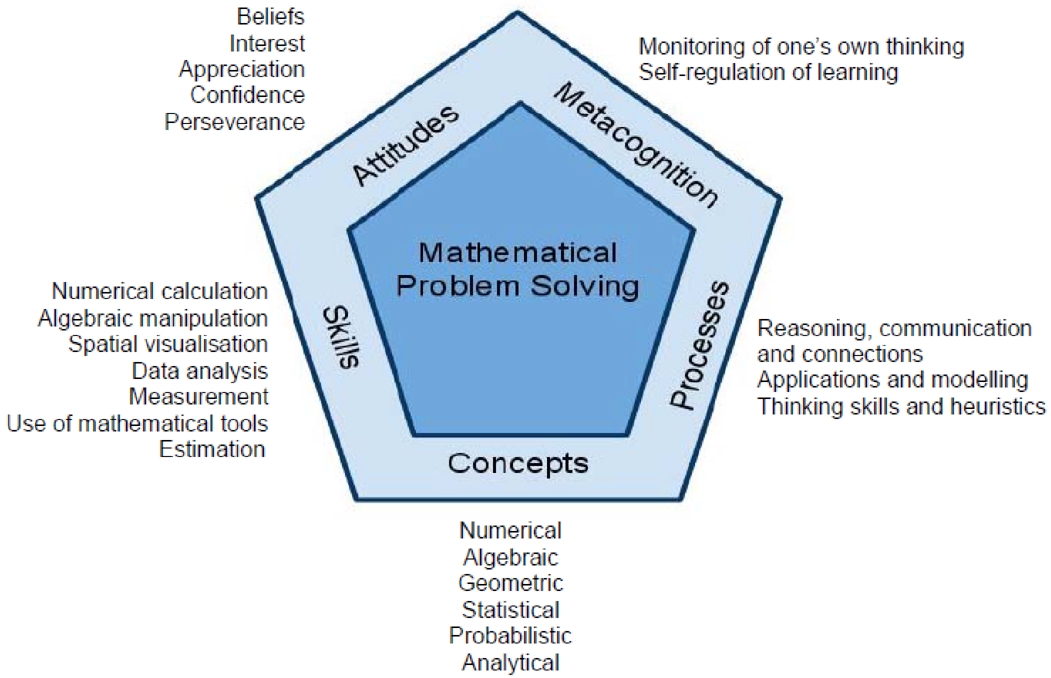
Context

The Singapore Mathematics Curriculum –

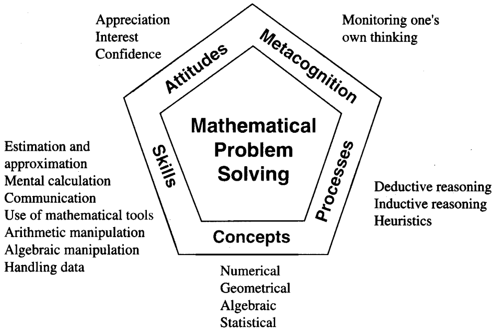
Basically a national curriculum.

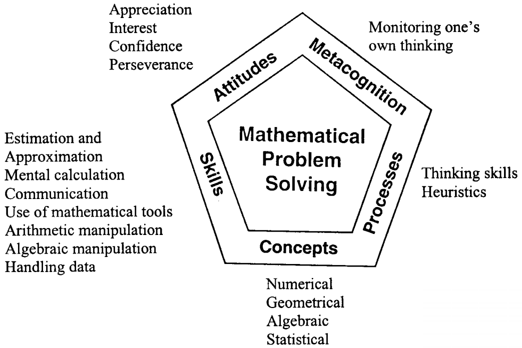
The Singapore Mathematics Curriculum

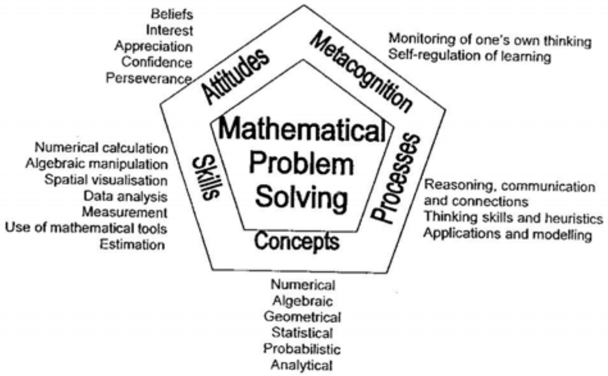


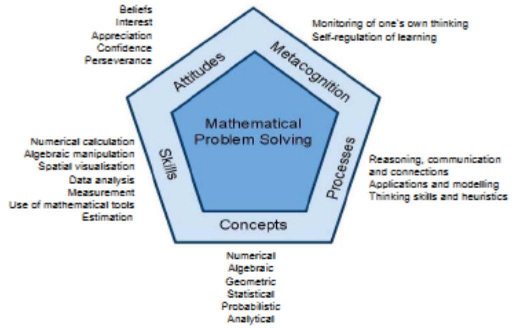
- Singapore Mathematics teachers are generally familiar and comfortable with the role mathematical problem solving in the mathematics classroom.
- The Singapore Mathematics Curriculum of the 1990s survived, with minor modifications, the major curriculum reviews for implementation in the years 2001, 2007, and 2013.

Framework of The Singapore Mathematics Curriculum









... A History

1992 ⇒ 2001 ⇒ 2007 ⇒ 2013

Singapore Mathematics Curriculum
&
Mathematical Modelling

- Applications and modelling were introduced in the Singapore Mathematics Curriculum Framework in 2003 (Balakrishnan, Yen, and Goh, 2010) to highlight the importance of applications and modelling in mathematics learning so as to meet the challenges of the 21st Century (Soh, 2005; Ministry of Education, 2009).
- Inclusion of the applications and modelling in the Singapore Mathematics Curriculum Framework was only reflected in the Syllabus Documents for implementation for the year 2007 (Ministry of Education, 2006), and of course also for the year 2013 (Ministry of Education, 2012).

Mathematical Modelling and Metacognition
In the Singapore Mathematics Curriculum Context

- **In the Singapore context, mathematical modelling is “the process of formulating and improving a mathematical model to represent and solve real-world problems” (Ministry of Education, 2006, p.4). Singapore appears to adopt a “pragmatic” perspective towards mathematical modelling (Blum, 2012, July). Teachers thus source for “concrete authentic examples” which reflects the local context well and which students could relate with.**

- **Metacognition, which is a feature of the Singapore Mathematics Curriculum since 1992, refers to the “awareness”, “monitoring”, and “regulation” of one’s cognition (Ministry of Education, 2007).** ***The act of reflecting on students’ awareness, monitoring, and regulation of their cognition during mathematical modelling and intervening strategically to facilitate students’ process through the modelling cycle is what Stillman (2007) refers to as meta-metacognition.***

Mathematical Modelling
&
Metcacogntion

- In exploring the kind of mathematical modelling competencies that students ought to develop, Maaß (2007) found in her study that “the teaching methods should support the development of metacognition”
- Not only must teachers design such lesson to promote the development of metacognition, teachers have to put in place features to “appraise the enactment of metacognitive activities by students” (Stillman, 2007) – **offline** vs **online**

The Study

- 2 case study schools – School A (2 teachers: Teacher G – conceptualised lessons, Teacher C – implemented lessons), School B (2 teachers: Teacher S, Teacher R – both conceptualised and implemented lessons)
- Meetings with teachers on the use of Framework
- Teachers used framework to plan and design modelling lessons
- Observation of implemented modelling lessons.
- Short and informal discussion with teachers after each observed lesson, and an interview with teachers involved after all lessons were implemented.

Research Questions

1. What features were included in the lesson planning to promote the development of metacognition – offline planning?
2. How was online strategic intervention to promote the development of metacognition, when needed, carried out during lesson implementation?

Observed Offline Planning

- Scaffold thinking to encourage students to be more aware of, monitor, and regulate their thinking during modelling activities.

- Questions posed do not warrant a specific answer; merely for scaffolding and making visible students' thinking

- Use of tables that are non-exhaustive in nature for students to record their attempts and make adjustments so as to encourage students to monitor and regulate their ideas (School A).

TASK IIb

(B) Mathematical Analysis Part 2

The cross-sectional shape of a shelter can be represented as a graphical function. With reference to your 2-D sketch in Task I, what type of graphical function do you think your shelter represents?

Type of graphical function: ____

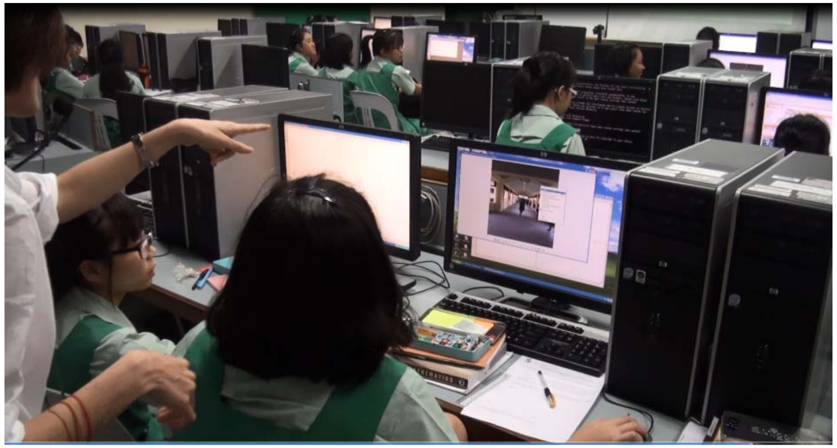
To match the graph of the function fully onto your shelter, you are required to adjust the coefficients of the function. You may need several attempts to come up with the complete equation of the graphical function. Record your attempts in the table below.

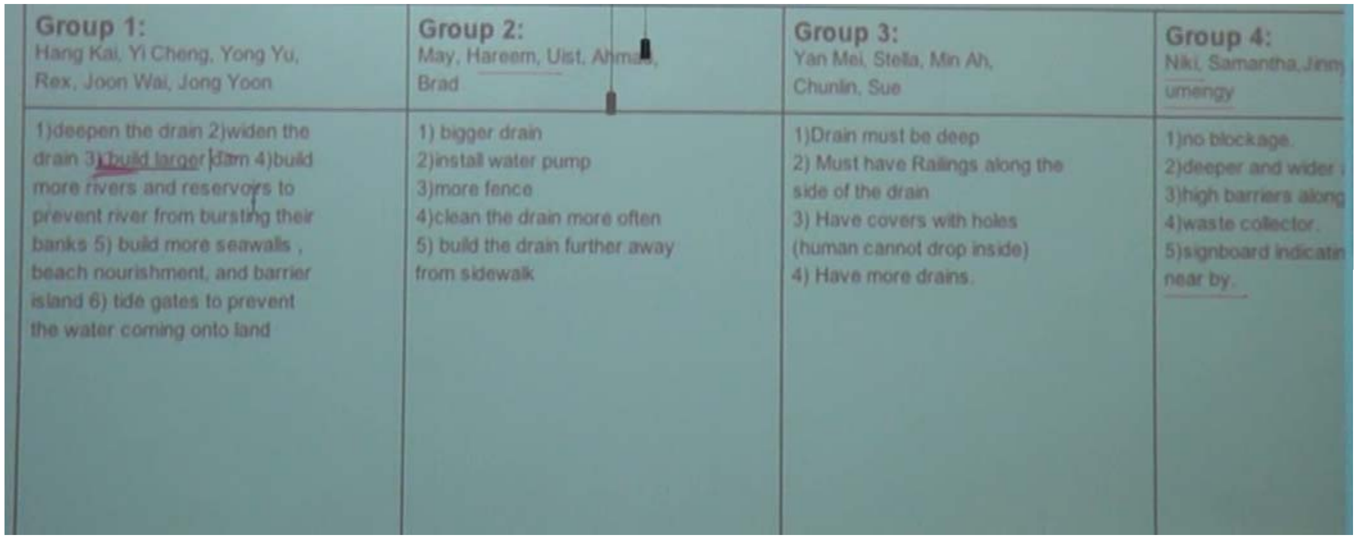
Attempt 1 Equation: Explanation:	If equation fails *(State reasons why the equation does not work and what did you do to adjust your attempt)*
Attempt 2 Equation:	If equation fails *(State reasons why the equation does not work and what did you do to adjust your attempt)*

- Scaffold thinking to encourage students to be more aware of, monitor, and regulate their thinking during modelling activities.
- Group discussion that promotes thinking aloud so as to enable students to be more aware of, monitor, and regulate their thinking during modelling activities

- There were conscious use of small group work and whole-class discussion to encourage students to monitor and regulate their thinking.

- Intentional lack of detailed instruction; students are encouraged to tap on each other's prior knowledge through purposeful discussions – use suitable math language to regulate each other's thought.





Observed Online Intervention

Issue:

- Students were unable to articulate their thinking process, demonstrating a possible lack of awareness of their thinking.

Online Intervention:

- Teachers provided more opportunities for peer discussion, including sharing of strategies between groups.
- Teachers tried to “explain” students’ thinking on their behalf.

Comments:

- Students appears to lack the vocabulary to describe their own thinking.
- There appears to be a lack of culture for an equivalent level of emphasis on the process as on the product.
- Teachers at time wrestle the control of thinking from the students

Issue:

- Students do not systematically record their attempts, reflecting an inability to monitor and regulate their attempts.
- In School A, for example, some students do not even bother to record their attempts, while others mechanically recorded their attempts but do not make use of the information to regulate and improve on their attempts.

Online Intervention:

- Repeated reminders
- Use of systematic questioning

Comments:

- There appears to be a need to establish this systematic approach towards monitoring of one's own thinking as an habit of a mind than a constant reminder from the teacher; there is a need for enculturation than depending on the physical presence of the teachers.

Issue:

- Students lack a ‘critical eye’ during peer sharing to evaluate and regulate their own strategy.

Online Intervention:

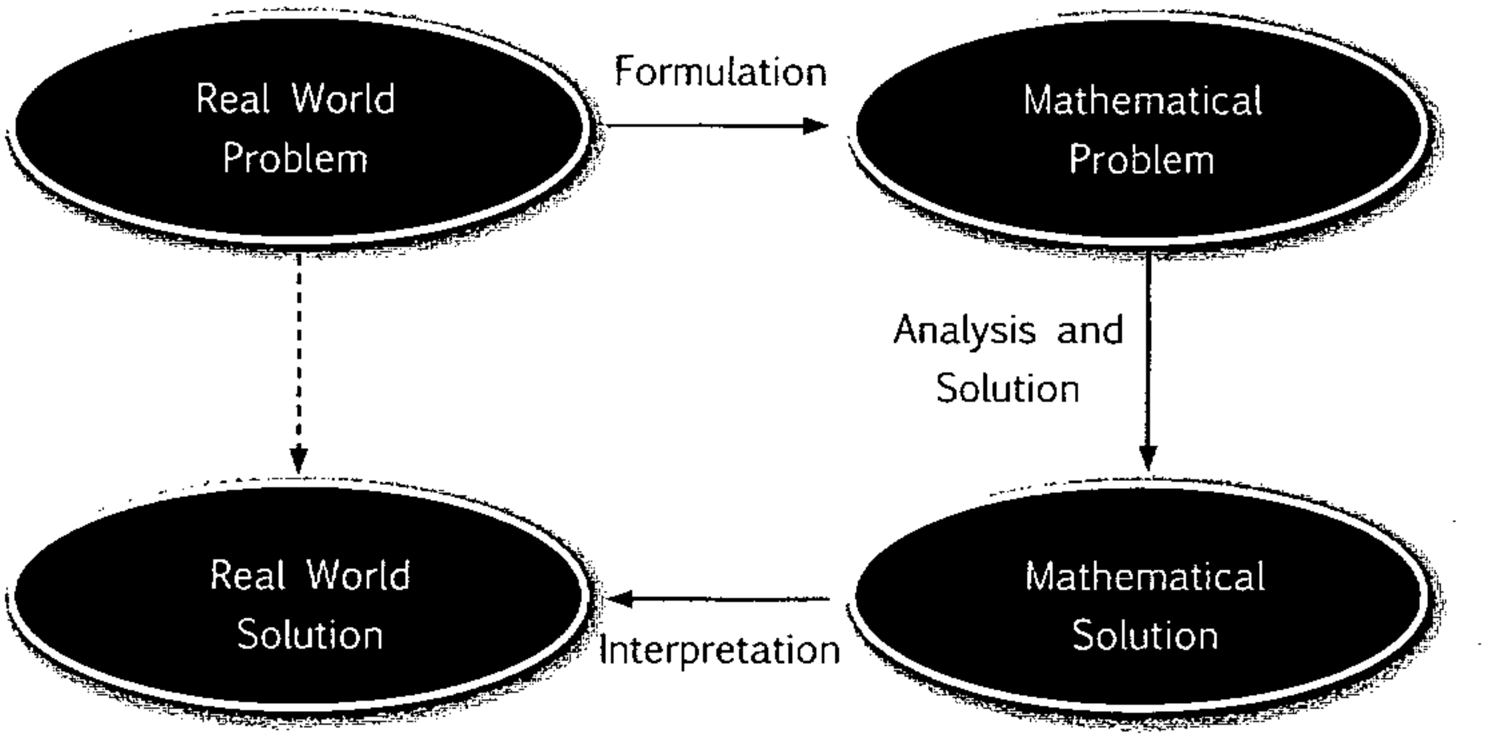
- Evaluative comments were provided by the teachers

Comments:

- There may be a need for teachers to explicitly address crucial and important strategies in the context of the mathematical modelling process to help students to develop the necessary metacognitive competencies for effective mathematical modelling.

SCHEMATIC DIAGRAM
OF
THE MATHEMATICAL MODELLING PROCESS

Ang (2009)



Discussion & Conclusion

1. The study points towards **rich opportunities for the development of metacognition** among students when mathematical modelling tasks are introduced in the mathematics classrooms.

   More work could be done to explore the actual provision at each of the stages of the mathematical modelling process to better facilitate teachers' offline planning of such lessons, and better support the ideal set forth in the Singapore Curriculum Framework.

2. However, the **students appeared to be lacking in an awareness of**, and thus unable to effective monitor and regulate, **their thinking**.

   - *Brown (1980) and Marksman (1977) – found that metacognition is a developmental skill that does not automatically increase with age*
   - *Schmitt and Newby (1986) – noted that supplementing instruction with metacognitive aspects would prove beneficial to most learners*
   - *Wong (1992) – found that students need guided instruction in the use of metacogntive strategies for (mathematical) problems solving.*

   It then appears to point towards the need for an explicit address of developing students' metacognitive competence in the context of mathematical modelling

Discussion & Conclusion

3. Modelling tasks **require teachers' explicit offline and online interventions** through task design, lesson planning, and strategic scaffolding during lesson implementation.

   While the teachers observed in the study appeared to carry out such interventions for metacognitive development of the students to a good extent, the lacking of such knowledge when addressing mathematics modelling in the mathematics classrooms may negate the rich opportunities afforded by the introduction of mathematical modelling. Such knowledge may thus constitute as a ***key pedagogical content knowledge for effective address of mathematical modelling*** *in the mathematics classroom, and which may warrant a more conscious attention in professional development of teachers . Artzt & Armour-Thomas (2002) also pointed out that teachers should be engaged in* ***structured activities*** *that get them in the habit of reflecting on and assessing their cognitions and instructional practices. Thus, it might be important that the professional development of teachers in addressing mathematical modelling should include the planning, implementing, and reflecting of such lessons .*

THANK YOU.