APPROACHES TO QUESTIONING THAT ENABLE STUDENTS' MODELLING DEVELOPMENT

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Project takeaways

What I thought…	What I got…
Assessments (or ideas) I could use in middle and senior years	Better understanding of the problem-solving process
How best to implement assignments	Realisation of how I used questioning as part of the process
How to write a mathematical report	Value of focusing on the process to help students become independent modellers

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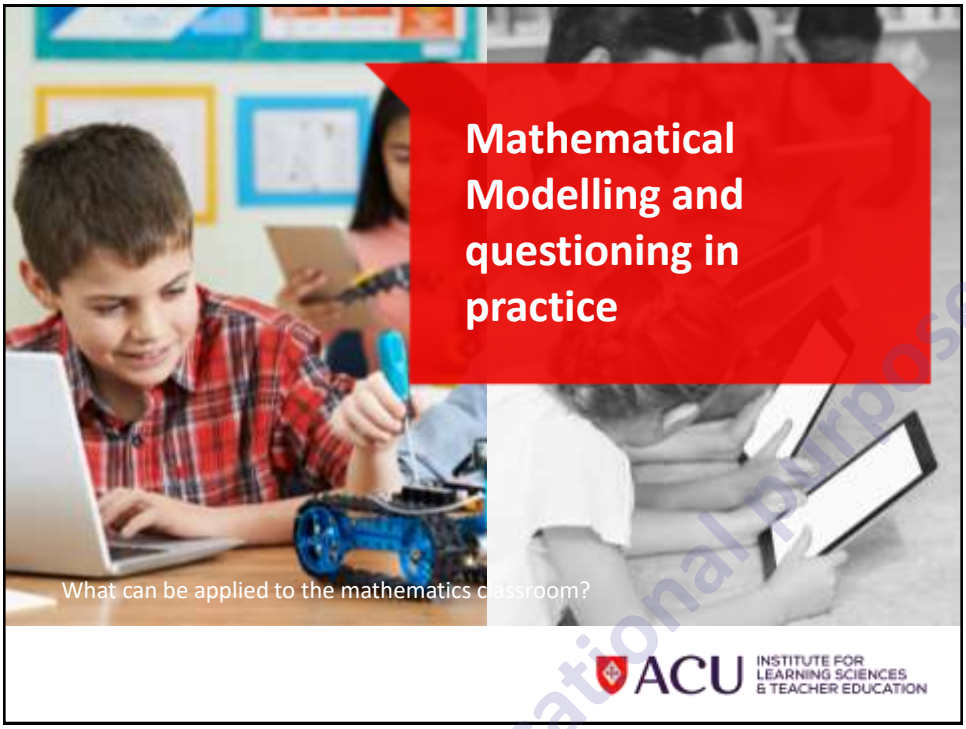

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Initial Phase

IS IT WORTH THE TRIP?

His car has the following attributes –
Car: Toyota Yaris Ascent Hatch Manual
Fuel Tank: 42 L
Fuel Consumption: 7.1L / 100km or 14.08km/L
Current Fuel Tank Level: about 4 L
Which Petrol Station is the best choice for Sam?

- **Open-ended**
- **Genuine link to the real world**
- **Mathematically accessible**

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Preparedness

Students

- Visitors coming to watch how they solved problems
- Linked the experience assessment – senior and upcoming
- No interaction with actual process

Teacher

- Engaged with the problem and developed a solution
- Engaged with the framework for design and implementation
- Focused on the suggested questions within the framework

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- Employ measured responsiveness – rather than providing specific advice about the problem, teachers should prompt students to think about where they are in the modelling process. Structure mathematical questions that promote a viable solution pathway.
  - Responses to students' questions or requests for assistance could include: What are you doing? What are you trying to do?; Where are you in the modelling process?; How have you checked your answer? (both mathematically and in terms of context); Can your solution be generalized?

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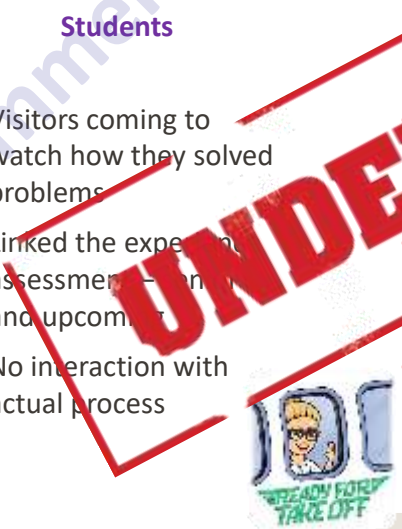

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What happened…

- Students solved the problem (!!)
- The process was undirected – nothing to refer to
- No progression or process leading to a written outcome
- Opportunity to hear the type of questions I asked

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What I learned…

- Activate my teacher meta-meta cognition
- Students were not independent modelers
- Rethink my intended learning outcome
- Not as good at questioning as I thought

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Second Phase

The focus of this task is on the new foundations that were built to support the "new" Las Arenas. If you look at the Figure 1, you will see that the lower section of Las Arenas is made of concrete. These are the new foundations in question.

As you can imagine, this was a time-consuming and costly project. The following table offers an overview of the renovation details:

Floors 5	**E-forum** 5.500m²	**Building Diameter** 100 m
Stores 100	**Gross Floor Area** 105.816 m²	**Roof Dome Diameter** 96 m
Commercial area 31.918 m²	**Foundation Height** 4.25 m	**Construction Cost** €105.000.000
Building 46.973m²	**Foundation thickness** 5 m	**Dome Height** 27 m

Feel free to make use of this table and whatever information you can find about Las Arenas on the internet to complete the task below. The websites provided are good starting points.

What would be the current cost of constructing the concrete foundations?

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Preparedness

Students

- Engaged with the process – explicitly introduced in class

Teacher

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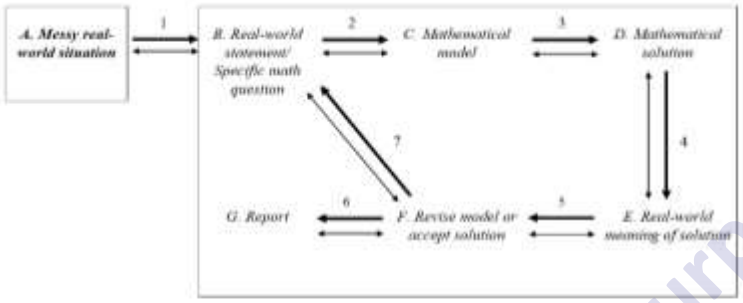
The process of mathematical modelling



1. Understanding, structuring, simplifying, interpreting context
2. Assuming, formulating, mathematising
3. Working mathematically
4. Interpreting mathematical output
5. Comparing, critiquing, validating
6. Communicating, justifying (if model is deemed satisfactory)
7. Revisiting the modelling process (if model is deemed unsatisfactory)

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Preparedness

Students

- Engaged with the process – explicitly introduced in class
- Explain that getting stuck is a natural part of the modelling process
- Reduced the expectation that I would give the answers

Teacher

- Worked through the problem, planning my questioning at each stage by considering when and why

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FORMULATE

- What do you know?
- What don't you know?
  - Where could you find this information?
  - Can we make an assumption about this?
- What mathematics do you know that could be applied here?
  - Have you solved a problem like this before?
  - What have we been working on that might help?

WHAT ELSE? WHAT ELSE? WHAT ELSE?

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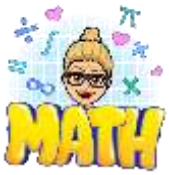
SOLVE



- How did you come to …?
- Why did you decide that…?
- Considering where you are at now, what can you keep, what do you need to reconsider?
- What do you think the next step is?
- How does this maths relate to the context, contribute to the final solution?
- Knowing the students in my class:
  What does …… think?

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INTERPRET AND EVALUATE (VERIFY)

- Has this group solved the problem? How do you know that?
- Have they considered all aspects of the problem? Can you give them feedback on what they have missed?
- Could a similar process be used to solve another problem?
- How does this solution compare to your solution?

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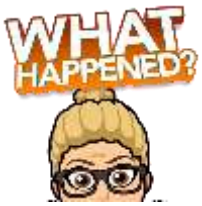
What happened…



- Students solved the problem (!!!)
- Students had more confidence in moving through the stages of the process
- Time was against us – time limits were set in each section
- Improvement in recording of information and answers – not so much in decision making

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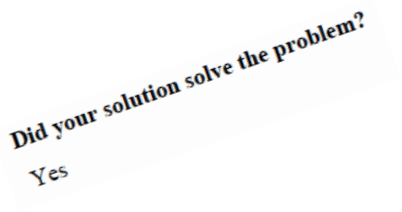
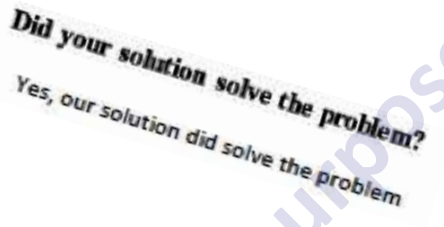
EVALUATE… Some Examples





Did your solution solve the problem?

Mostly, except for any labour and travel costs required to assemble the arena.

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What I learned…

- Collaboration page was successful – allowed collection of everyone's ideas
- Encourage seeking answers – What do modellers do? – What questions can I ask to get to the next stage?
- Issues recording information – importance of including wrong answers, documenting when they changed directions

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Overarching – Questioning Techniques

- Changing the culture
- Assessment design
- Focus on anticipation
- Trusting the process

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Student Focus

- Include activities that allow students to take risks and that have more than one answer
- Introduce the language early
- Focus on the process in junior and middle years
- Provide students with ways to ask questions to increase their own understanding

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Teacher Focus

- Questioning techniques – department project – How and when do we ask questions?
- Assignment design – solution as a team – anticipation
- Drafting process to develop a calibration document

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Modelling Process Focus

- Grade 6 – 7 (and 8)
  - Problem solving lessons – youcubed, IMMC, Mathspace
  - Focus on patterns leading to generalisations
- Grade 9 and 10
  - Modified the QCAA essential maths booklet as template for assignment
  - Year 9 – focus on writing, making links between formulate and evaluate sections
  - Year 10 – focus on what adds values to the report (include and exclude), use of appendices

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