SHORT READING – REASONING

Introduction

Fundamentally, Mathematics is about a way of seeing the world. It's functional; it helps to solve everyday issues; and it's social. It's a way of understanding the complexity of the world for example, in science, in economics, and psychology

The Australian Curriculum Mathematics has two fundamental components. The first is the content – knowledge, concepts and understandings. We can think of these as being the nouns, It's a list of mathematical development that students will progress through from year to year. The second aspect is the verbs – the things that we do. One way to think of this is if you want children to think and be like mathematicians, that means doing things – communicate, problem solve and reason. The verbs work with the nouns. We have to find ways of teaching them that are not separate from content – they are part of the content. (Emeritus Professor Peter Sullivan, Youtube)

"Reasoning is the glue that holds everything together, the lodestar that guides learning" Kilpatrick et al, 2001

Mathematics is distinguished amongst the areas of human knowledge by the special way in which claims of what are true is justified. Our assumptions and definitions are stated, and gradually, piece by piece, all other mathematical knowledge is built up by the rules of logical deduction. It's an enormously complex web, but the consequence is that mathematical results can be definitely proved. This is not true to the same extent in any other subject.

Right from the start, students can get to know mathematics as a subject where they do not need to remember rules without reasons. They should not focus on memorising what the teacher says, but know they can think through things for themselves. Mathematics makes sense as a coherent whole. Wherever possible give reasons (Professor Kaye Stacey, University of Melbourne).

Reasoning means planning a strategy for something, implementing it, communicating it and being able to convince someone that this strategy is one that communicates the answers. Reasoning is fundamental to knowing and doing mathematics. Some would call it systematic thinking. Reasoning enables children to make use of all their other mathematical skills and so reasoning could be thought of as the 'glue' which helps mathematics makes sense. Reasoning in the Australian Curriculum: Mathematics is defined as:

*Students develop an increasingly sophisticated capacity for logical thought and actions, such as **analysing**, **proving**, **evaluating**, **explaining**, **inferring, justifying** and **generalising**. Students are reasoning mathematically when they **explain** their thinking, when they **deduce** and **justify** strategies used and conclusions reached, when they **adapt** the known to the unknown, when they **transfer** learning from one context to another, when they **prove** that something is true or false and when they **compare** and **contrast** related ideas and **explain** their choices.*

Three Key Reasoning Actions

These resources divide mathematical reasoning into three main reasoning actions: *Analysing, Generalising,* and *Justifying*. Together, these three actions cover all the components of reasoning described in the Australian Curriculum Mathematics. The learning trajectories show how these three reasoning actions develop.

Analysing

Analysing involves exploring the problem using examples provided or generating examples to form or test a conjecture about a common property, pattern or relationship. Analysing occurs by comparing and contrasting cases to notice:

- what is same and what is different, and to sort and classify the cases.
- what stays the same and what changes and to recall, repeat or extend the pattern.

Analysing involves using numerical or spatial structure, known facts or properties when sorting cases or repeating and extending pattern. Categories of cases and patterns are identified by labelling using terms, diagrams or symbols

Generalising

Generalising involves forming conjectures that is, developing statements that are thought to be true but not yet known or shown to be true.

- Generalising involves identifying common properties or patterns across more than one case and communicating a rule (conjecture) to describe the common property, pattern or relationship.
- The statement or rule is communicated orally or written using words, diagrams or symbols.
- The meaning of the statement or rule is communicated using particular examples to explain the property or pattern. Further examples are used to explain how the rule applies to other cases, that is to show that how it is a generalisation.

Justifying

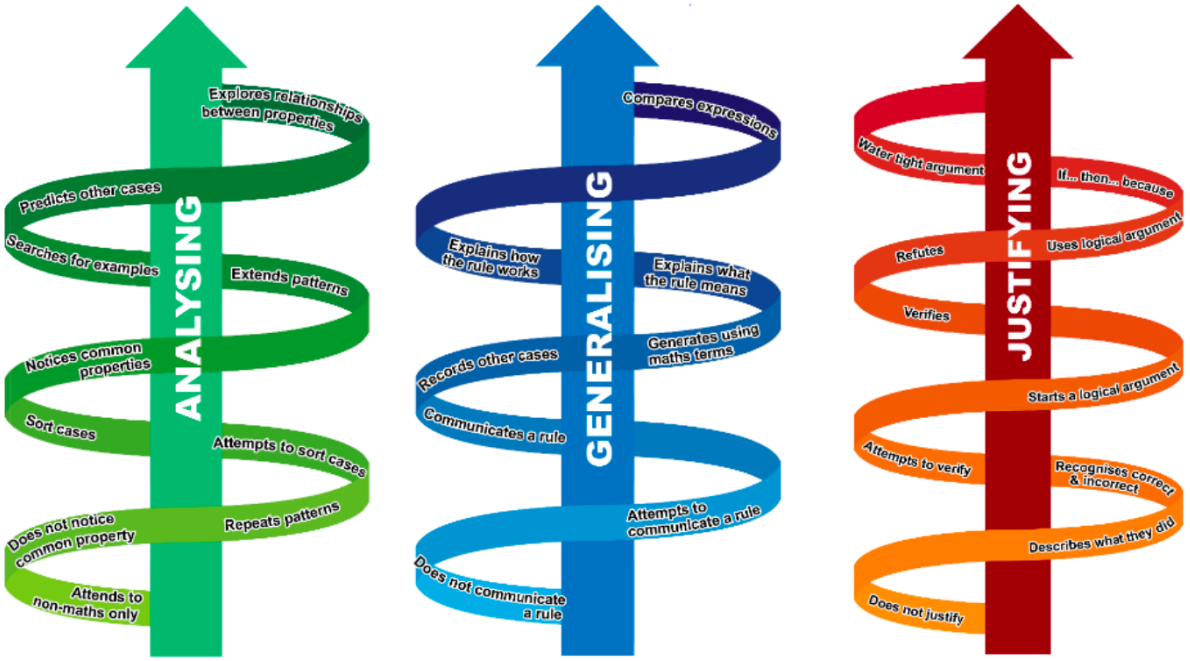
Justifying involves ***checking the truth of conjectures and generalisations*** to demonstrate or refute the truth of a claim.

Justifying uses ***logical argument*** to convince others of the truth of the claim or to refute the claim.

A ***logical argument*** is made by:

- using ideas that are already understood;
- following agreed processes or steps for making arguments; and
- using terms, diagrams and symbols that are known and understood.

Tasks are usually approached by first analysing, then generalising, then justifying. Some tasks provide a conjecture to prove or disprove, and so the generalising is already done. There are three learning trajectories that show how students typically progress in each key reasoning action.



Communicating reasoning

We now turn our attention to the other aspect of reasoning - that of communicating reasoning in a succinct, elegant and mathematical way. It is helpful to model the communication ourselves (both as articulating our own thought processes and also staging conversations with other adults in the room), give sentence starters to help children construct their argument and also give time in lessons to improving children's expression of their reasoning processes. Here are some possible sentence starters:

- I think this because ...
- If this is true then ...
- I know that the next one is ... because ...
- This can't work because ...
- When I tried xxxx I noticed that ...
- The pattern looks like ...
- All the numbers begin with ...
- Because xxxx then I think xxxx
- This won't work because ...

Conclusion

Developing excellence in reasoning with young learners is a complex matter. We need to think about the reasoning itself and understand the progression in that, as well as think about how we are going to support children to develop the communication of their reasoning. We need to value and promote reasoning explicitly, persistently, consistently and frequently and, in particular, help children to develop complete chains of reasoning. This aspect of mathematics will help us to deepen and extend our higher attainers as we take them onto generalisations and proof, whilst focusing on the same mathematical content.

All mathematics lessons, at whatever level need to convey the impression that knowing the reasons why mathematical rules are important is the key to learning it well.