

Planning Interdisciplinary Maths/Science Learning Sequences for System Impact

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ENRICHING MATHS AND SCIENCE LEARNING: AN INTERDISCIPLINARY APPROACH

This is an international, longitudinal project which aims to investigate the effectiveness of an innovative interdisciplinary learning approach in mathematics and science. Through collaborating primary schools in Australia and the United States of America (USA), it will investigate how students' invention and transformation of representational systems can connect to support deeper reasoning and learning.

The project will form the bases for new curricular designs that leverage students' representational practices across science, technology, engineering and mathematics (STEM) disciplines to promote more robust and generative knowledge.



Science and Maths are like colours

You mix them together and you get something else that's really good, but it's sort of still the same.

Year 1 student

<https://imslearning.org/>

Background to the IMS pedagogy



Learning as induction into the multi modal discursive practices of science and mathematics (Latour, Peirce, Lemke)

Model based reasoning, socio semiotic perspectives (Lehrer & Schauble, Lemke)

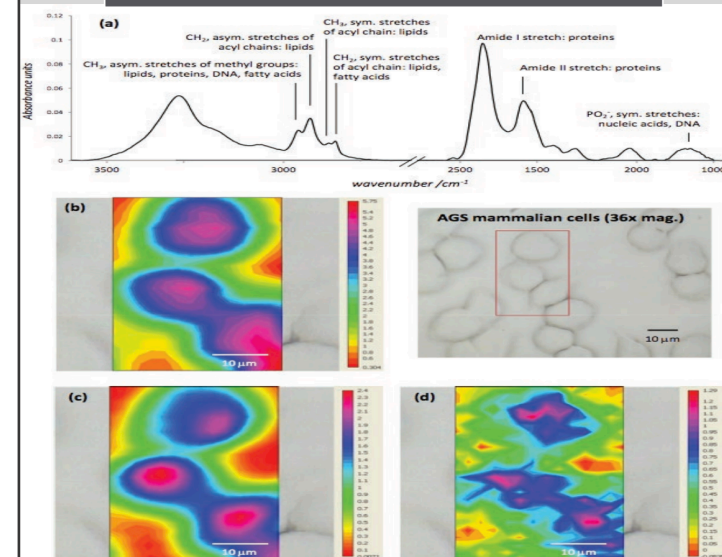
Pedagogy: guided inquiry where children generate data/observations and **invent, compare, assess and revise**, and coordinate representations.

Maths and science interact productively, each raising questions that advances the other. There is a focus on constructs that are common to both.

Representational tools are crucial resources for speculating, reasoning, contesting and justifying explanations, knowledge building, and communicating.

Constructing Representations to Learn in Science

Russell Tytler, Vaughan Prain, Peter Hubber and Bruce Waldrip (Eds.)

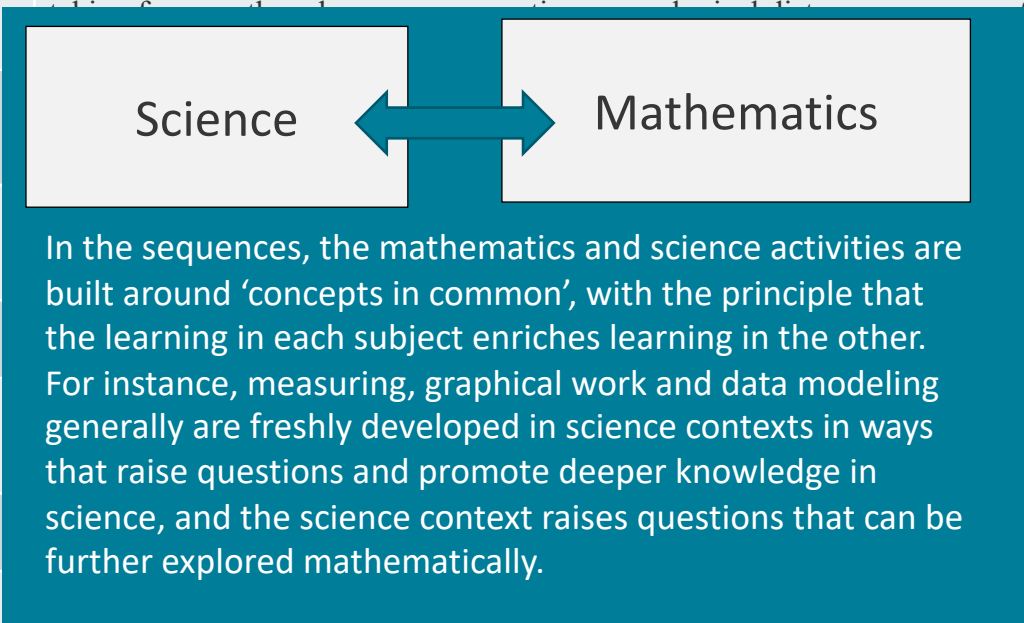


SensePublishers

The IMS topics



Topic (predominantly science)	Grade level	Mathematics concepts and practices
Chemical science: Dissolving and mixing, chemical change, cooking.	2	Representing time sequences of mixing and dissolving under different conditions, timing cooking- measurement for cooking recipes: standard and informal units, fractions, proportion.
Astronomy: Shadows, sun movement, explaining day and night: earth and space perspectives.	1, 4	Angle as rotation and length of shadow (formal and informal measures), graphing shadow length, time sequencing, perspective taking.
Ecology: Living things, diversity, distribution and adaptive features related to habitat.	1, 4	Variation, data modeling of living things in sample plots, tables and graphs, space and mapping, measurement, area, coordinates, directionality, sampling, using a scale.
Astronomy: Solar system, day and night, planetary features, moon movement and phases.	5/6	Conceptualizing ratio of planetary size and distance, angle measurements for moon observations, compass points, tracking position over time, perspective
Plant growth: plant structure and function, life cycle, growth needs and patterns.	2	
Measurement (height): height measure and variation, differences between populations.	5/6	
Flight: Whirlybirds: Flight and air flow, modeling and design.	2	
Motion: Representing speed, distance and time relations, constant speed, acceleration.	1, 4	
Water: personal use and conservation of water.	2	
Light: vision, reflection and image creation.	4/5	



Working with teachers: The challenge of teacher change



- The design of the IMS research involves following case students longitudinally over 3 years. We work with all their teachers in their particular year level.
- This means that generally we need to introduce teachers to our approach each year, and we have a year to induct them to become confident practitioners
- This process has forced us to think about how to characterise the approach clearly, and how to frame the sequences to clearly flag the nature of the pedagogy
- In this design based research, we collaborate with teachers to design and refine the sequences. Inevitably, some teachers and teaching teams are more actively involved than others.



Our challenge is how to frame sequences for our project teachers, and how to represent these sequences on our website, for extended impact.

Therefore, the problem of how to frame the sequences to clearly signal the pedagogy is essentially the problem of scaling up the approach.

In this, we have a long history of research into teacher change issues and professional learning associated with representation construction, to draw on.

Research questions:

1. What are the challenges for teachers in interpreting the IMS curriculum sequences to implement the pedagogy with 'fidelity'?
2. How can the sequences be framed to best signal the nature of the approach, and pedagogy?

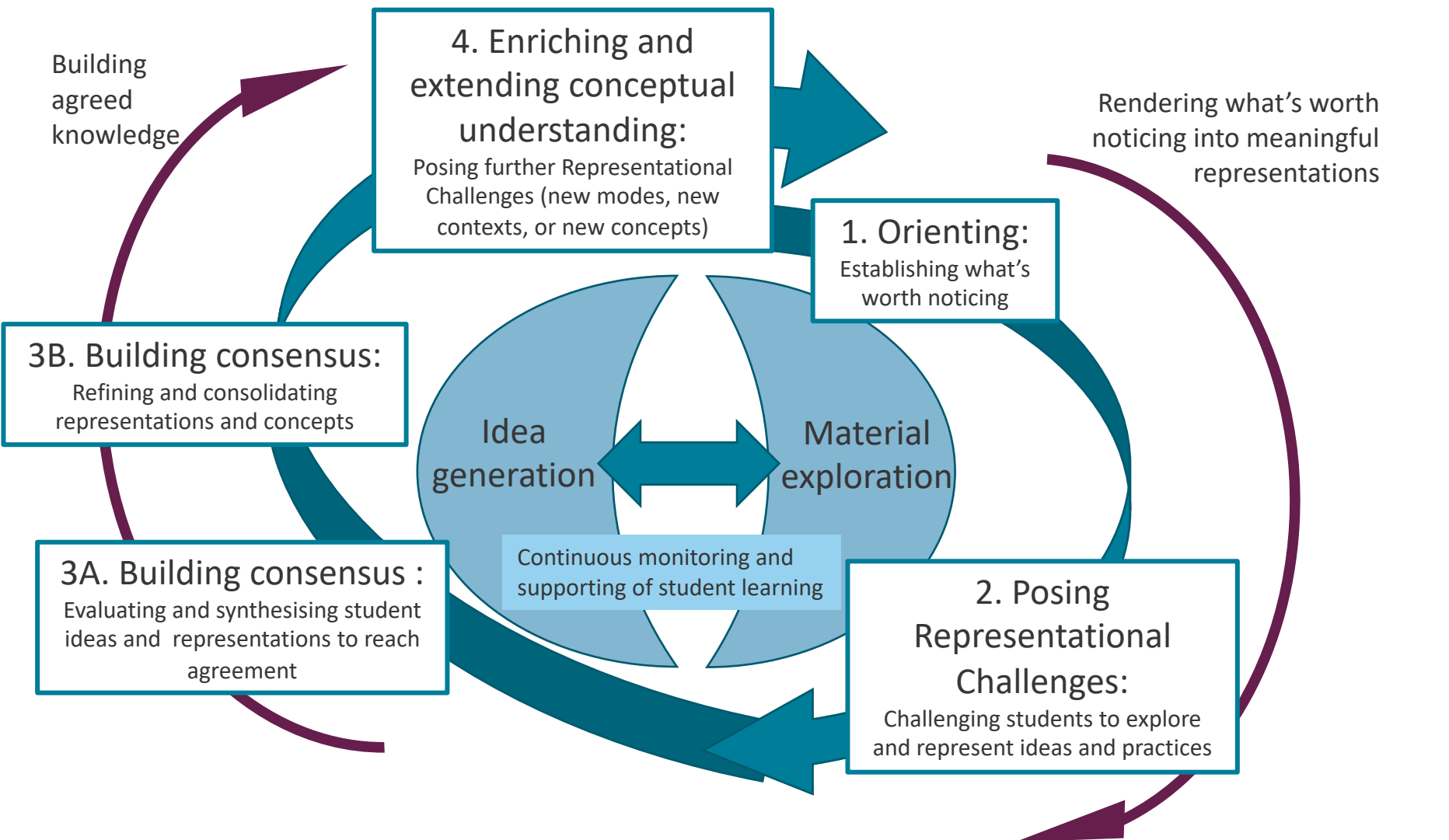
Step 1: Clarifying the nature of the pedagogy

- a. Video capture of case study teachers and field notes and student work samples from all classes
- b. Drawing on theory to discuss, debate, refine the stages and variations within these that teachers followed
- c. Encapsulating the pedagogy into 4 key stages, informed by our theoretical perspective

Step 2: Refining the sequence designs through this new pedagogical lens, drawing on our experience of teachers' responses to the sequences in each topic, and innovations they had made.

- a. A series of team meetings to discuss our shared experience of teacher issues, mainly anecdotal but also drawing on notes from team meetings, and classroom observations
- b. The drafting of a template for the sequences and it's iterative refinement as team members used it to reconstruct sequences

Clarifying the IMS Pedagogy



The challenges in signalling the approach to teachers



Over the process of discussing the variation in teachers' response to the approach, and the challenges it posed, a number of issues emerged, that needed to be addressed in the reframing of the sequences:

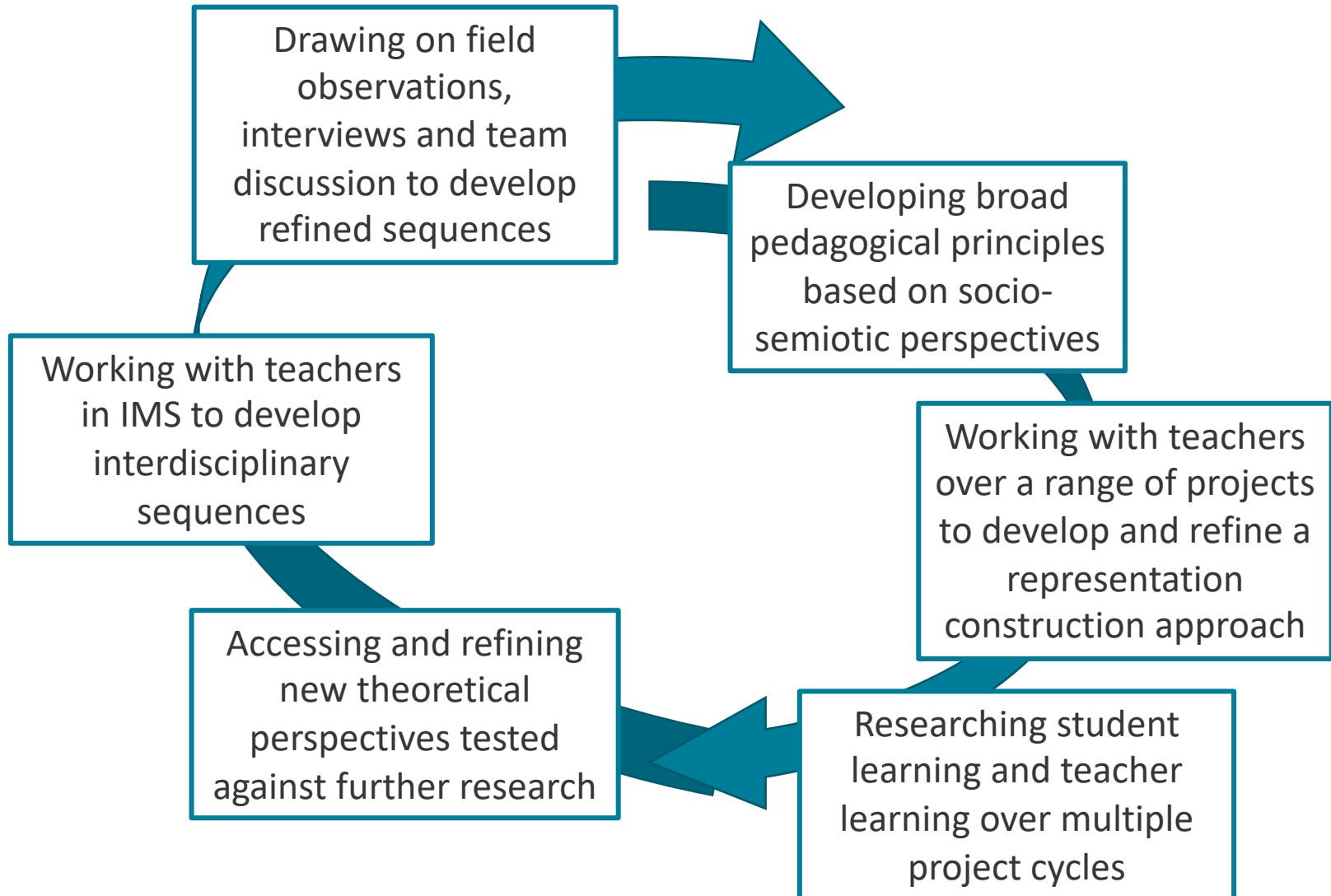
1. The need for teachers to be able to tick off curriculum outcomes
2. The need to clearly specify details of teaching moves, but also to provide an overview of the lesson and the sequence direction (teachers need to conceive of the sequence at a range of levels, and time scales)
3. The need to signal to teachers the key elements of the pedagogy, and its rationale
4. The need to encapsulate the key science ideas at a relational level so teachers could strategically frame their teaching interventions
5. The need to address a tendency for teachers to either a. tell the answer, short-circuiting student reasoning, or b. letting discussions proceed without clear direction
6. In comparison of student work, and gallery walks, there was a tendency for teachers to accept all ideas, and not critique and shape student thinking
7. For difficult concepts it can be a struggle to provide the right level of challenge
8. For the team, and for teachers, it was often difficult to get the timing of lessons right.

Original sequence layout



Session focus	Resources & Preparation	Lesson Outline (NB: time allocations a guide only)	Assessment & Data
<p>Stage One: Analogy to Humans Criteria for habitat are based on analogy to home.</p> <p>Stage Two: Associate Organisms and Places</p> <p>Science Concept : HABITAT</p> <p>MATHEMATICS: Spatial mapping Counting Comparative analysis Display of data in tables/maps and diagrams identify questions in familiar contexts that can be investigated scientifically</p>	<p>Student Science Journals</p> <p>Whiteboard, ruler & markers</p> <p><u>STUDENTS</u> Pencils Colouring pencils Ruler</p>	<p><u>Learning Intentions:</u> Introduce Habitat – Places where animals and plants live. Students predict animals/plants that live in the school grounds *Reinforce understanding and recognition of living and non-living things</p> <p><u>Orientation and Revision task:</u> Whole Class Discussion (10 mins) What lives in our school? (students referencing their Science Journals-previous activity) Student discuss their previous predictions of what living things might be found in the school grounds? Teacher lists the living things students think will be found in the school grounds Discuss how students know they're living? (<i>Student reasoning - Reinforcing living things v's non-living things previous lesson</i>) Discuss where they live and might be found? Why? (<i>food, water, protection and shelter</i>) EXPLICIT TEACHING OF TERMINOLOGY – Where living things live is called their HABITAT</p> <p><u>Lesson Body:</u> Whole class discussion (15 mins) 1) Teacher models tabulation of student responses from list, revise students answers and write up as a list. Example of layout for predictions tables- Completed as whole class one column at a time, as explained below (<i>only an example/stimuli for teacher layout do not copy – use student data & ideas</i>) LESSON TWO CONTINUED> Class prediction: What living things are in our school grounds?</p>	<p>FORMATIVE</p> <p>Observation of student contributions to discussion</p> <p>Student demonstrated understanding of living things and their habitats</p> <p>ARTEFACTS Science Journal & (Pre-test data) <u>Knowledge & Understanding</u> *Differentiate between living and non-living things *Habitat matching/ suitability</p> <p><u>Application: Prediction & Reasoning</u> * Where living things might be found in the school grounds? Why?</p> <p><u>Students:</u> •Recognise the characteristics of living things.</p>

Design based research



These sequences will be available on the IMS website. We anticipate they may be attractive for teachers and for use in teacher education.

We have no formal plans for validation of the sequences, but would appreciate any feedback following their use.

On the website also are papers and presentations about the project findings.

<https://imslearning.org/>



Resources



1. Sequence overview
2. Sequence outline (Lessons at a glance)
3. Resources required
4. Science and mathematics learning foci, and curriculum links
5. An overview of the pedagogy
6. For each lesson:
 - Curriculum focus – concepts and representational processes
 - Learning intention
 - Lesson at a glance
 - Equipment/resources
 - A pre- and post-test is provided, and other resources in appendices.

Heat and temperature Year 3

Excerpt from Lesson 1



Conceptual focus	Pedagogical stage	Lesson Outline (NB: time allocations a guide only)	Monitoring and supporting learning
<p>Science: The distinction between heat producers and heat receivers.</p> <p>Mathematics Organising patterns of phenomena</p> <p>14</p>	<p><i>Orienting</i> Students learn to notice that some things produce heat and others get hot from external sources</p> <p><i>Posing representational challenges</i> Students are challenged to organise hot things into categories</p> <p><i>Building consensus</i> Students share, compare, evaluate each others' ideas and the teacher synthesises these</p>	<p>Heat producers and heat receivers (Whole class) 20 mins Overall questions</p> <ul style="list-style-type: none"> ❖ <i>How can heat be produced/made in different ways?</i> ❖ <i>How can heat move from one object to another?</i> <p>Probing question</p> <ul style="list-style-type: none"> ❖ <i>What things around the house can you think of that are hot or can get hot?</i> ❖ <i>How does that happen?</i> <p>Construct a list on the board.</p> <ul style="list-style-type: none"> ❖ <i>How might we best organise our information?</i> (Enter student ideas on board) <ul style="list-style-type: none"> • Move the discussion toward the distinction between heat producers (things that produce heat themselves- a fire, or toaster), and heat receivers (that are warmed by something else-e.g. a pot of water on a stove, something in the sun). • Jointly, on the board, <i>classify some different objects</i> in the examples. <p>Student book task</p> <ul style="list-style-type: none"> • Ask students to complete the task of classification in their workbooks. • Organise in your student workbook these ways to warm up into things that are similar and things that are different. <i>What differences can you see? Which are similar?</i> <p>Class sharing/discussion of bookwork & student ideas</p>	<p>Can students distinguish between different categories of hot things, from their experience?</p> <p>Can students talk about heat as something that flows to an object, or something that an object can create?</p> <p>Can students articulate distinctions between objects creating heat, and receiving heat from outside? Can they justify their responses?</p>



- Conceptual focus for each of science and mathematics
- Pedagogical stage made explicit for each teaching move
- Lesson outline includes: Overall guiding questions, probing questions, task instructions, representational challenge tasks or tasks for building consensus, advice on the focus of discussion,
- Examples of student work are included, also photographs of teachers' board work
- Monitoring and supporting learning advice – ideas to look out for, key conceptual questions to consider, suggestions for drawing on student ideas
- Timing advice, with possible break points for longer lessons

Thank you

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Russell Tytler

