Exploring Innovative Pedagogies Through Interdisciplinary Mathematics and Science Learning in the Primary School

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https://imslearning.org/

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IMS LEARNING

Interdisciplinary Maths and Science Learning

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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/

Tytler, R., Prain, V., Mulligan, J., White, P.J., Xu,, L., Lehrer, R., Schauble, L., Kirk, M., Speldewinde, C., & Neilsen, C. (2018). Enriching Maths and Science learning: An interdisciplinary approach.

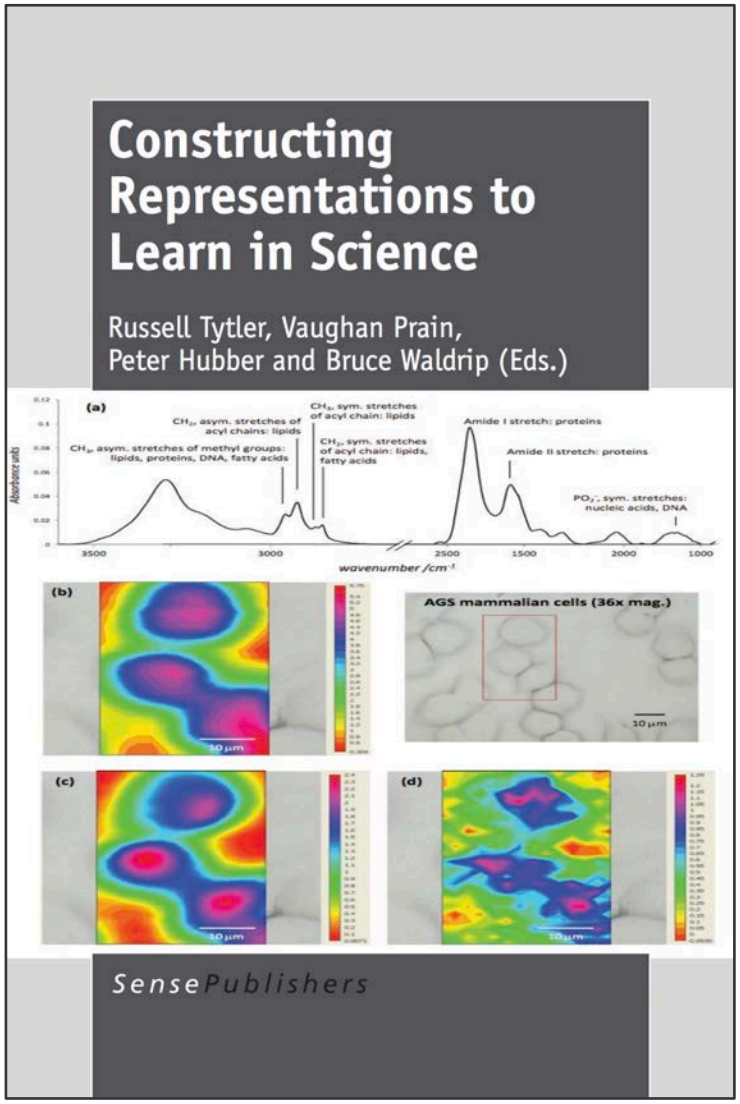
Background to the IMS pedagogy

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.

Representation construction approach

1. Sequencing of representational challenges involving students generating representations to actively explore and make claims about phenomena
    a. Clarifying the representational resources underpinning key concepts
    b. Establishing a representational need
    c. Coordinating / aligning student generated and canonical representations
2. Explicitly discussing representations
    a. The selective purpose of any representation
    b. Group agreement on generative representations
    c. Form and function
    d. The adequacy of representations
3. Meaningful learning
    a. Perceptual context
    b. Engagement / agency
4. Assessment through representations

Development of a refined IMS pedagogy

- Since RiLS the team has developed our ideas and extended the topic reach through successive ARC projects (Design based research)
- The approach (representation construction) has underpinned a number of government funded professional learning programs
- We have sharpened our view about the nature of a ‘representational challenge’
- An alliance with Rich Lehrer and Leona Schauble has sharpened our thinking about the orchestration of student representations and ideas, with a focus on opening up the conditions for ‘new ways of seeing’.

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Engaging students in disciplinary epistemic processes

Lehrer, Konold, and Kim (2006)

Core principles:

a) *problematics*, where students are introduced to the necessity of the foundational practice;

b) *meta-representational competence*, where students explore representations for what they attend to or hide;

c) *invented measures*, in which students make decisions about what is worth attending to; and

d) *changing the representational landscape*, where students extend their exploration to new representational tools.

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Design based research

Working with teachers: Notes of planning meetings, team discussions

Video capture of case study teacher and field notes and student work samples from all classes

Drawing on theory to discuss, debate, refine the stages and variations within these that teachers followed

Encapsulating the pedagogy into 4 key stages, informed by our theoretical perspective

We will present the pedagogy, and illustrate the stages using a Grade 1 Ecology Unit

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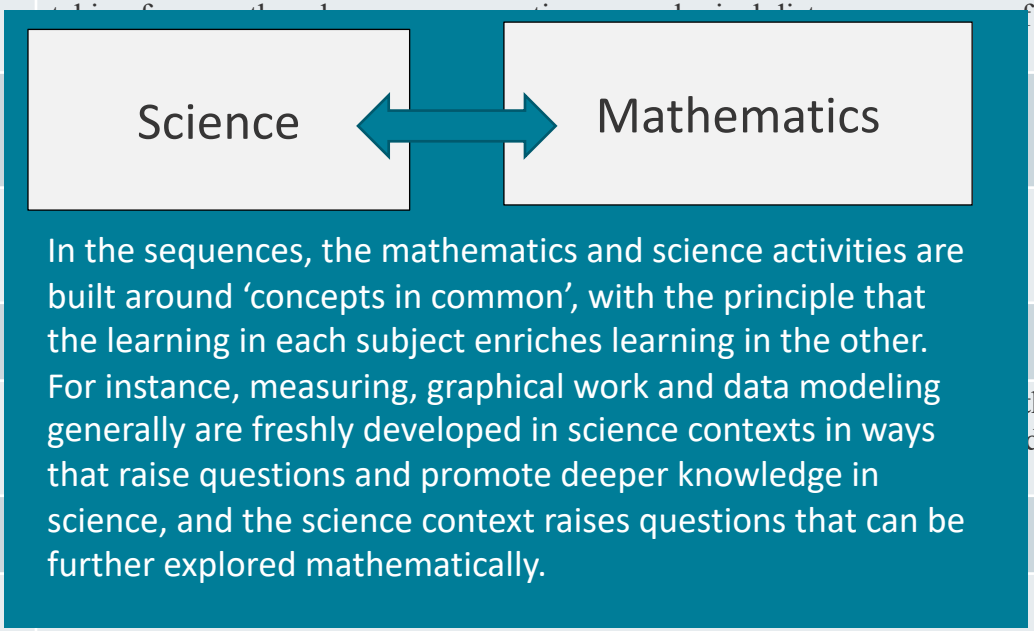
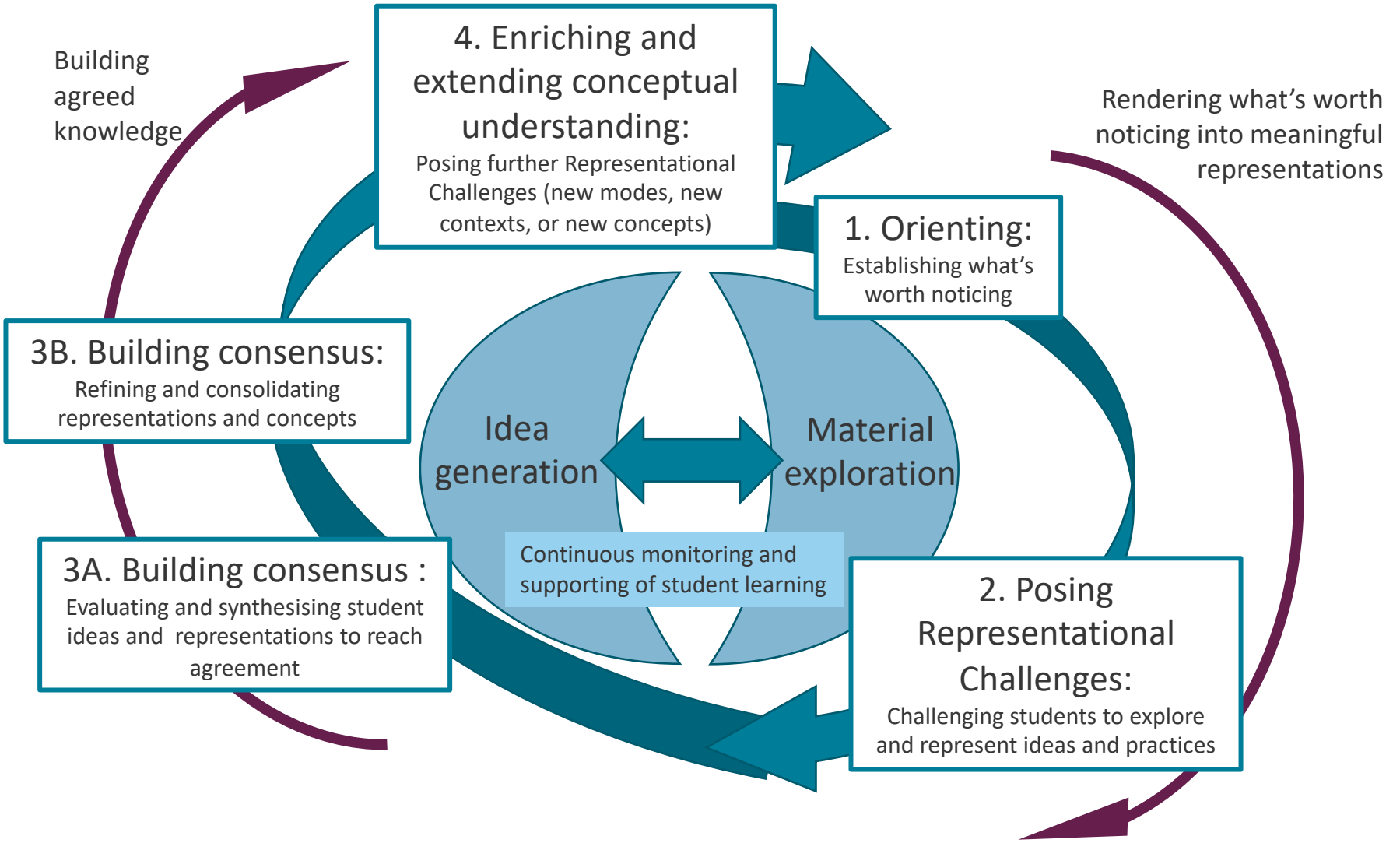
The IMS topics

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	



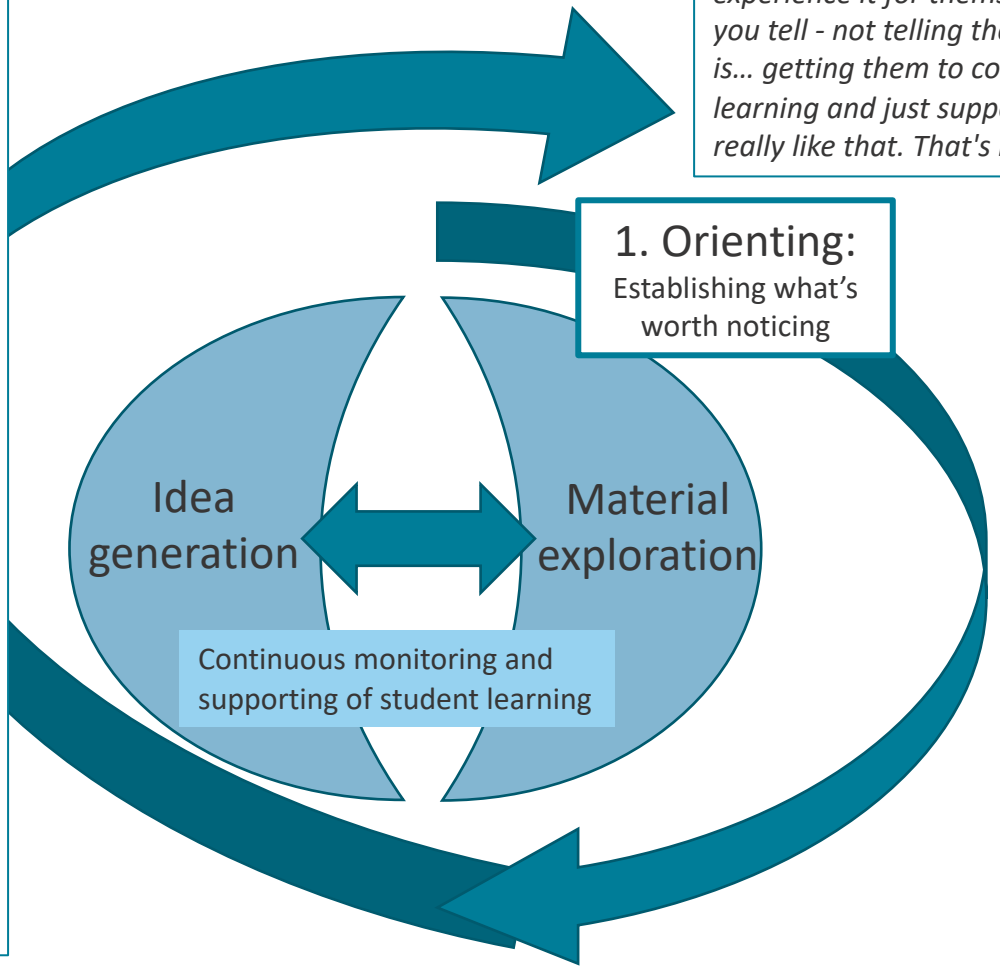
IMS Pedagogy



Orienting: Establish what's worth noticing

Teachers pose questions, explore student ideas/ conceptions, and orient students to the learning focus by a variety of means such as asking for predictions, questioning what they have noticed, asking for ideas about what could be measured, etc. This provides a way to focus students' attention on what is worth noticing about the school environment, or about data sets for instance, and could be interesting to explore.

"I really like getting the kids to experience it for themselves, before you tell - not telling them what it is… getting them to come to the learning and just supporting that. I really like that. That's really good!"



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Orienting: Establish what's worth noticing

Colin:

a. establishes what we mean by 'living thing'
b. organises a preliminary exploration to alert students to what living things might be in the schoolground, where, and why.
c. challenges students to represent areas of the schoolground they might explore
d. asks the class to predict what they might find, and creates a list on the board.

s1760: *Because there is more soil & hundreds and hundreds of millipedes are right in that section.*

Colin: *"Why are they in that section? (pointing to garden with soil - and then rephrasing) Why do you think you'll find more millipede right in here (pointing to garden & soil) than here (pointing to sand area)? Why do you think s1760?*

s1760: *Because there, there's more darkness and they need darkness to camouflage from the birds*

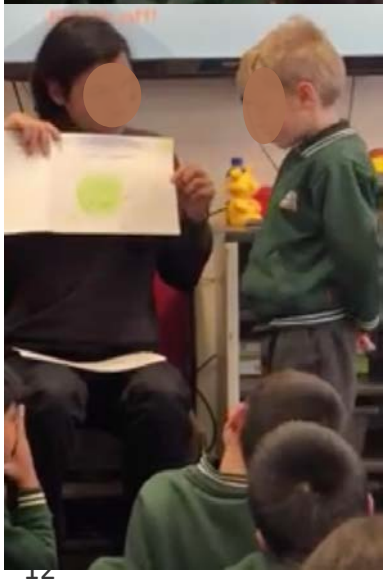
Colin: *OOOH Did you hear that? That was a really good answer (student affirmation). s1760 said that they like the soil, they like the dark because they can blend in.*

S1760: *so they don't get eaten.*

Note: teacher responsiveness and adaptation, clarity of purpose

Orienting: Establish what's worth noticing

Colin: challenges students to represent areas of the schoolground they might explore (this is moving into the representation challenge phase)



s1857: *I did snails and birds on the oval where the Yr6's go.*

Colin: *On the big oval? and how did you show that on your map?*

s1857: *I used red texta to do a red arrow and a circle so you'd know where to go.*

Colin: *Great, so you've labelled, you've drawn on the section where you thought you might find the snails and you've drawn a label and written snails. to give a bit more information. Where is this place (pointing to labelled location on map)?*

s1857: *The 1/2 playground. ……*

Colin: *So do you think maybe you could have written the 1/2 playground - to give a bit more information? s1857 (nods)*

Colin: *s1804 didn't use a map (provided print of school map), he made (up) his own. Let's have a look and see what he did.*

s1804: *I did ants at the 1/2 playground.*

Colin: *And how did you show that?*

s1804: *I tried to do my own 'birds map'.*

Colin: *Oh a birdseye view map, yes, and what did you draw?*

s1804: *(pointing to and reading from his map) Our classroom and the bungalows and the Eucalyptus and the orange building.*

Colin: Fantastic, and what did you write?

s1804: I wrote ants near the 1/2 playground (T repeats).

Colin: Fantastic, so you've done some drawing, you've tried to do your own 'birdseye view map', and some writing... you could have done some labelling too, maybe next time to give some more information...

Note: Colin's use of student work to refine their mapping skills

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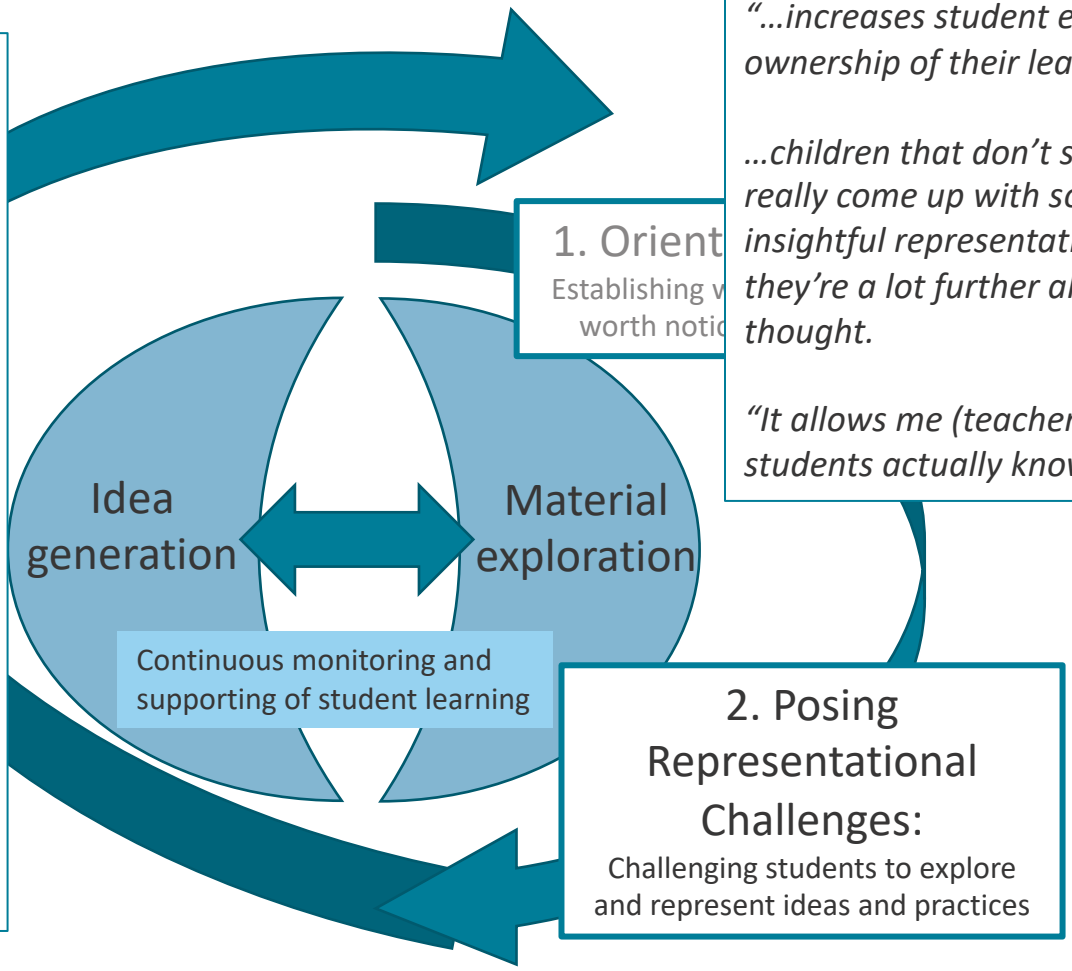
Posing representational challenges

Students are challenged to explore and represent their ideas and practices, for instance they may be challenged to represent the movement of their shadow over a day, involving decisions about what to measure and how to represent patterns in length, and angle, or to use particle representations to predict, investigate and explain why a saucer of water evaporates more quickly in warm, or windy places.



"…increases student engagement & ownership of their learning"

…children that don't speak up as often really come up with some really insightful representations. I mean, they're a lot further ahead than what I thought.

"It allows me (teacher) to see what the students actually know and can do…"

Posing representational challenges

Ellie works with groups as they explore their plots and record what living things they find

Students drawing where they are and what they find
Ellie: *How are you going to show s2542 that we're passed the top playground? s2542: Show what we're near?*
Ellie: *OK what are we near?*
s2542: *? edge trees (inaudible?)*
Ellie: *So how could you show that's what we're near? … So you've written tree*
s2542: *(mumbling - draw and write label?) Ellie: Ok - so you're going to write a label are you?*
…
Ellie: *How many spiders did you see XXX?*
s2542 & XX *"1"*
Ellie: *So are you going to just draw one spider or are you going to do what s2542 has done and use tally marks? How are you going to show what you've seen (clearly)? (Student adds tally marks)*

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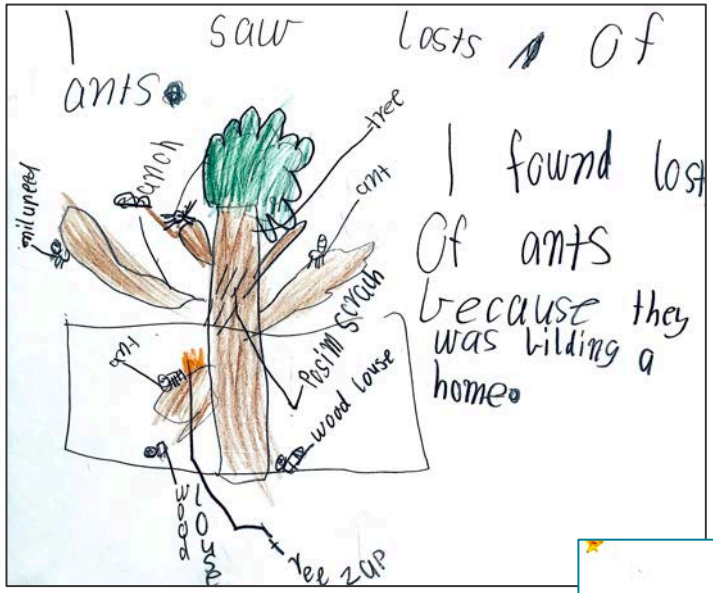
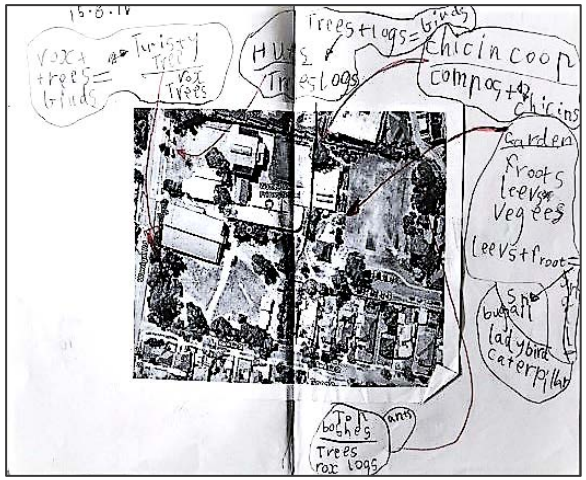
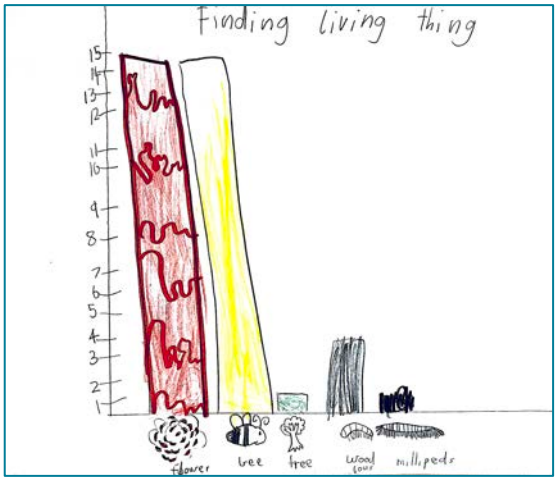
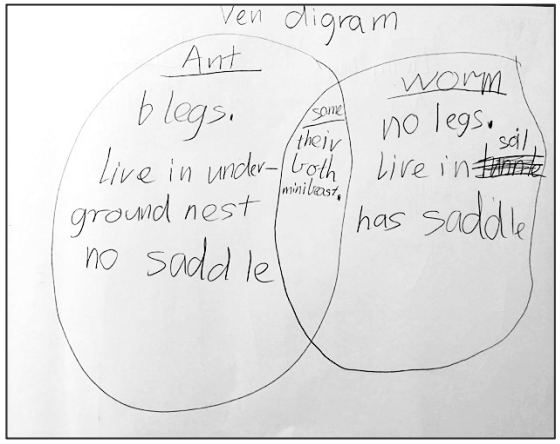
Note: strong teacher framing and working with student productions

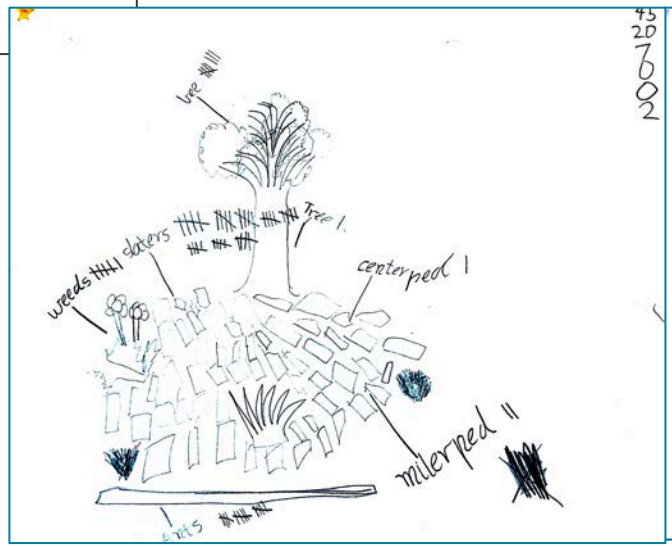
Student representational work

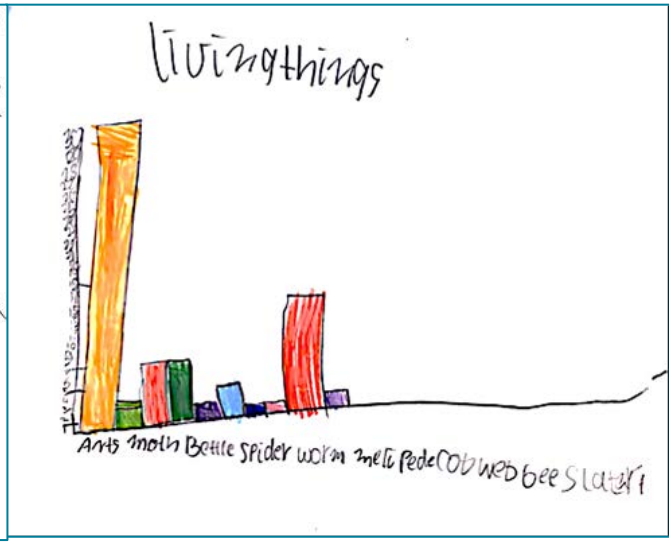










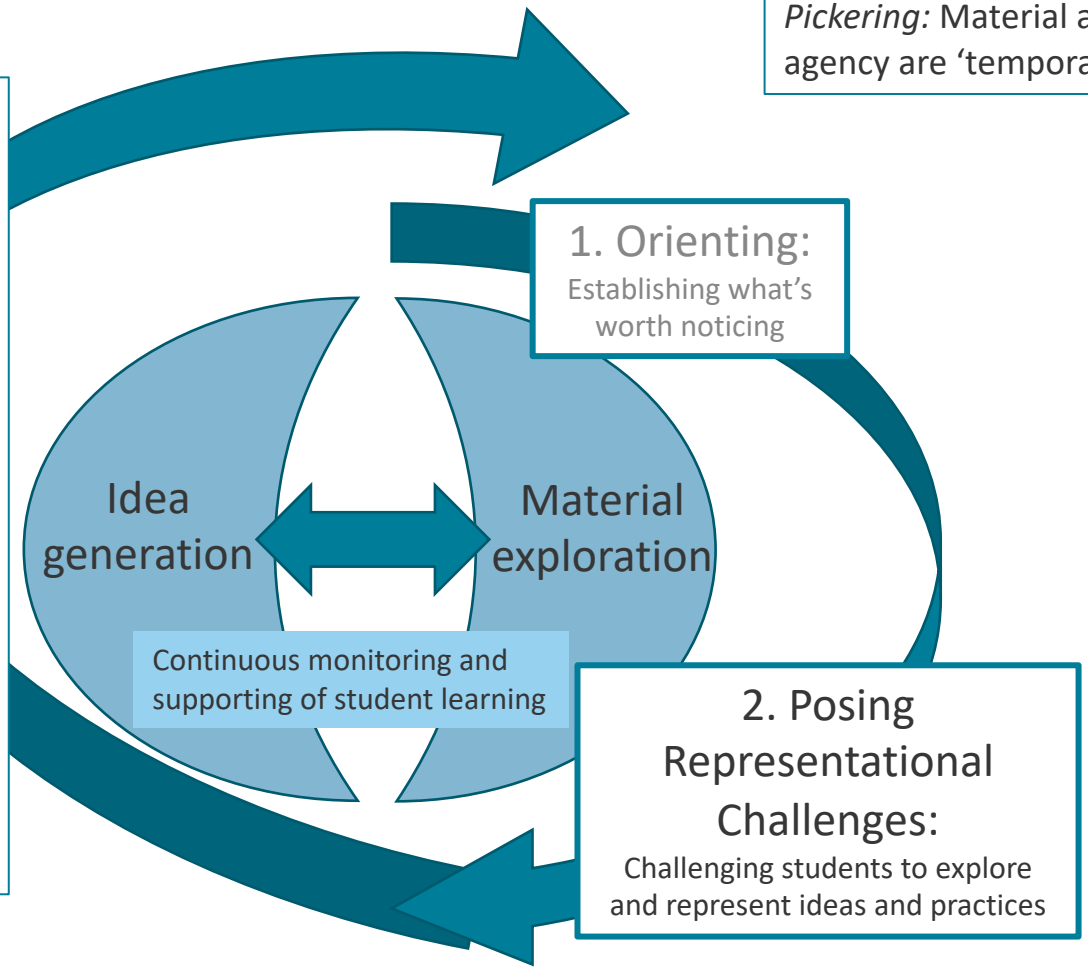


The material and the theoretical

Pickering: Material and human agency are 'temporally emergent'

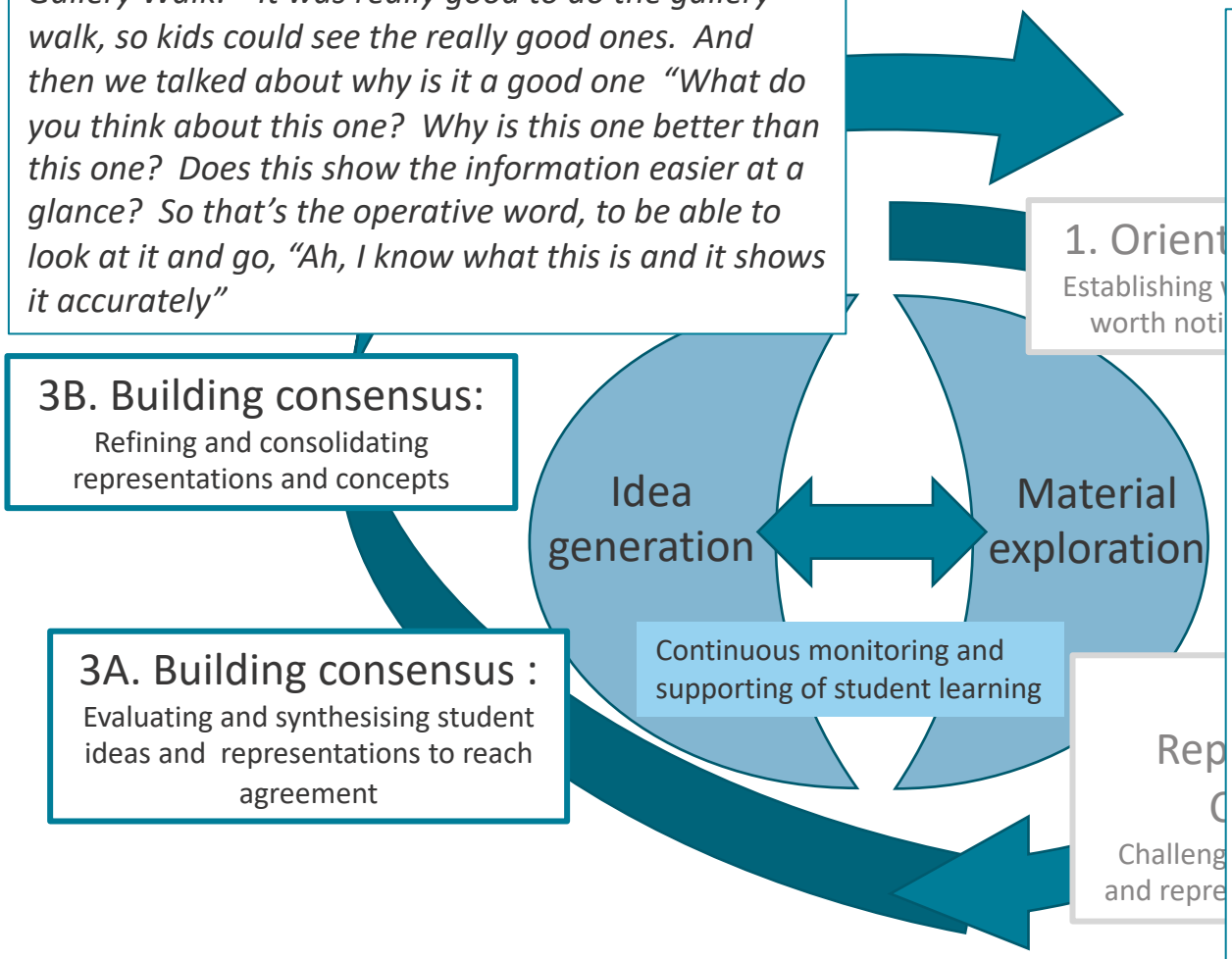
Note:

- Constructing representations is not a passive process but involves manipulation of materials
- Students had to decide on a process for exploring and counting. Which plots? How deep to dig? Where to look?
- The data thus presumes a number of material decisions



Building consensus: comparing, evaluating, synthesising, refining and consolidating

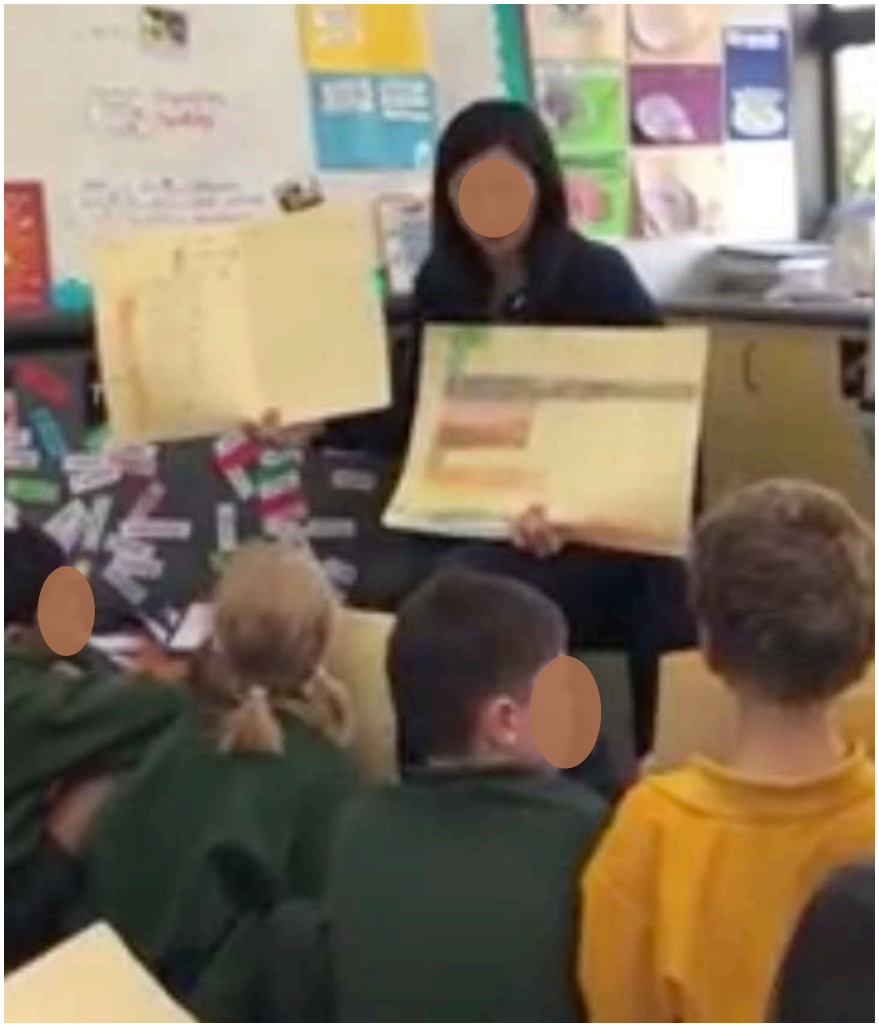
Gallery Walk: "It was really good to do the gallery walk, so kids could see the really good ones. And then we talked about why is it a good one "What do you think about this one? Why is this one better than this one? Does this show the information easier at a glance? So that's the operative word, to be able to look at it and go, "Ah, I know what this is and it shows it accurately"



This involves two stages:

1. Using the student ideas and representations to compare, evaluate and then synthesise these to reach agreement about which aspects of these effectively show patterns in data, or suggest explanations.
2. These ideas are refined by students, and consolidated to establish a shared understanding of the concept and associated representations. In this process students develop knowledge of the role of representational work in learning.

Building consensus: comparing, evaluating, synthesising, refining and consolidating

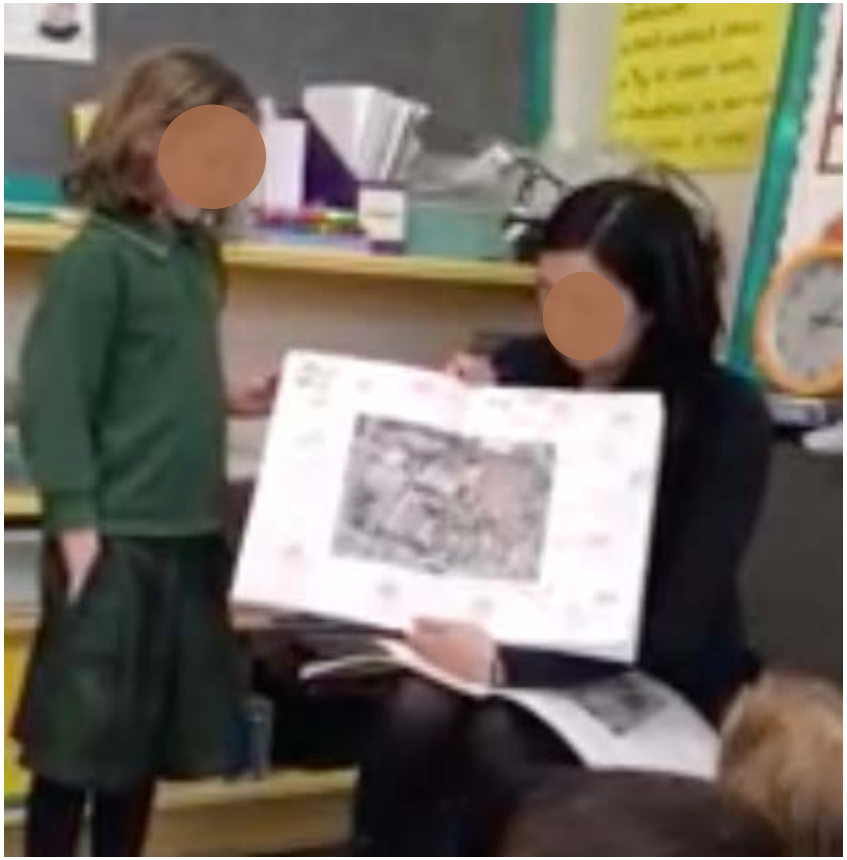


Comparing, evaluating

Ellie: *IS this graph as easy to read as s2511 & s1535?*
Students: *No*
Ellie: *Why is it not as easy to read?*
Student: *Because the squares are different sizes - it's easier to tell if they're the same size you can just tell which ones smaller*
Ellie: *OK I see you can see by telling which ones taller*
Student: *It's a bit messed up and mucky (Student - that's how I could put them in order s2554)*
Ellie: *That's ok - so the different sizes make it a little bit harder to compare the number of living things...*

Note: Ellie uses comparison to establish particular features of graph form and function

Building consensus: comparing, evaluating, synthesising, refining and consolidating



s2511: *There's a little code up here (referring to legend) and it says/shows that a green box and beside the green box it says good.. and the same things with the red, but it says bad instead of good. So red means bad and green means good*
Ellie: *and good for what?*
s2511: *good for living things …*
Ellie: *Oh good, can you tell us some of the good places for finding living things and minibeasts & why it would be a good place?*
s2511: *So, you could find some snails under the plant because when it rains water could get trapped under the leaves (meaning making)*
Ellie: *Why would snails need wet leaves to survive?*
s2511: *Because that what they eat and what they need...(goes onto other areas of the school- twisty trees, chicken coup, carpark etc.)*

Note: Ellie uses open questions to establish ideas about animal adaptation to habitat

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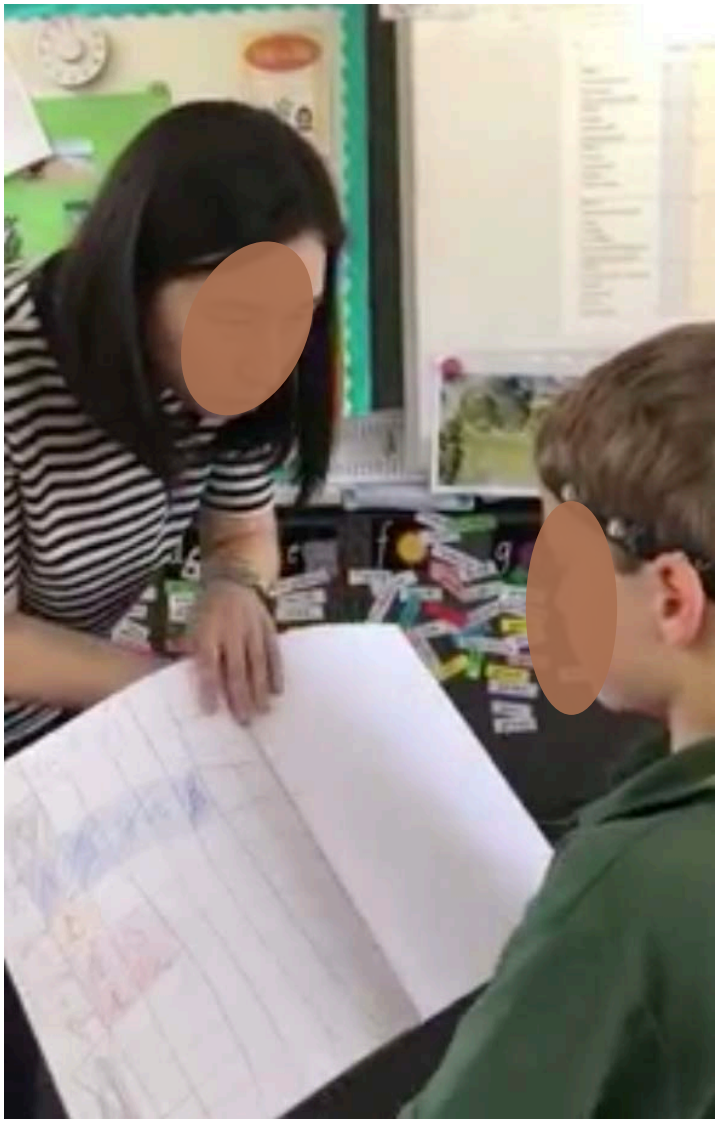
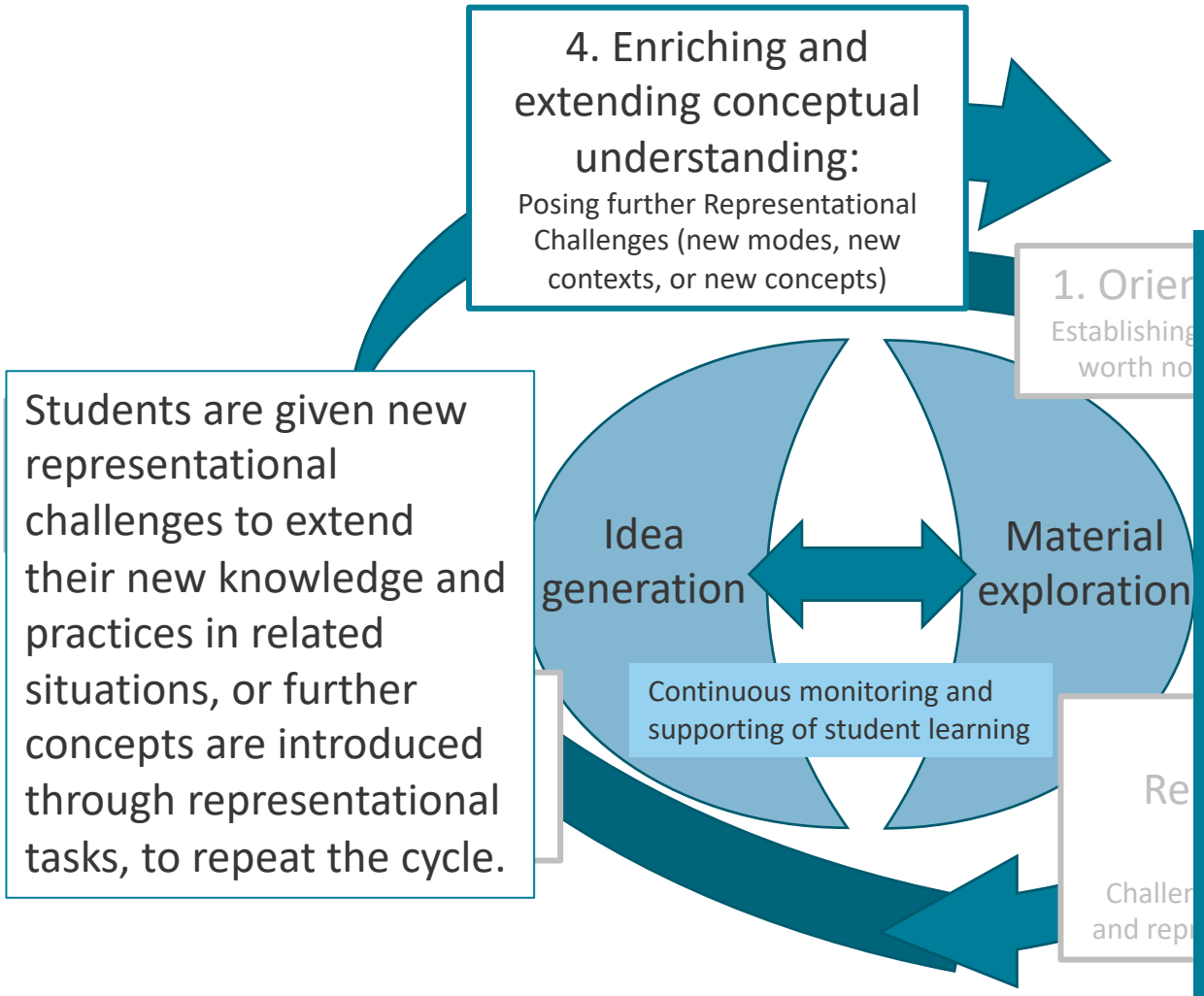
Building consensus: comparing, evaluating, synthesising, refining and consolidating



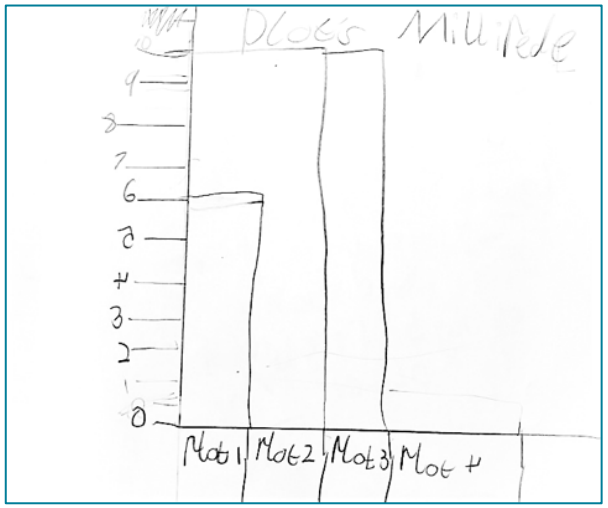
Ellie: *So does that make sense? Is that easy to read? s2526 (mumbles)*
Ellie: *Because if I look here - so (reading and pointing to bar graph) This plots got five spiders, this one's got 1 this ones got 2, plot 5's got 2- yep. This one also looks like it's got 1, but you've got a zero here (pointing to number written in bar graph representing 1)... So did Plot 1 have a spider?*
s2526: *No*
Ellie: *So do you think there should be something in this box?*
s2526: *mmm no!*
Ellie: *Why do you think there shouldn't be something in this box?*
S2526: (very quiet) *there should be nothing there*
Ellie: *Yes! there wasn't anything there... Do you think you could maybe show me that - make a more accurate graph?.....*

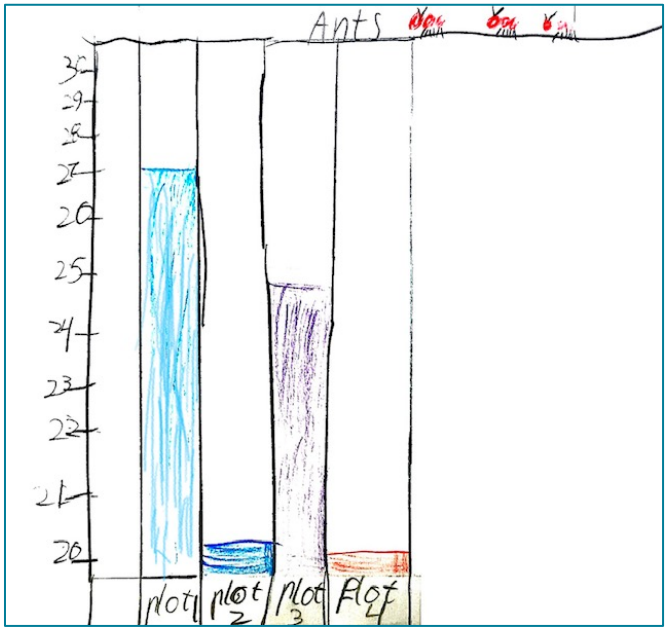
Enriching and extending conceptual understanding

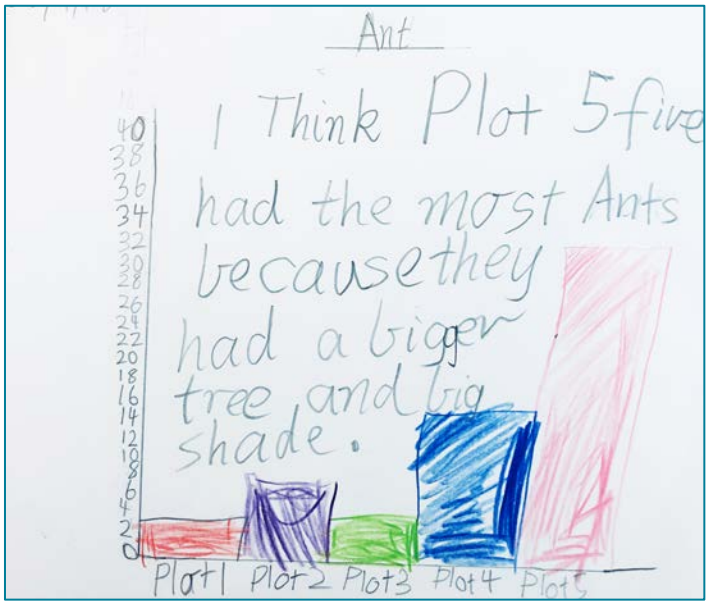


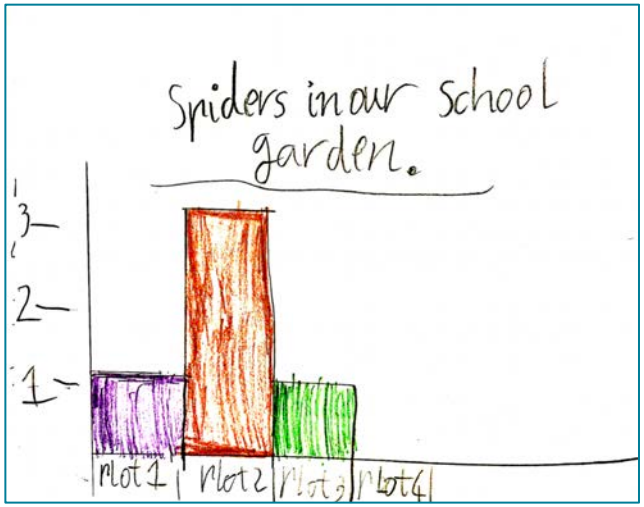
In the case of the ecology unit the teacher organised to pool the group data to facilitate an overview of the living things across all sample plots. This allowed further discussion and decisions and participation in tabulation, opportunities to refine graphical work, and more informed discussions of why certain animals are distributed differently across habitats.

Graphical work focusing on distribution of particular animals



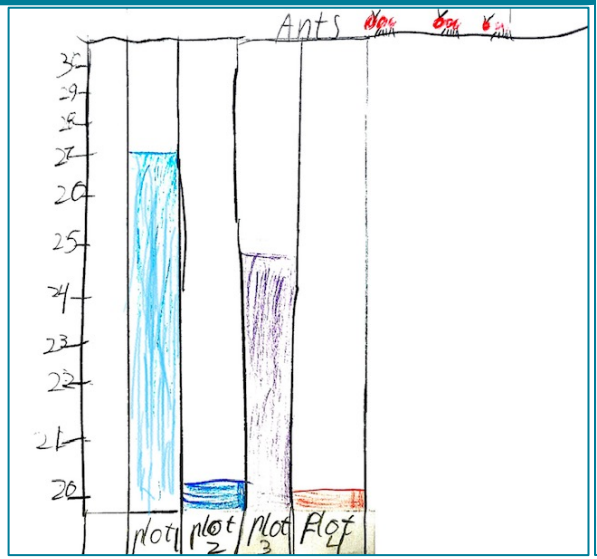


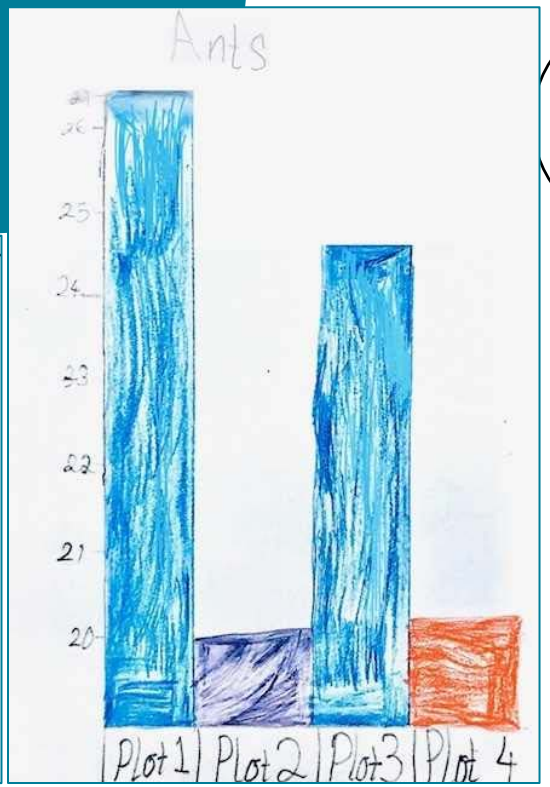




Look what I can do now!

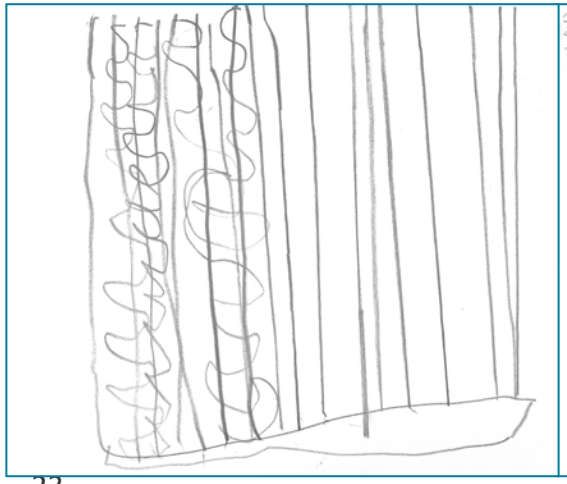
Student 1 refinement

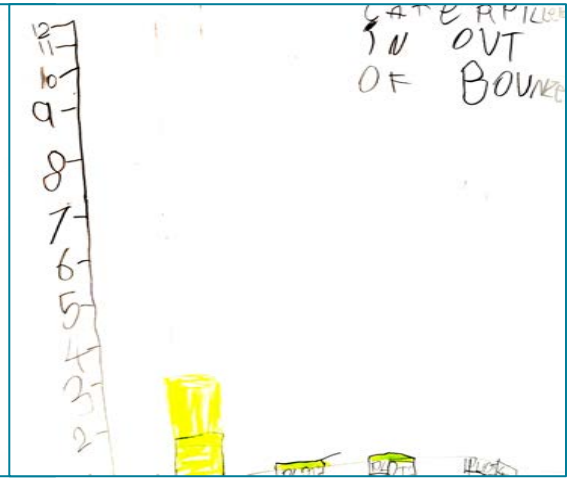




Year 1 students!

Student 2





I didn't know what I was doing

But look what I can do now!

School B: Pulling it all together

Sequence completed in conjunction with Mini Beasts Unit. Students compared and represented different plot data.

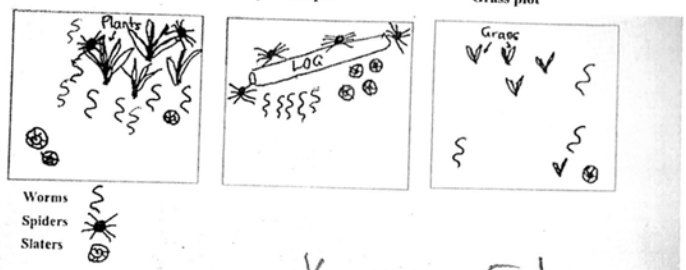
Wall Displays shared with parents as part of Science Sharing

Post tests

Investigating the schoolyard

A grade 1 class explore their schoolground looking for animals in different places.
Their drawings show where they found worms, spiders and slaters in three different plots.

Garden plot **Dry mulch plot** **Grass plot**



In which plot are most spiders found? DRY MULCH PLOT

Why do you think more spiders are found there? BECAUSE THERE ARE 4 SPIDERS IN THE PLOT

Draw a graph showing the worms in each plot.

What does the graph tell us about where worms mostly live, and why? UNDER SOIL BECAUSE IT'S DARK

Investigating the schoolyard

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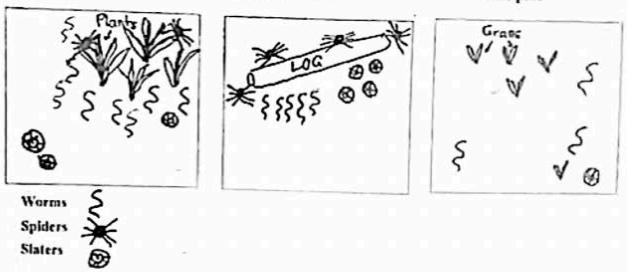
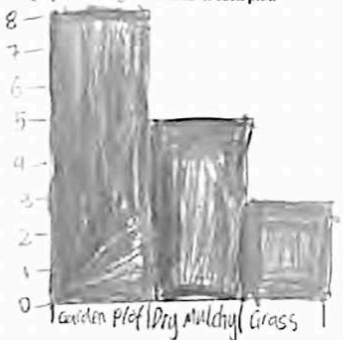
Garden plot **Dry mulch plot** **Grass plot**



In which plot are most spiders found? Dry mulch plot

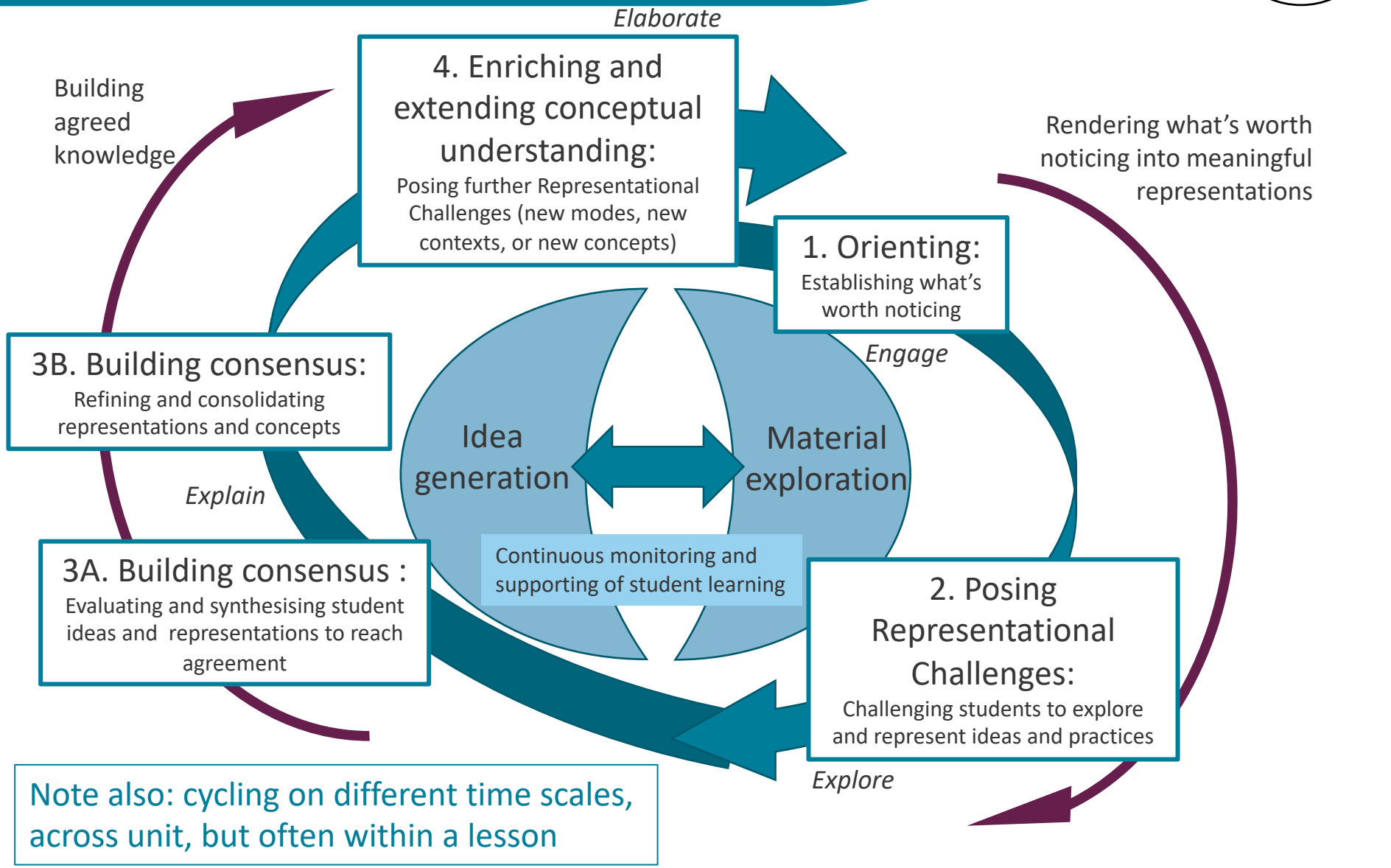
Why do you think more spiders are found there? Becase they're most webs in some logs.

Draw a graph showing the worms in each plot.

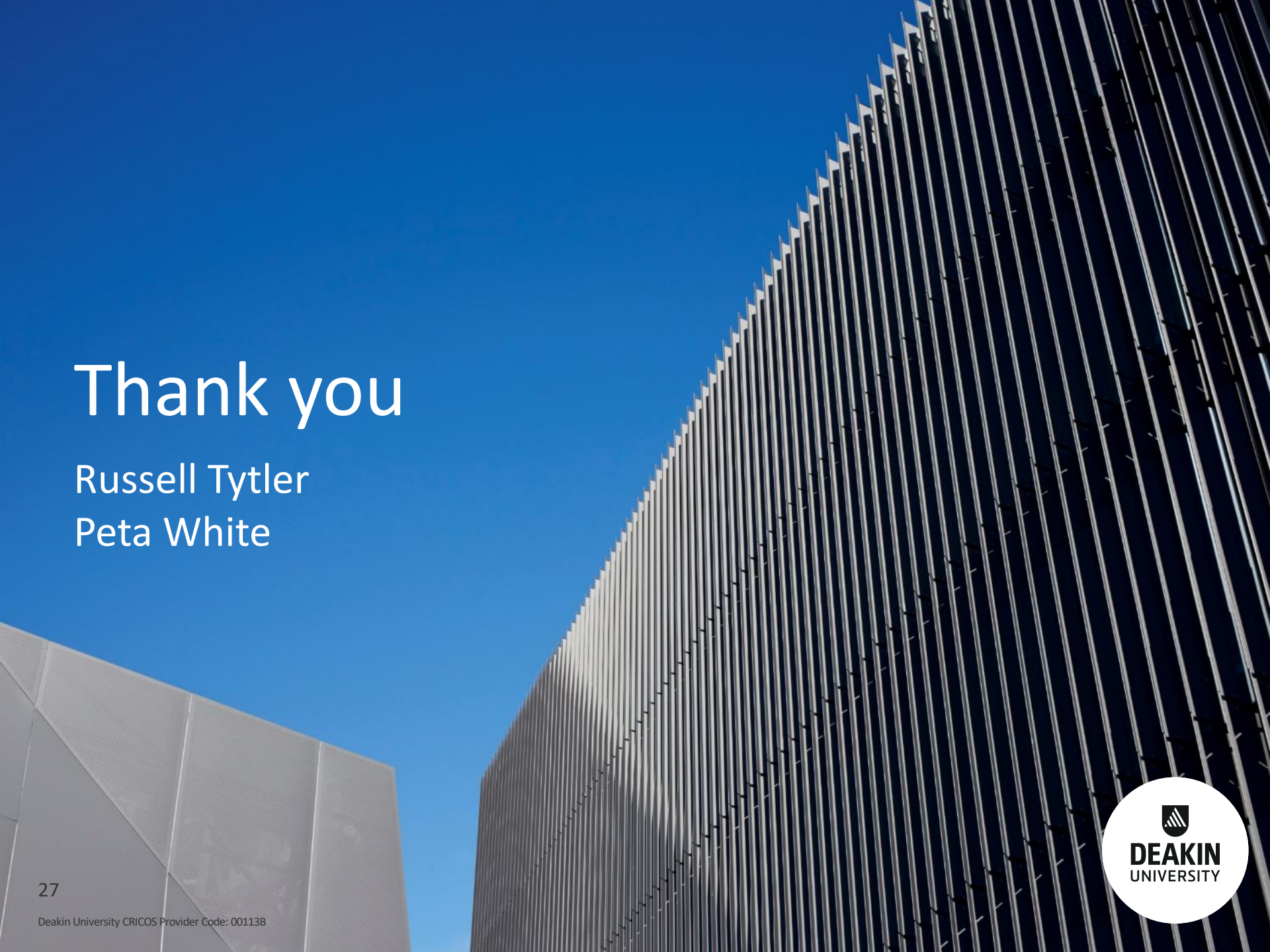


What does the graph tell us about where worms mostly live, and why? Most worms live in Graden plot Because there is Plants and Plants have soil.

IMS Pedagogy in relation to the 5Es



Note also: cycling on different time scales, across unit, but often within a lesson



Thank you

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Peta White

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