Supporting Learning Across the Multimodal Languages of Science

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It is increasingly being accepted that learning in science can be productively viewed as a process of induction into the multimodal languages of the discipline. Science concepts are expressed not only through verbal accounts, but through a range of representations including visual diagrams, graphs and tables, 3D models and simulations. A key, but problematic aspect of learning is the 'transduction' of meaning across these multiple modes. How do students align the meanings available in different modes, such as text to image, and 3D models, and how can they be supported to reason through these multimodal resources? Often, the capacity of students to align these different modal representations is assumed, since for teachers this alignment has been understood and is intuitive. In this presentation I will draw on two Australian Research Council projects, one exploring the languages of senior secondary science, and one generating interdisciplinary science and mathematics sequence involving cross-modal generation, to show how this cross-modal transduction is pervasive, and fundamental to learning science. We will draw on different topics to explore the nature of the challenge for students, and present and discuss examples of how teachers can explicitly support students in reasoning across modes.

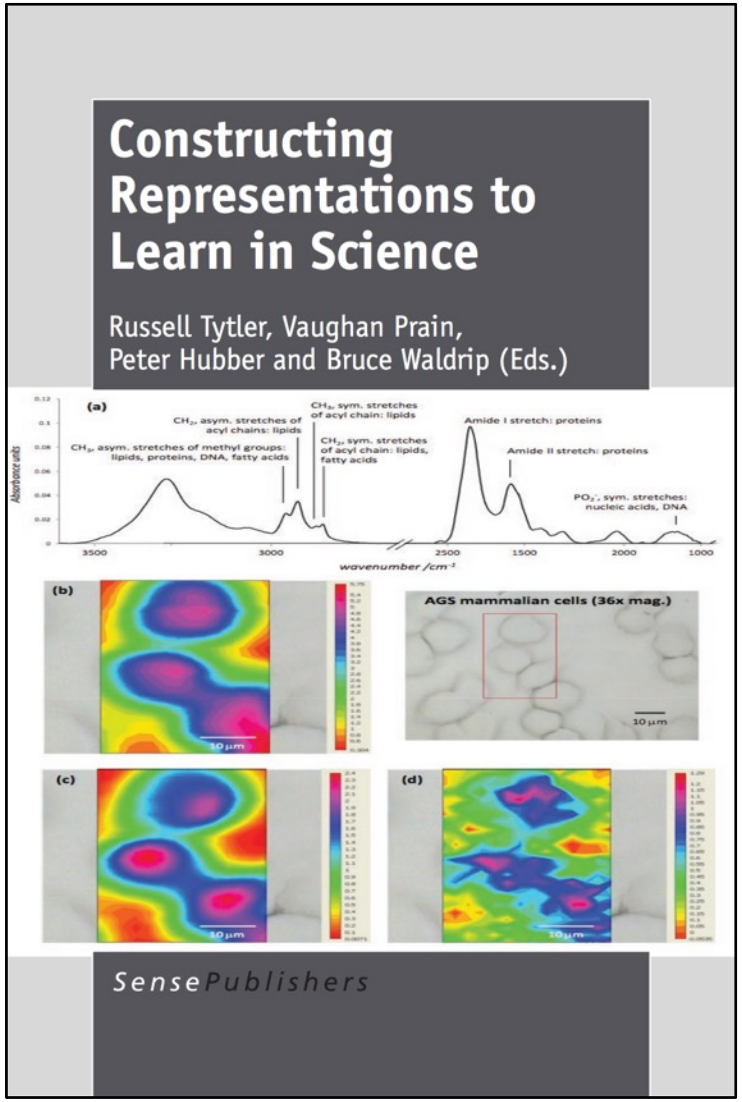
The languages of science are inherently multimodal

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

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

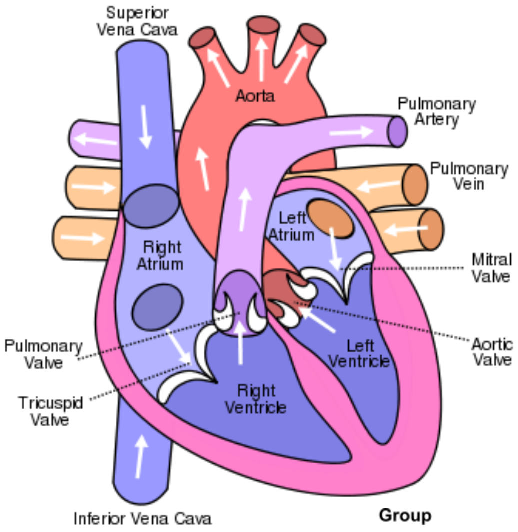
Pedagogy: guided inquiry where children generate data/observations and **invent, compare, assess and revise**, and coordinate representations.

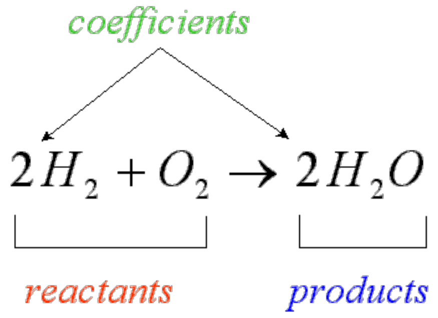
Shifting meaning across multiple, multimodal representations is a crucial aspect of learning science

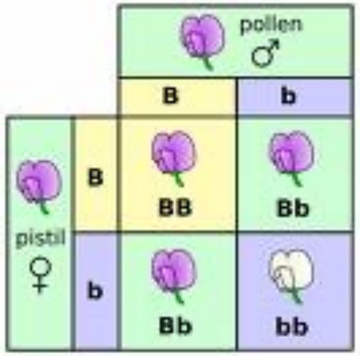


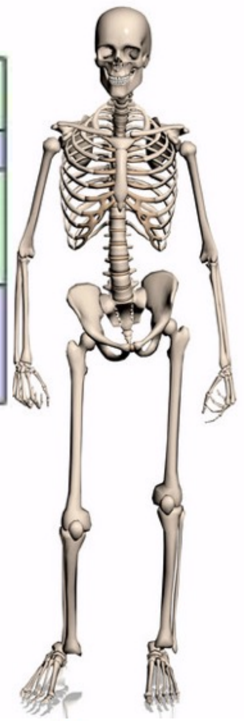
The process of coordinating meaning from one mode to another was named ‘transduction’ by Gunter Kress in 2000

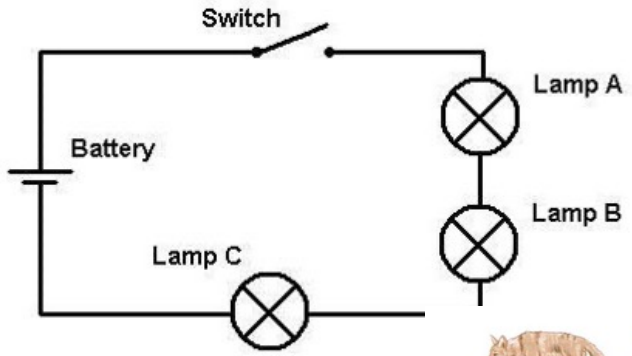
Multiple, multimodal representations are a crucial aspect of the languages of science

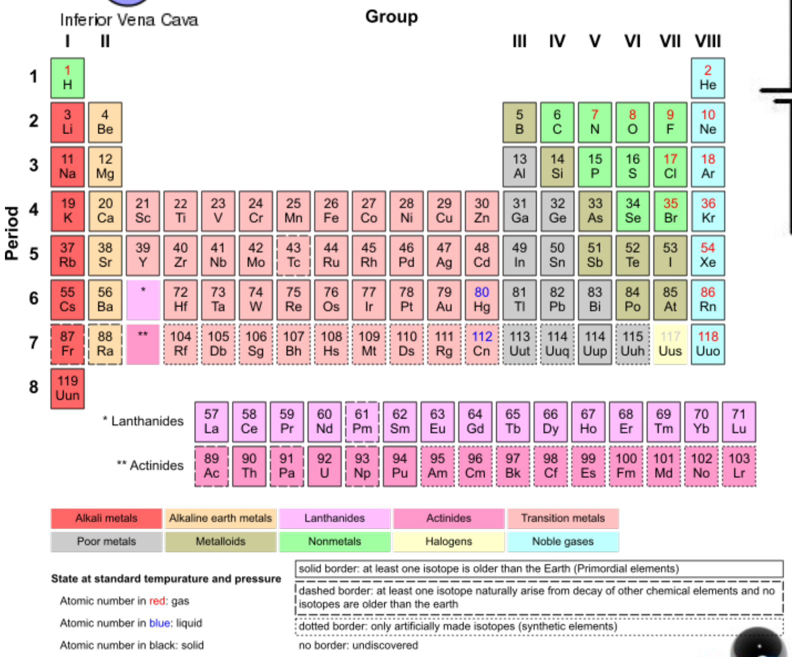


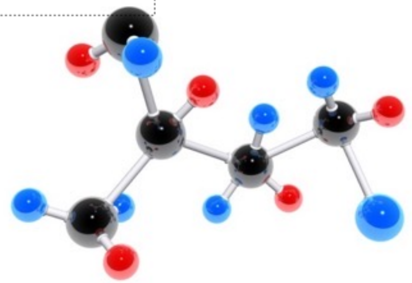


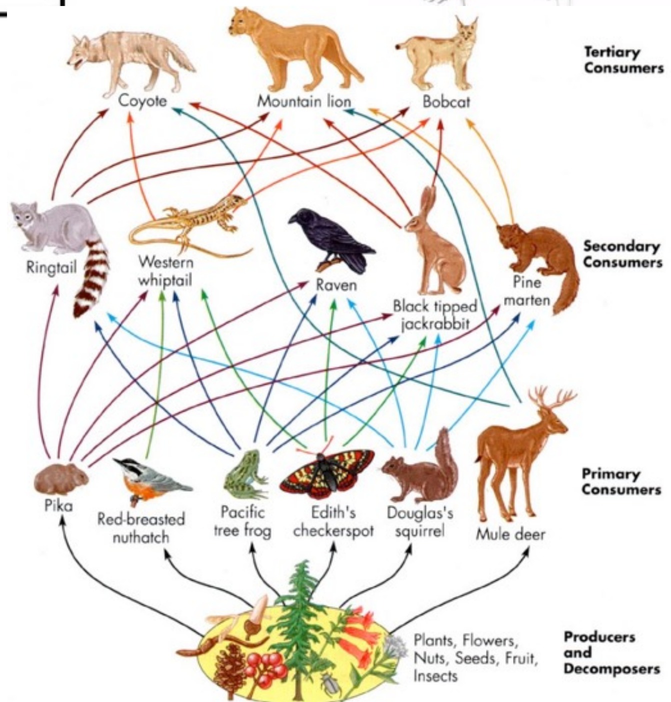












Transduction

Understanding a science concept such as voltage and current relations in an electric circuit involves orchestrating multiple, multimodal representations.

How do students learn how to coordinate meaning across modes? This is the problem of transduction

There are a number of ways to visualise the energy changes in this circuit. One common analogy is to think of the charges as water being pumped around an elevated water course. The water gains potential energy as it is pumped higher, and as it flows back down the potential energy is converted into other forms. The diagram in Figure 4.1.5 shows how the analogy works with the energy changes that occur in a circuit. The battery acts as a 'pump' that pushes electrons up to a higher energy level and the electrons gain potential energy. As the electrons pass down through components in the circuit, their energy is transformed into other forms.

The change in electrical energy available to electrons can also be represented graphically, as shown in Figure 4.1.6.

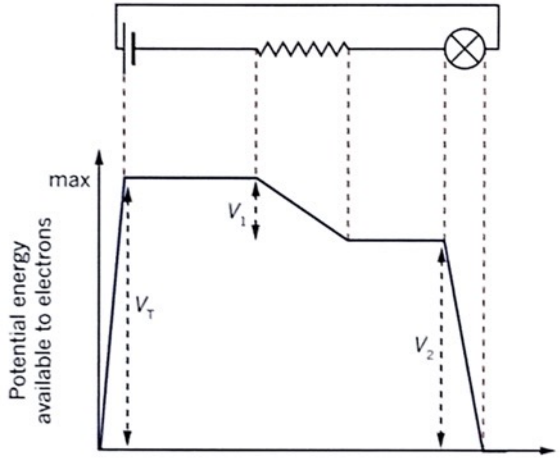


FIGURE 4.1.6 The electric potential energy of an electron changes as it moves around the circuit. Some of this energy is lost as the electrons pass through the resistor. The remaining energy is lost as the electrons pass through the bulb. In this circuit, the bulb has more resistance than the resistor.

Equivalent series resistance

Consider the circuit in Figure 4.1.7. If the resistance of the fixed resistor is R_1, the resistance of the lamp is R_2 and the current flowing through both of them is I, then Ohm's law gives:

$V_1 = I \times R_1$

and

$V_2 = I \times R_2$

The total voltage drop across the two components is:

$V_{Total} = V_1 + V_2 = IR_1 + IR_2 = I \times (R_1 + R_2)$

This equation shows the relationship between the potential difference supplied by the cell and the potential differences of the lamp and resistor. The last part of the equation also shows that the lamp and resistor can be replaced with a single resistor, without changing the current in the circuit. The single resistor needs to have a total resistance of $R_1 + R_2$.

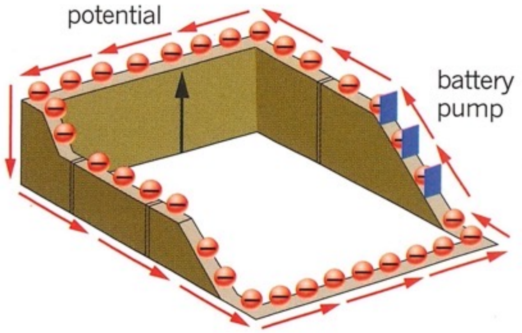


FIGURE 4.1.5 An analogy for analysing a circuit: the battery acts as a 'pump' which transfers potential energy to electrons. The electrons lose potential energy as they flow 'down' through components in the circuit.

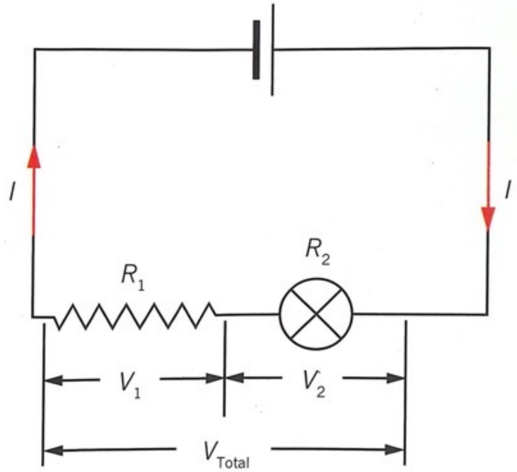


FIGURE 4.1.7 Using Ohm's law, it is possible to show the relationship between the potential difference supplied by the cell, V_{Total}, the current flowing in the circuit, I, and the resistances of the two components R_1 and R_2.

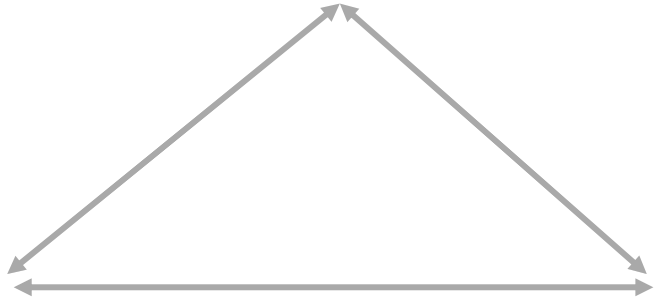
Explaining Transduction:
Lemke' s (2003) Peircean Semiotic Account

For Lemke (1998, p. 87), concepts in science, although having verbal components, are better understood as "semiotic *hybrids*, simultaneously and essentially verbal-typological and mathematical-graphical-operational-topological".

For Lemke (2003) Peirce's triadic sign system explains reasoning processes in general and in science. This system is seen to enable understanding of the multimodal nature of scientific concepts.

Transduction entails moving beyond meanings of individual signs to focus on correspondence and coherence in meanings within and across modal representations (Prain & Tytler, 2021)

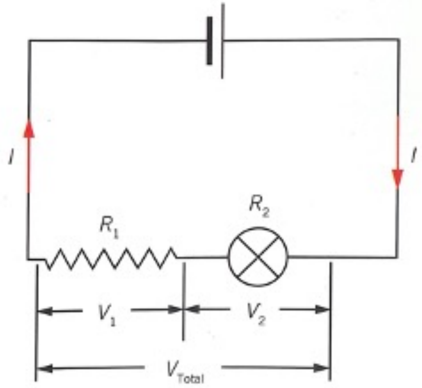
Interpretant:
Reasoning about resistance relations around the circuit



Representation:
Symbolic relation between voltage, current and resistance

$V_1 = I \times R_1$
and
$V_2 = I \times R_2$
The total voltage drop across the two components is:
$V_{Total} = V_1 + V_2 = IR_1 + IR_2 = I \times (R_1 + R_2)$

Object:
A series circuit diagram



Images in a glass of water (lens)

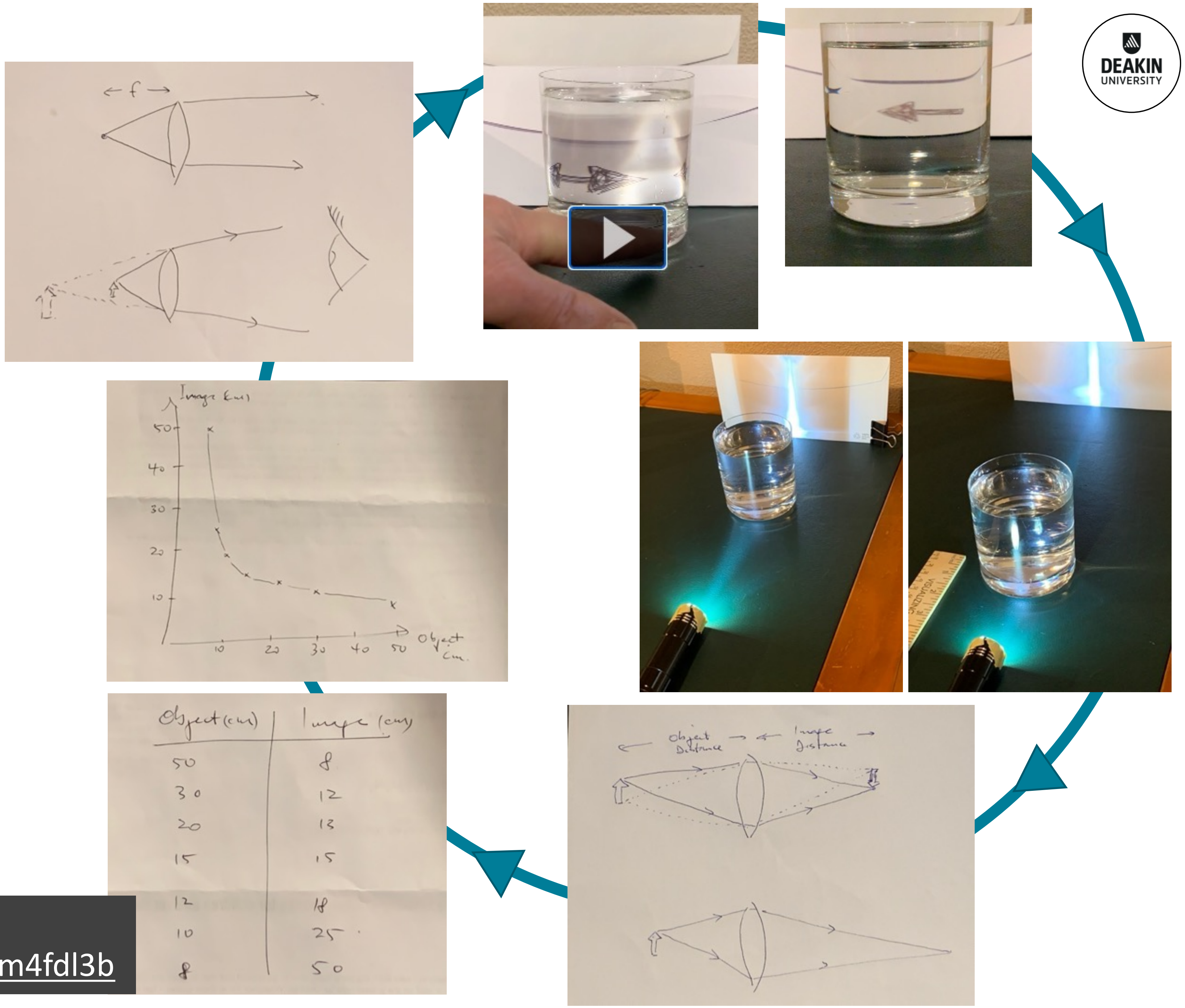
What representations are involved in explaining imaging in a glass?

What challenges do you see in coordinating meaning between these?

What moves are made to help transduct meaning across the representations?

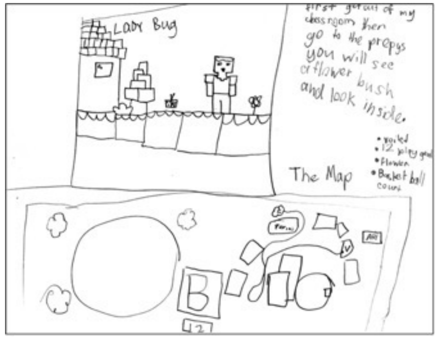
How would having students engage with the activity, with their own lenses or glasses, help with the transduction process?

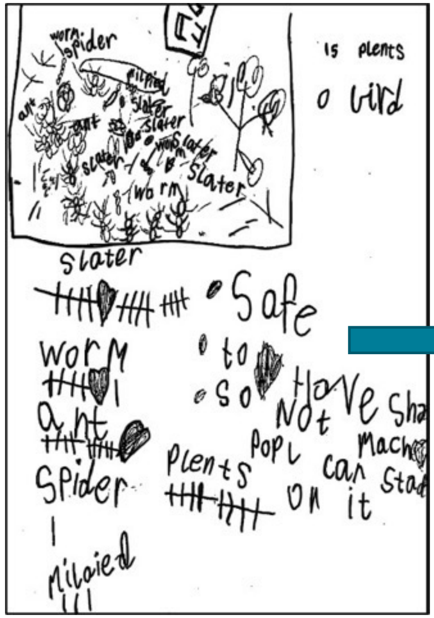
How would you as a teacher support the transduction process in that case?

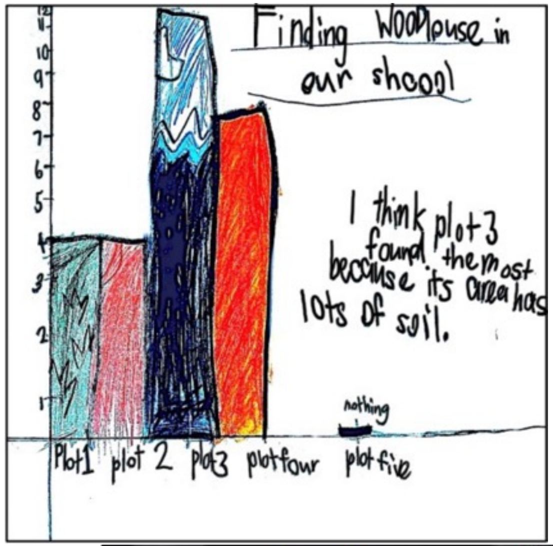


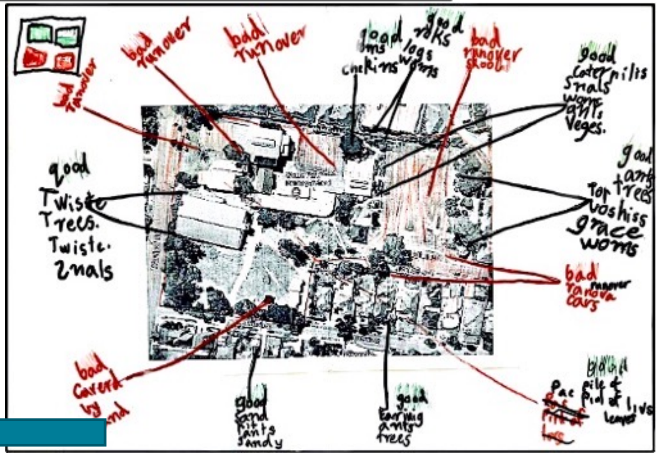
The accompanying video can be found at: https://video.deakin.edu.au/media/t/1_4m4fdl3b

Grade 1 learning sequence in schoolground ecology









Supporting transduction between students everyday views and representations to inject meaning into scientific representations (students predict what they will find, and where)

Samantha: I think caterpillars live in the school ground, because – there are lots of leaves. I know that caterpillars are living because it moves and eats.
Colin: Oh, that's a really good sentence. Oh – and what are you doing here?
Samantha: drawing a caterpillar
Colin: (Drawing a caterpillar)- And are you going to add anything else to your drawing?
Samantha: I'm going to draw some spots on it.
Colin: Yep
Samantha: and I'm going to draw a background.
Colin: Oh, and what is going to be in your background?
Samantha: Trees, and grass and leaves
Colin: Fantastic, and why have you chosen those things to put in the background?
Samantha: Because – caterpillars live there.
Colin: Okay, fantastic – keep going. Show me… I like how you have this bit here, caterpillars are living because they move and eat (Reading student sentence – following with finger). See if you can think, show me a way – how you could add to this picture to maybe give a bit more information about how they move and eat.
Samantha: Oh – maybe I could show it eating a leaf.
Colin: Ok – yes, maybe you could show it eating a leaf
(Student continues refining representation)

Transduction: Coordinating meaning across students' everyday ideas and the formal representations of science and maths

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

Anna: At the moment it tells me you've found 15 of something but it doesn't tell me what they are. So how are you going to show me … 15 what?
Brad: I .. actually found 15 spider webs
Anna: So … OK, what can you draw here to show me there were 15 spider webs? (Brad draws)
Anna: What have you found?
Gemma: Earwigs …. and spiders.
Anna: So, how are you going to record that and write that down?
Gemma: Drawing
Anna: Ok. Are you going to record somewhere on your page where you found these spiders, spider webs and earwigs?

- Brad - a tree
- Anna: A tree - how are you going to show that?
- Brad: maybe like (drawing)
- Anna: you're going to draw a tree - ok - where's this tree in the school though? How could you show us where the tree is in the school?

Using the graphs and table data, and plot characteristics, to make sense of patterns

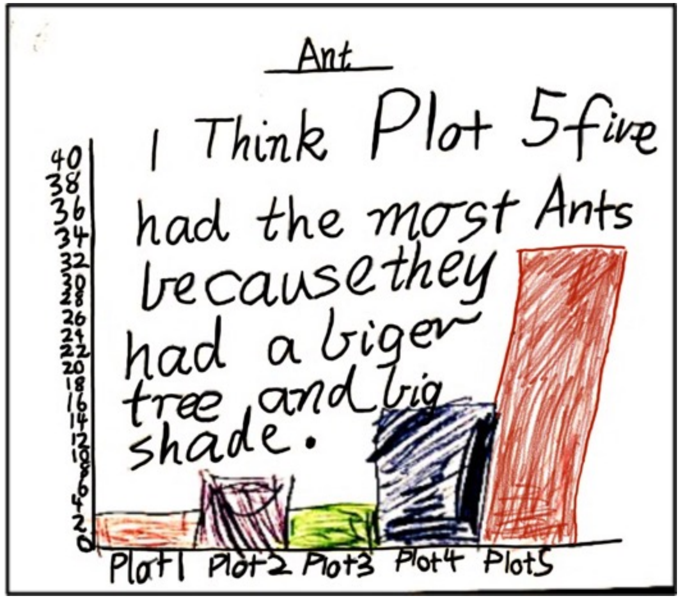
Anna: I don't know what 'good tree' means though? So, we've got Amy saying protection. Are you saying it's a good tree for protection perhaps?

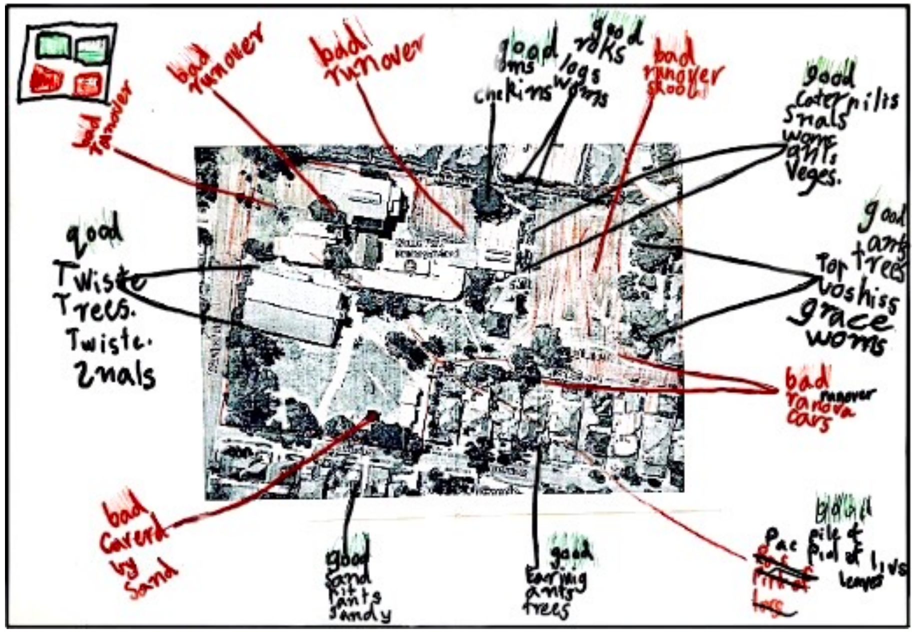
Tanner: Oh! I think I might know… because we have shade, there was more shade under the tree.

Anna: and what does that mean for the living things in your plot?

…

Tanner So, the tree gave the shelter to things in our square.





Questions and comments please!

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