Enriching Mathematics and Science Learning Through an Interdisciplinary Approach

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Vaughan Prain, Joanne Mulligan, Richard Lehrer, Leona Schauble, Melinda Kirk, Chris Speldewinde, Chris Nielsen

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https://www.asera.org.au/2019-conference

Paper presentation

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Enriching Maths and Science Learning Through an Interdisciplinary Approach

There has been increasing interest in interdisciplinary as an approach to more deeply engage students, especially as part of advocacy of integrated STEM approaches. However, there are concerns that this integration can do violence to the distinctive ways of knowing and practising represented by the disciplines. The Interdisciplinary Mathematics and Science (IMS) project (https://imslearning.org/) is developing and investigating an approach to primary school mathematics and science that consists of classroom activity sequences in which students' invention and transformation of representational systems (see Hubber et al., 2010) in the two subjects can support deeper learning in each. In this way the guided inquiry pedagogy involves students in epistemic practices that approximate those in the discipline, such that concepts that sit at the intersection of the two disciplines (variation, sampling, symmetry, spatial reasoning) are approached from the distinct perspectives of each. The project is tracking students longitudinally over 3 years to investigate the development of representational competence. Sequences thus far have included motion, ecology and astronomy, and data modeling, graphing, variability, and geometric reasoning. The presentation will include examples of the interdisciplinary approach, its affordances, and evidence of enhanced student learning. We will also demonstrate the data management system we have generated as a methodological innovation.

Reference

Hubber, P, Tytler, R., & Haslam, F. (2010). Teaching and learning about force with a representational focus: Pedagogy and teacher change. *Research in Science Education*, 40(1), 5-28.

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

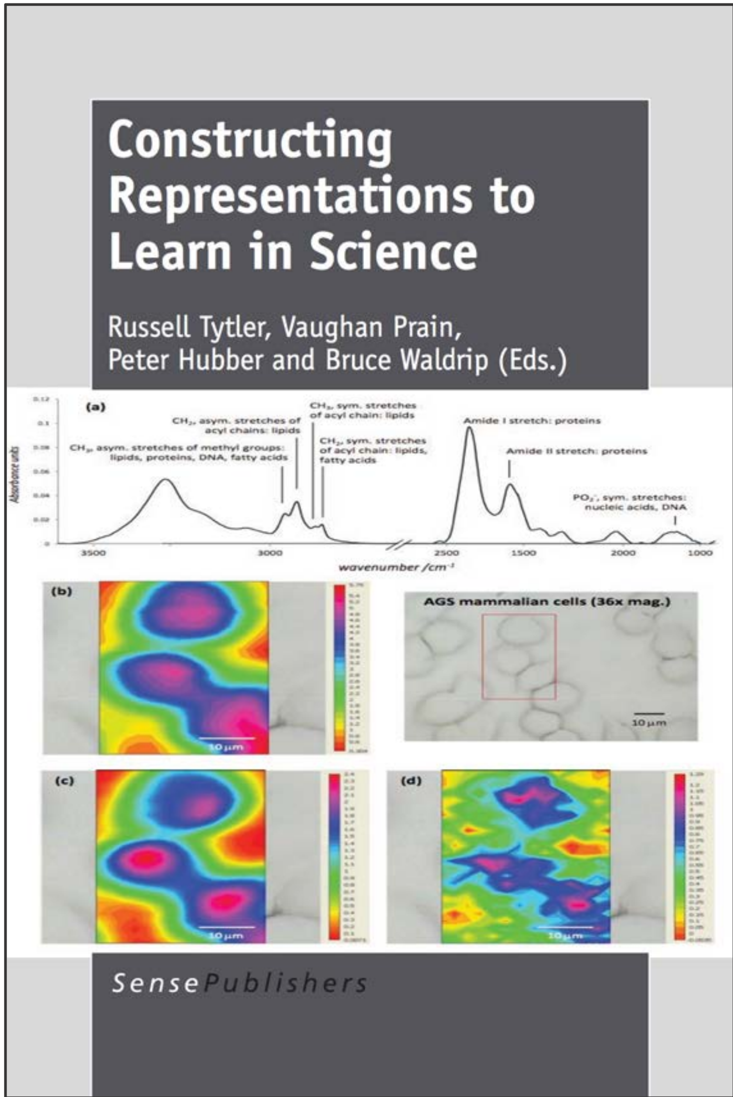
This is an international, longitudinal project which aims to investigate the effectiveness of an innovative interdisciplinary learning approach in mathematics and science. Through collaborating primary schools in Australia and the United States of America (USA), it will investigate how students' invention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

> **Maths and Science together makes sense!**
>
> **Year 4 student**

Key features of the IMS project

1. Learning as induction into the multi modal discursive practices of science and mathematics (Latour, Peirce, Lemke)
2. Model based reasoning, socio semiotic perspectives (Lehrer & Schauble, Lemke)
3. Pedagogy: guided inquiry where children generate data/observations and invent, compare, assess and revise, and coordinate representations.
4. 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.



Project aims

1. Develop an inter-disciplinary framework, focused on the creation and evaluation of representational systems, to guide students' foundational learning in science and mathematics.

2. Design, implement and evaluate a longitudinal intervention for primary students using this framework.

3. Develop constructs to characterise and assess students' developing understanding and dispositions

4. Identify strategies that support teacher professional learning

5. Review and inform current Australian curricular policy and practice in mathematics and science.

MATHS & SCIENCE TOGETHER

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Topics so far:

- Representing motion
- Ecology of the schoolground
- Astronomy
- Chemical Science
- Fast Plants
- Light
- Paper helicopters
- Water use

Representations in common

- Measure and variation
- Sampling
- Number, tallying, coordinating units
- Graphing – categorical and continuous data
- Spatial awareness and reasoning
- Perspective taking
- Area and perimeter
- Coordinating horizonal and vertical alignment

IMS LEARNING

Interdisciplinary Maths and Science Learning

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Overview

"Enriching mathematics and science learning through an interdisciplinary approach"

This ARC Discovery Project, is a response to a widely recognised need for significant innovation in early mathematics and science learning. Despite rapidly increasing technologies and curriculum reform, a growing number of students fail to acquire the essential quantitative and scientific skills required for work and life. Consequently, it is critical that change is built upon sound, current research that provides direction for effecting positive change and relevancy. The research takes an inquiry based approach examining classroom practice and the relationship between STEM disciplines, rather than separate entities, to support student reasoning and collaborative problem solving skills. A core focus of this project is around understanding how to make Science Technology Engineering and Mathematics Education (STEME) more innovative and engaging for teacher, students and industry. This STEME research program seeks to create greater links between the education system, policy makers, international partners such as the University of Manchester and the STEM research community for improving student learning with the broader goal of achieving social, environmental and economic sustainability.

The project aims to

- Identify and capitalise on young children's potential for developing rich, coherent mathematical and scientific knowledge.

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Profiles

Professor Russell Tytler

Researcher

Deakin Univeristy staff profile

Dr Peta White

Researcher

Deakin University staff profile

Professor Vaughan Prain

Researcher

Deakin University staff profile

Dr Lihua Xu

Researcher

Deakin University staff profile

Professor Joanne Mulligan

Researcher

Macquarie University staff profile

Christopher Speldewinde

Research Assistant

Deakin University staff profile

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Interdisciplinary Maths and Science Findings

(January 2019)

During 2018 the IMS team worked with three schools in Melbourne and Geelong, with 12 teachers spread over classes at grades 1, 2/3 and 4. At each cohort level we worked with all teachers who collaborative planned with the research team and monitored and discussed approaches to teaching as they went along. As a research team we also visited regularly, videotaping classes, collecting student work, and interviewing and discussing next steps with the teachers.

During the year we produced lesson sequences in three distinct topics, with versions for each of the cohort levels. The topics were:

Modeling motion: Measurement of constant motion; representing relationships between distance, speed and time; motion down a ramp. The mathematics was concerned with data measurement and variation, and graphical representation and relationships.

Ecology: Living things in the schoolground: Investigating and counting living things in different parts of the schoolground. Sampling using plots in different habitats. Representing and comparing data for different organisms. Investigating and explaining variation. Animal adaptation. In the grade 1 classes this unit was linked to the PC schoolyard safari module.

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Publications

ESERA'19 EUROPEAN SCIENCE EDUCATION RESEARCH ASSOCIATION

Use Of Visual Representations In Astronomy Education: Issues, Affordances And Research Perspectives

ESERA conference, Bologna, Italy, 26 to 30 August 2019

Our paper "Use Of Visual Representations In Astronomy Education: Issues, Affordances And Research Perspectives" has been accepted for presentation at the 2019 ESERA Conference.

Read More…

2019 Mathematics Education Research Group of Australasia (MERGA) Conference

42nd MERGA Conference 2019, Perth, 30 June – 4 July 2019

"Interdisciplinary Mathematics and Science (IMS) Learning in the Primary School"

The Interdisciplinary Mathematics and Science (IMS) project* (https://imslearning.org/) is developing and investigating an approach to mathematics and science learning that implements learning sequences in which students' invention and transformation of representational systems in the two subjects can support deeper learning in each. The guided inquiry pedagogy involves students in epistemic practices that approximate those in the discipline, such that concepts that sit at the intersection of the two disciplines (variation, sampling, symmetry, spatial reasoning) are approached from the distinct perspectives of each.

Methods, Data handling, and Analysis

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Case study – teachers and students

Data collection
- video of classrooms (using swivl technology and an ipad) focussing on the teacher
- video of case study student groups
- student work books (scanned at the end of each lesson)
- pre and post tests
- photos of board work
- student interviews
- teacher interviews and meetings
- field notes

Stored on the website – in password protected area for easy access by our international research team

Analysis – ability to select data in several ways due to specific search features.

Home

All Teachers

Schools

Please select

Home

Schools

Home

All Classes

Cohorts

Please select

Schools

Please select

Year when class existed

2018

Submit Reset

Home

All Students

Search

Schools

Please select

Cohorts

Please select

Permissions Tier

Tier 0

Teacher

Submit Reset

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Home

All Lessons

Use the filters below to dig down. Right click and open links in new browser tabs to preserve this page.

Filter Sequences

- [ ] Astronomy
- [x] Ecology
- [ ] Motion
- [ ] Water
- [ ] Whirlybird/Helicopter

Schools: Please select

Cohorts: Please select

Lesson Number: Lesson 3

Submit | Reset

Lesson link	Sequence	Lesson Number	Class	Posted (y-m-d)
WPPS Ecology lesson 3 – A 1C	Ecology	Lesson 3	WPPS A 1C	19-02-11
WPPS Ecology lesson 3 – A 1B	Ecology	Lesson 3	WPPS A 1B	19-02-11
WPPS Ecology lesson 3 – A 1A	Ecology	Lesson 3	WPPS A 1A	19-02-11
EHPS Ecology lesson 3 – B 4O	Ecology	Lesson 3	EHPS B 4O	19-02-11
EHPS Ecology lesson 3 – B 4R	Ecology	Lesson 3	EHPS B 4R	19-02-11
EHPS Ecology lesson 3 – B 4CB	Ecology	Lesson 3	EHPS B 4CB	19-02-11
EHPS Ecology lesson 3 – A 1P	Ecology	Lesson 3	EHPS A 1P	19-02-11
EHPS Ecology lesson 3 – A 1J	Ecology	Lesson 3	EHPS A 1J	19-02-11
EHPS Ecology lesson 3 – A 1G	Ecology	Lesson 3	EHPS A 1G	19-02-11
EHPS Ecology lesson 3 – A 1D	Ecology	Lesson 3	EHPS A 1D	19-02-11

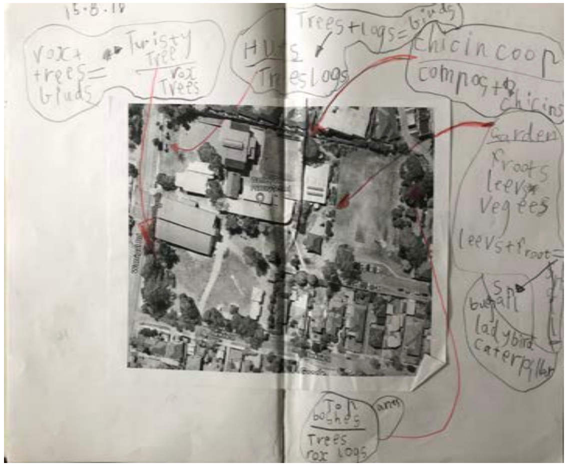
Findings to date: Ecology unit

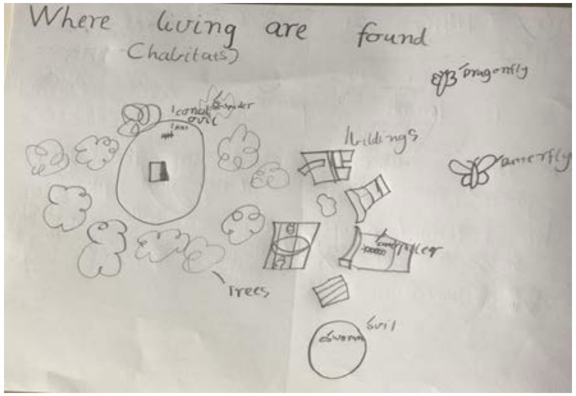
1. Children discussed, then explored schoolground quadrats for living things
2. They constructed maps of the schoolground and their quadrats
3. They tallied and invented graphical representations which were refined, to characterise their findings
4. They tallied the class data and discussed how to represent distribution of particular animals
5. They explained why particular things lived in particular habitats
6. They constructed a display of ’living things in the schoolground’

variation, sampling, symmetry, spatial reasoning

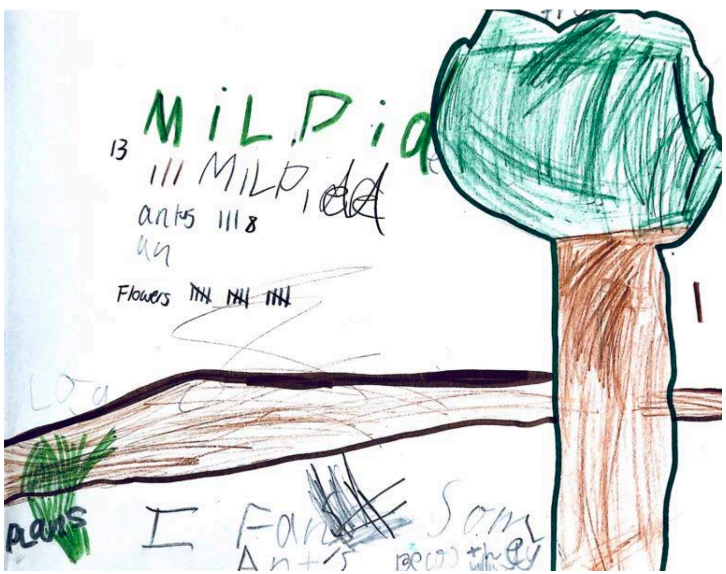
REPRESENTING LOCATION

Birds eye view mapping & Scaffolding Googlemap





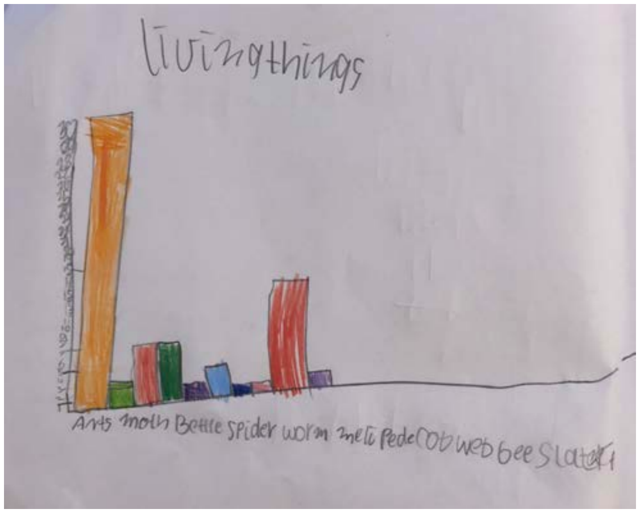
Plan views

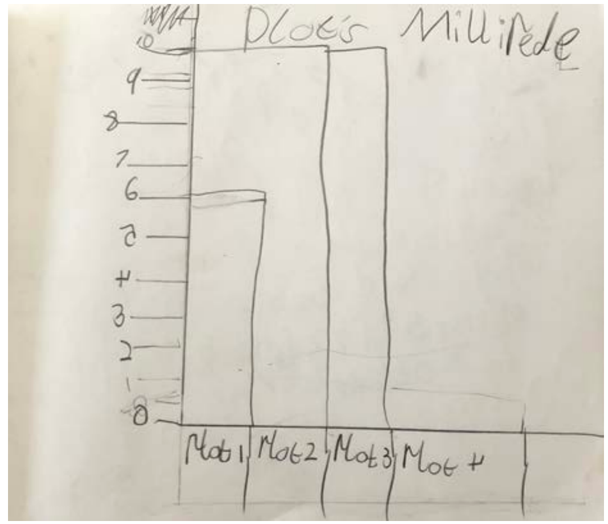


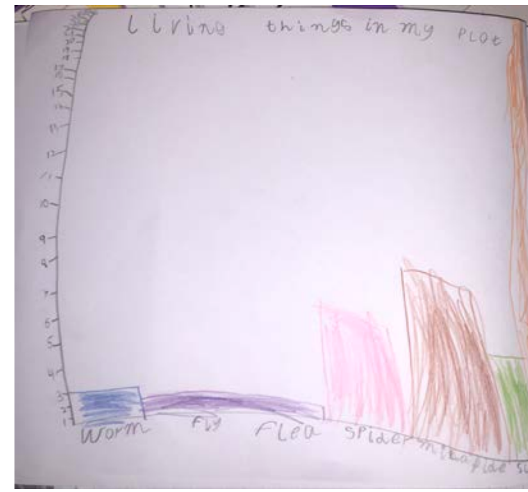
ants
Flowers

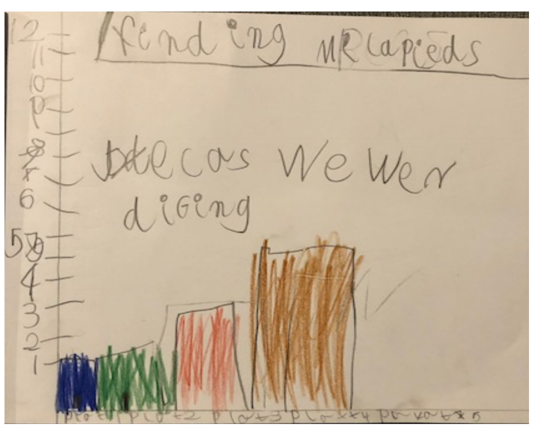
bee
Tree
slaters
weeds
centerped
milerped
Ants

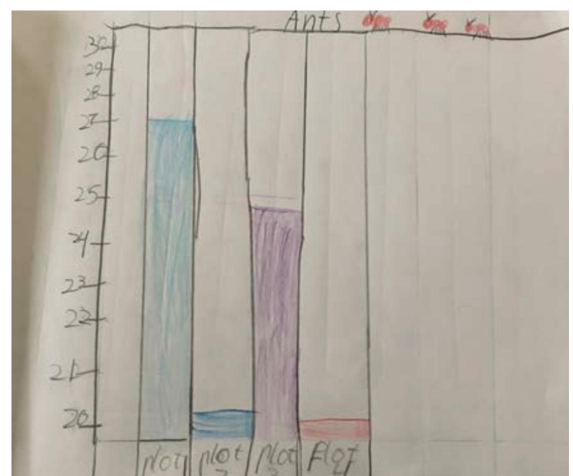
GRAPHS: REPRESENTATIONS







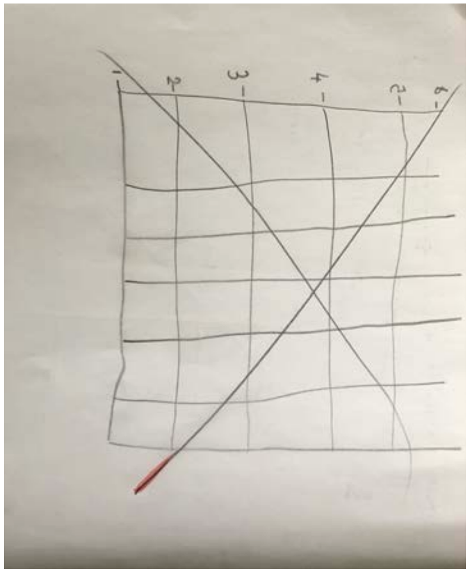


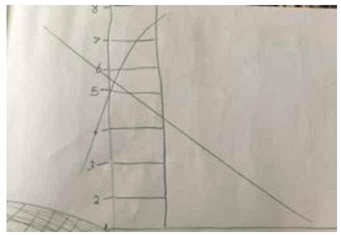


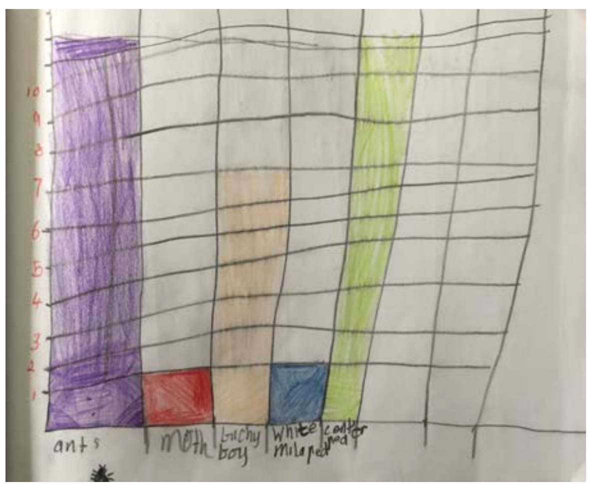
Language modelling
& Co-Constructed Data Modelling

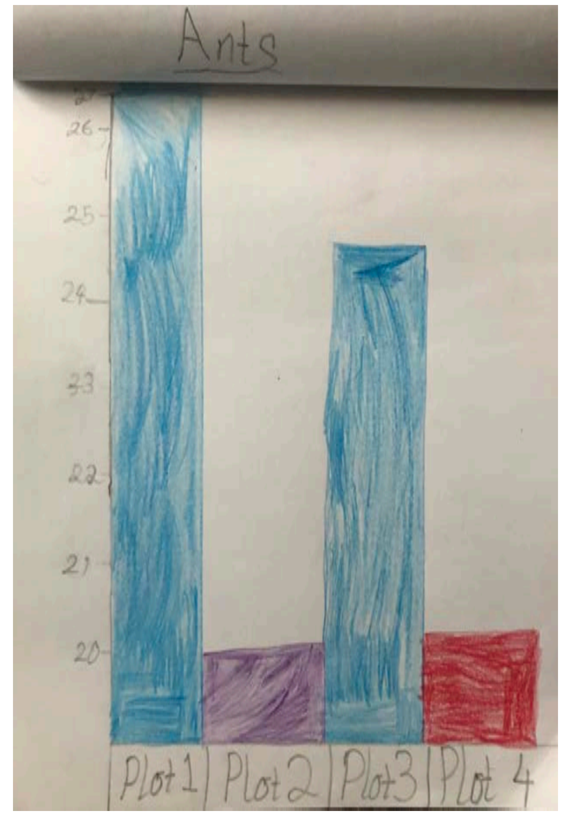
- Students sharing their data, graphs and representations
- Gallery Walks
- Probing questions…
- What makes a clear graph?
- What makes the data clear?

STUDENT GAINS…

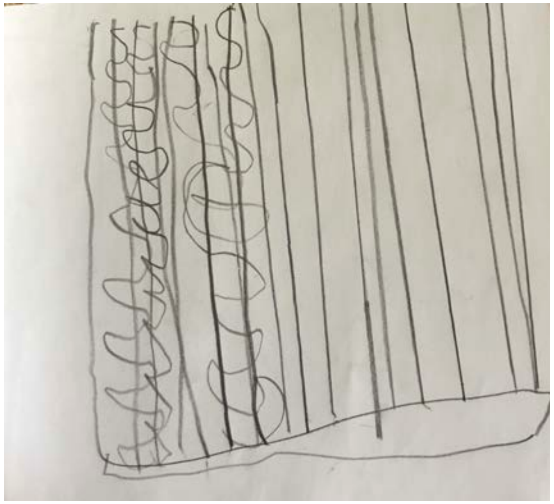


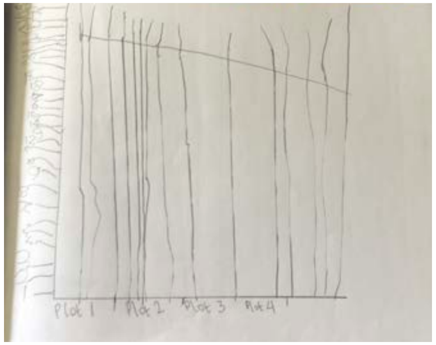




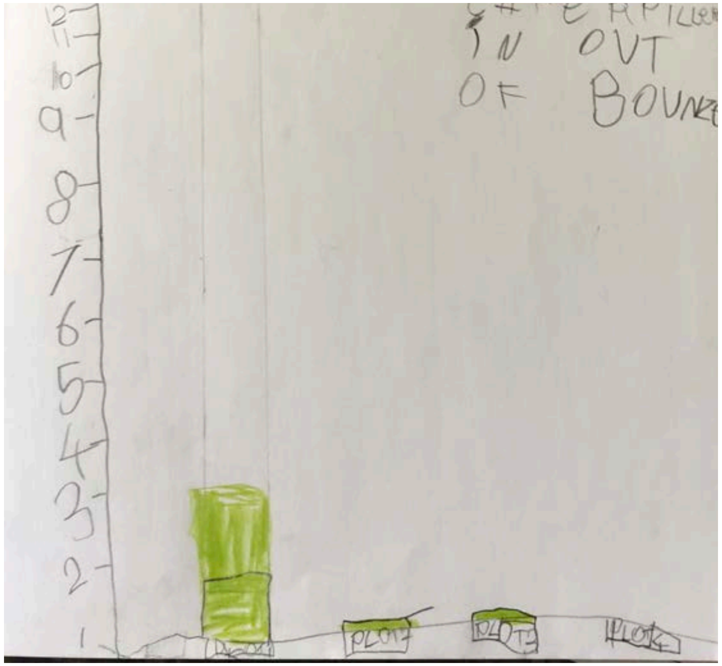


Look what I can do now!





I didn't know what
I was doing



But look what I can do now!

School B: Year one

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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 test
Year 1

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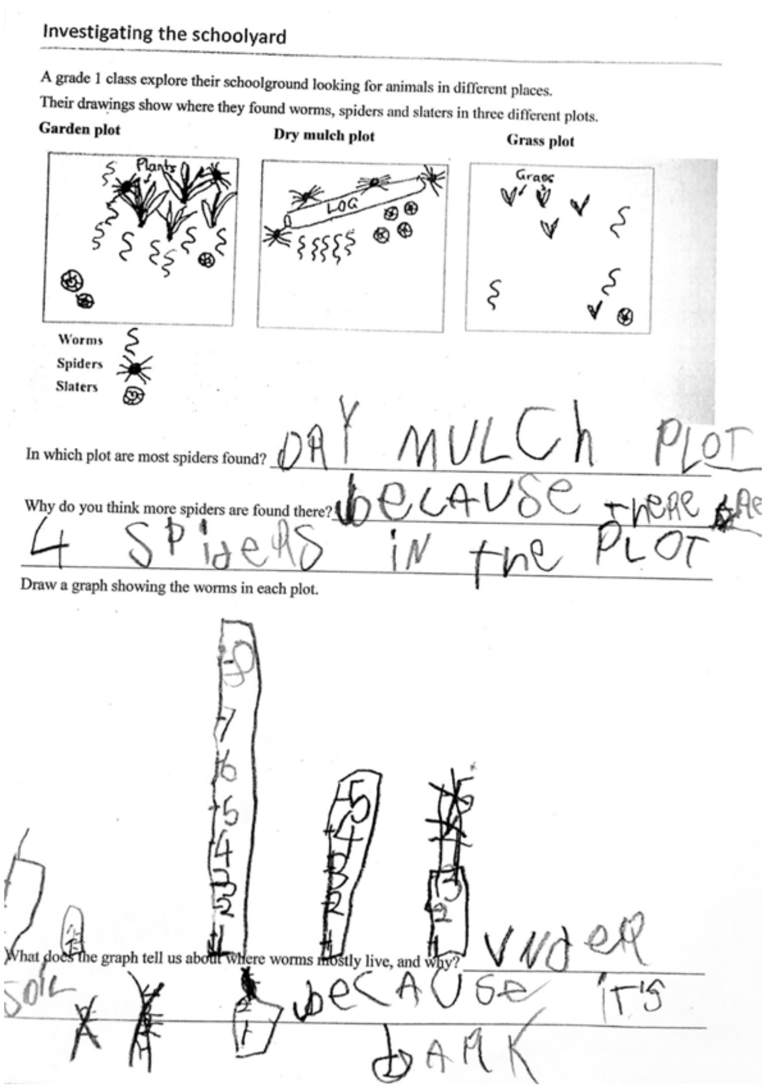


Investigating the schoolyard

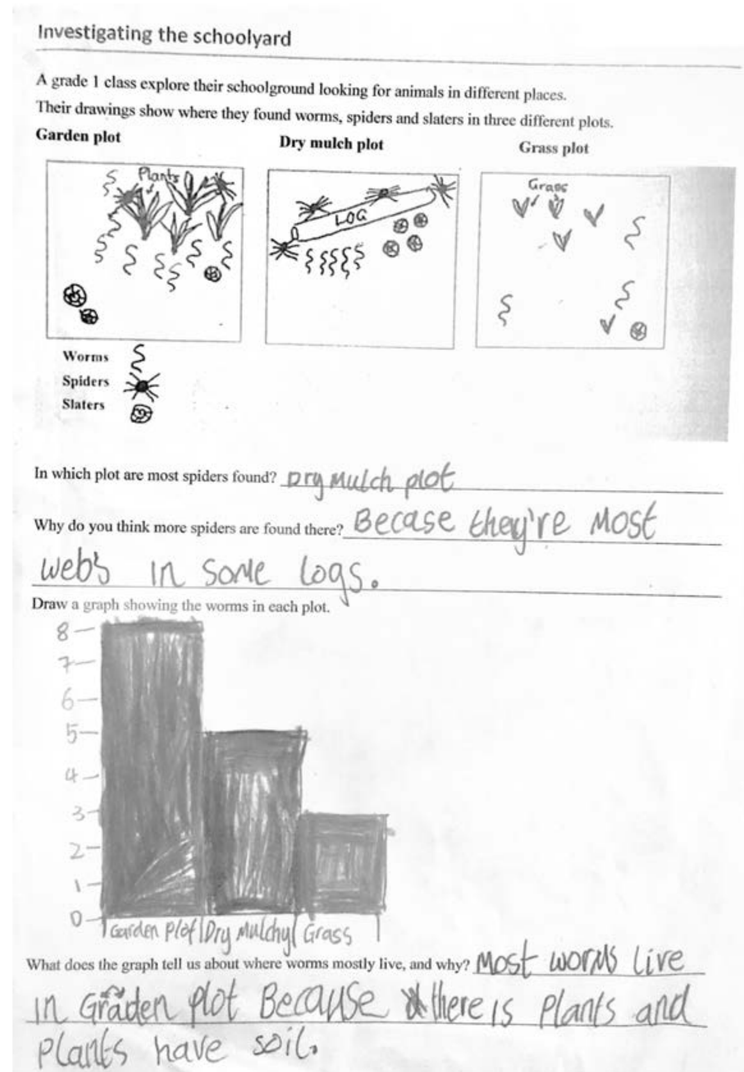
A grade 1 class explore their schoolground looking for animals in different places.
Their drawings show where they found worms, spiders and slaters in three different plots.

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

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.

In which plot are most spiders found? Dry Mulch plot

Why do you think more spiders are found there? Becase they're Most web's 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.

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Post test
Year 4

LIVING THINGS IN THE SCHOOLGROUND INVESTIGATION

Grade 4X was doing a scientific study of small animals in different parts of the schoolground. Six groups were each given a sample plot to study, and they recorded the animals they found in it. Their results are shown in the table. Three habitats – a dry mulch area, a wetland area, and a garden area, each had two sample plots the same size.

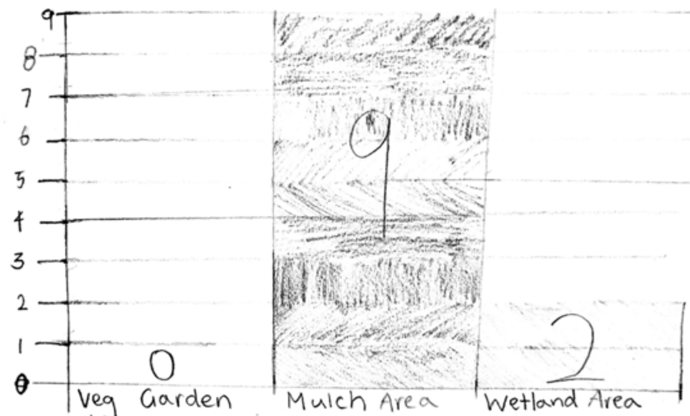
	Earwigs	Spiders	Ants	Millipedes	Grasshoppers	Woodlice	Beetles	Larvae	Worms
SAMPLE PLOT 1 (Dry mulch with tree)	2	4	1000+	7	0	1	1	0	3
SAMPLE PLOT 2 (Dry mulch with shrub)	0	1	5	2	0	0	0	7	1
DRY MULCH HABITAT TOTAL	2	5	1000+	9	0	1	1	7	4
SAMPLE PLOT 3 (Veg Garden)	0	6	100+	0	2	2	0	0	6
SAMPLE PLOT 4(Veg Garden with plants)	0	1	100+	0	0	3	0	0	7
VEGE GARDEN HABITAT TOTAL	0	7	200+	0	2	5	0	0	13
SAMPLE PLOT 5 (Wetland with grasses)	0	0	500+	3	3	0	0	0	8
SAMPLE PLOT 6 (wetland with grasses)	1	0	1000+	2	2	0	1	0	6
WETLAND HABITAT TOTAL	1	0	1000+ 1500+	2	2	0	1	0	6

Questions

1. Why do we call these 'sample plots'? Why do the sample plots have to be the same size?
I think ~~their~~ they're called 'sample plots' because we collect samples from the area.
The sample plots have to be the same size because if one plot was bigger than the other, it wouldn't be a fair test.

2. Which habitat are most woodlice (slaters) found in? Why do you think they are found mostly there? Wood lice was most found in the vegetable garden. I think ~~they~~ ~~th~~ wood lice was found there because the soil in the vegetable garden is moist and soft, so it is easier to dig in.

3. Draw a graph to compare the number of millipedes found in different places and explain why you think millipedes live where they do.

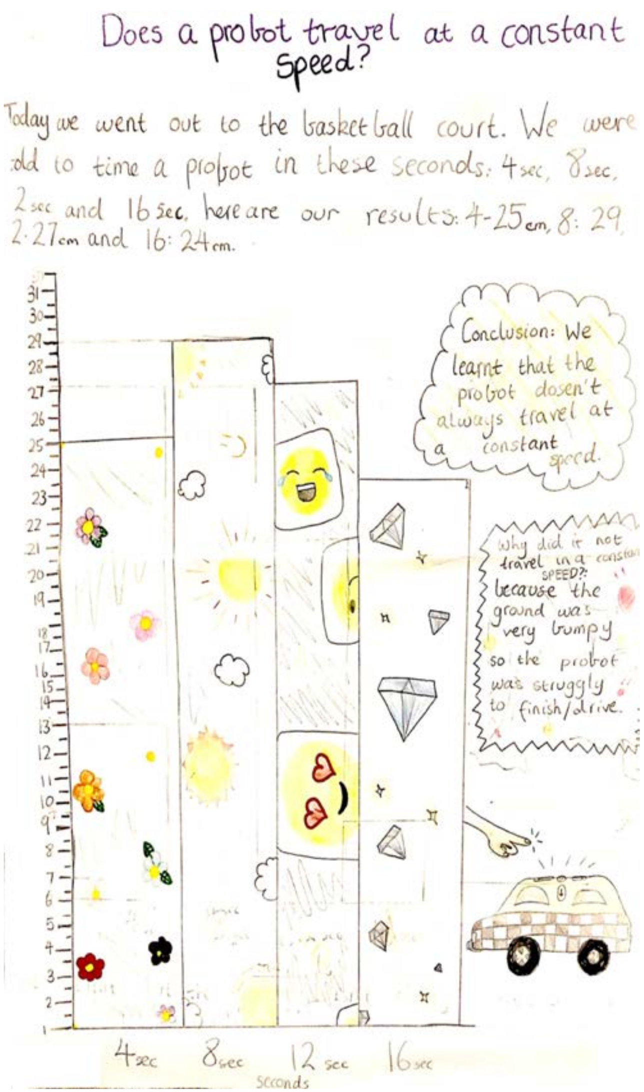


Why? I think ~~the millipedes~~ most of the millipedes ~~live~~ was found in the mulch area because the mulch area has what the millipedes need, like shelter (like tanbark).

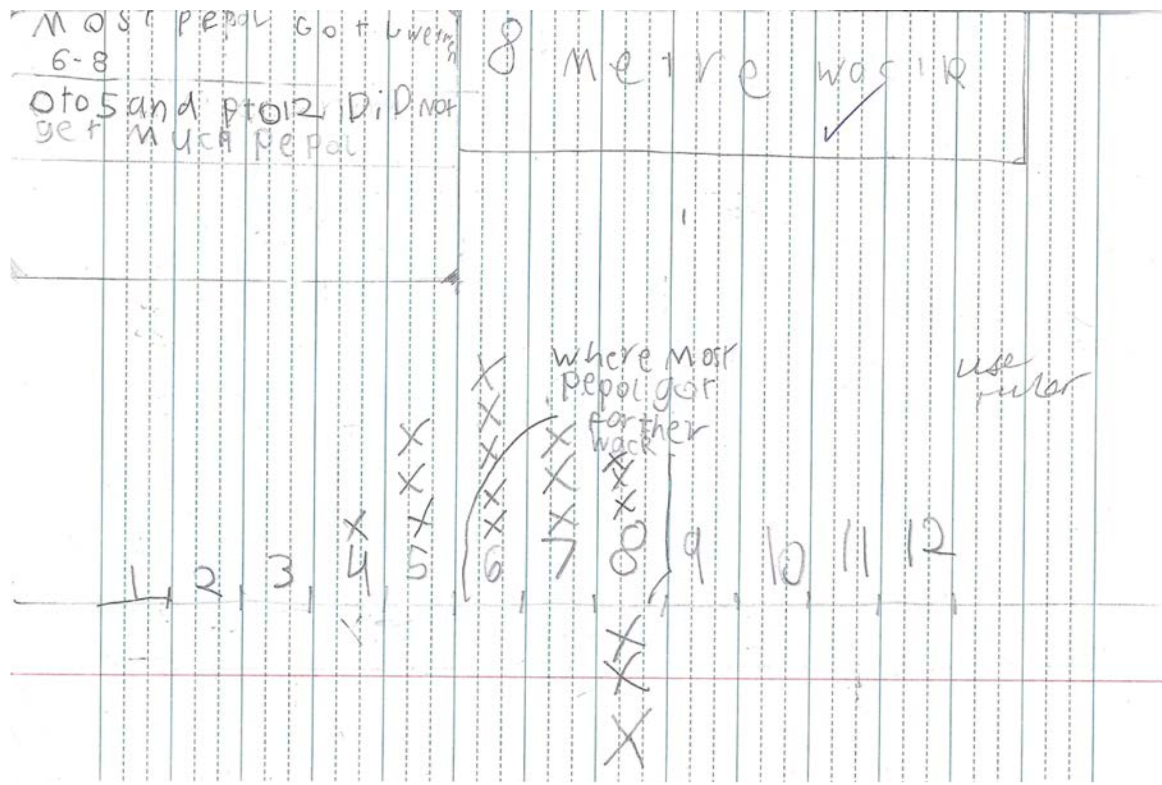
4. Why doesn't each group in the sample plots in the same habitat find the same amount of animals?
Because not all the animals need the same thing. In one plot, ~~there~~ in the vegetable garden, there was lots of plants. In another, ~~th~~ plot in the vegetable garden there wasn't that many plants. If we went out today, to our plot, there wouldn't be the same amount of animals as we found last time because the animals would've moved.

5. Write down one interesting thing you notice about the different living things found in the plots?
Something interesting is that the vegetable garden had 7 spiders. I didn't know that spiders lived in the garden. But the garden has alot of insects which spiders feed on.

Representing motion

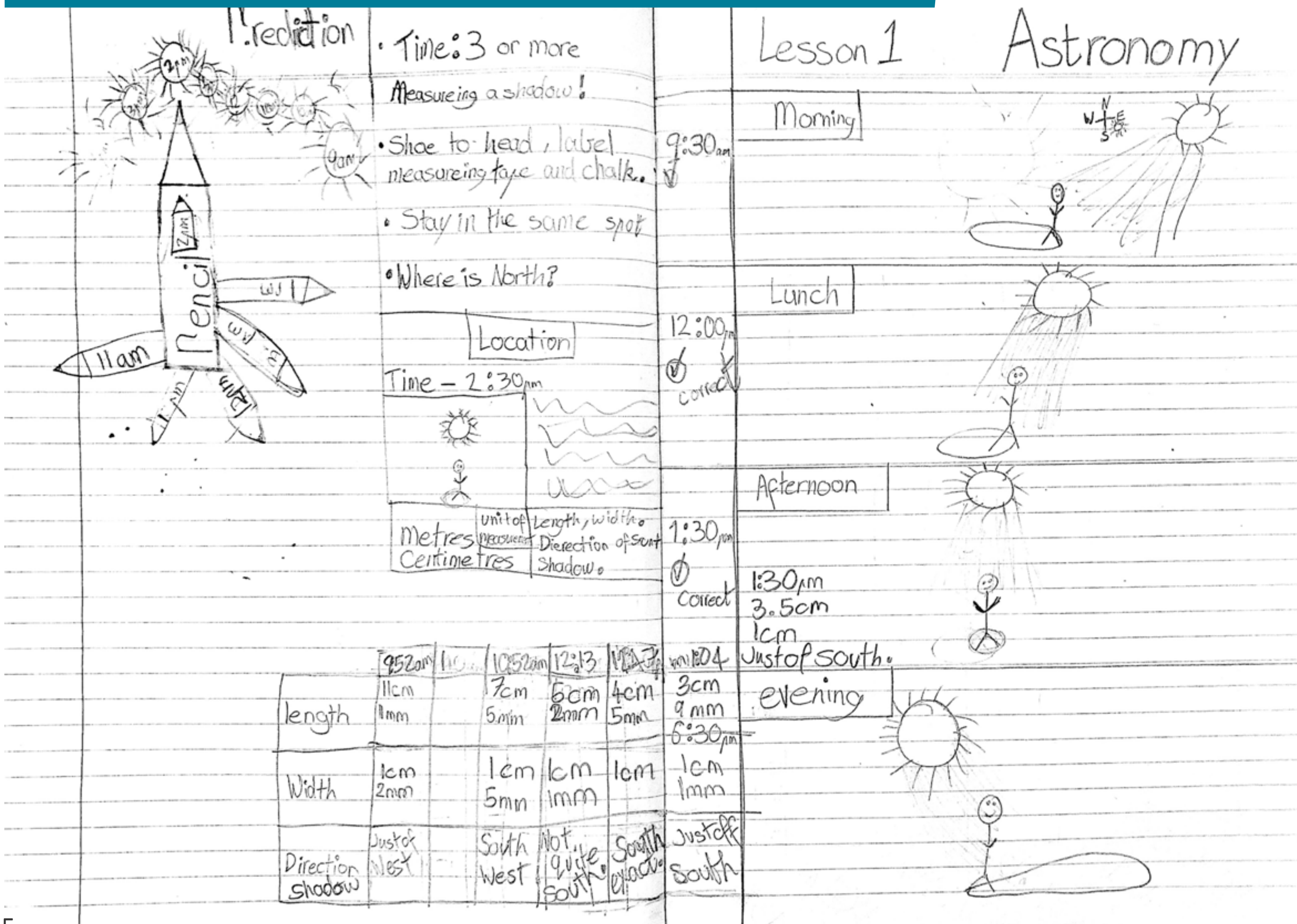


Does a probot travel at constant speed?



Variation in time to walk 8m

Astronomy


Prediction
Pencil
11am
Time: 3 or more
Measureing a shadow!
Shoe to head, label
measureing tape and chalk.
Stay in the same spot
Where is North?
Location
Time – 2:30pm
metres
Centimetres
Unit of measurement
Length, width.
Dierection of sun
Shadow.
length
Width
Direction shadow
9:52am
11cm
7cm
5mm
5cm
2mm
4cm
5mm
1cm
2mm
1cm
5mm
1cm
1mm
1cm
Just of West
South West
Not quite South
South exactly
Just of South
Lesson 1
Astronomy
Morning
Lunch
Afternoon
evening
9:30am
12:00pm
correct
1:30pm
Correct
1:30pm
3.5cm
1cm
Just of south.
3cm
9 mm
6:30pm
1cm
1mm

Analysis intentions

1. Construction of developmental progressions in ideas /representational work:
   a. Specific scientific concepts such as adaptation and habitat
   b. Mathematical constructs – measure, variation, data modelling
   c. Meta representational understandings e.g. the way systems can be mathematised
2. Construction of exemplar sequences with student outcome measures
3. Tracking case study students over the three years
4. Refinement and theorising the pedagogy
5. Refinement and theorising the nature of interdisciplinarity
6. Teacher change- the challenges for teachers and productive professional learning support

Current challenges

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For the team:

- Conceptualising productive relations between science and mathematics in the different topics
- The writing of multiple detailed sequences to parallel the curriculum
- Teachers' busy lives - finding time to workshop and debrief
- Blowout in the numbers of classes

Regarding teachers:

- Constraints of curriculum, particularly commitment to a very tight sequencing of mathematics
- Time constraints – fitting in both activity and discussion around students' ideas within a lesson
- Pedagogical and epistemological challenges – how to support student invention and work with their ideas to move them forward
- Teacher variability in trusting what students can bring to the table. The urge to 'tell'.
- Constructing a clear and shared view of the pedagogy and our purposes

Successes

- Teachers generally have loved the sequences
- Students are engaged with the activities
- The quality of learning for students
- Teacher learning
- Working closely and productively with teachers

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Thank You