



# Developing Adaptive Expertise in Primary Science & Mathematics Education

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**Australian Government**  
**Australian Research Council**

# Project team

Our team represents a collaboration between researchers at Monash University, Deakin University and University of Melbourne.

## Investigators



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*(Chief Investigator)*



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## Research Fellows



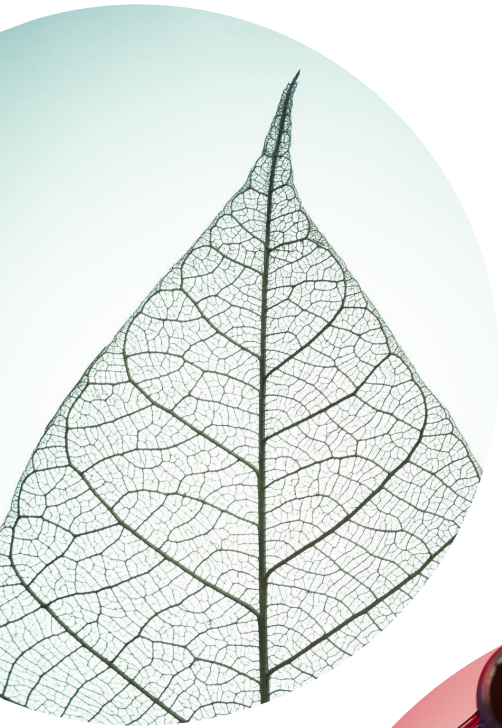
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Monash Education

# Context & problem

- Equipping young people with knowledge and skills that can enable them to critically analyse, problem solve and innovate solutions to real-world challenges *requires connecting skills and knowledge* across disciplines.
- Interdisciplinary approaches to teaching mathematics and science have been shown to lead to deeper learning, enhanced engagement and development of skills such as problem solving, creative and critical thinking.
- Traditional school curricula are designed to separate, not connect different disciplines.
- The shift from disciplinary to interdisciplinary approaches requires new skills from teachers and students.



# Interdisciplinary maths & science

- In interdisciplinary maths and science teaching, typically, science provides the context and the content; the mathematics becomes an add-on (Williams & Roth, 2019).
- Teaching mathematics and science in interdisciplinary ways is challenging for teachers (Ríordáin, Johnston & Walsh, 2016).

# Adaptive Expertise Project Overview

**Project aims:** to improve theoretical and practical understanding of the nature and development of primary teachers' adaptive expertise in interdisciplinary mathematics and science.

## **Key research questions:**

1. How can primary teachers' adaptive expertise in interdisciplinary mathematics and science be characterised in terms of components and levels?
2. To what extent, and how, does primary teachers' adaptive expertise change and develop during a trajectory across two school years aimed at interdisciplinary mathematics and science in a co-plan, co-teach and co-reflect approach?



***“Imagine two sushi chefs: one who makes every piece perfectly but routinely makes the same few types over and over (classic or routine expertise), and one produces new menus frequently (adaptive expertise)”***

- Hatano & Inagaki (1986)



Photo by [Fadya Azhary](#) on [Unsplash](#)



Screenshot of video by [Make Sushi](#) on [Youtube](#)

# Two kinds of Teacher Expertise

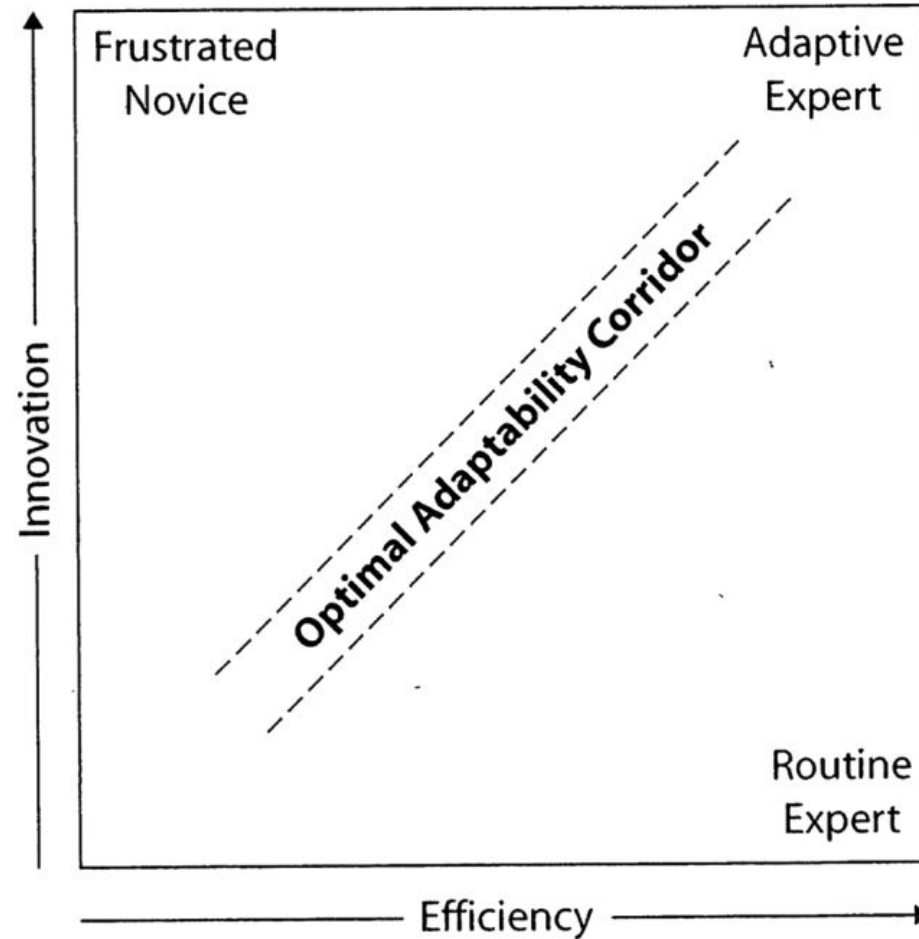
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**Routine expertise:** established ways of responding to problems and standard ways of approaching new tasks; effective in stable environments.

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**Adaptive expertise:** the capability to use knowledge to understand and work effectively to problem solve in novel situations and changing contexts.

# Adaptive and Routine Expertise



The trajectory towards adaptive expertise balances efficiency and innovation via the optimal adaptability corridor (Schwartz, D. L., Bransford, J. D., & Sears, D. , 2005).

# Adaptive Expertise components (Yoon et al., 2019)

## Component

**Flexibility:** the ability to opportunistically plan, change enactments faster than non-experts, and flexibly and critically apply their knowledge to new situations while constantly learning.

**Deep-level understanding:** addresses the need to not only have acquired content and pedagogical knowledge, but to have a deep understanding of it in order to use such knowledge effectively.

**Deliberate practice:** addresses the need for teachers to receive feedback about and reflect upon their teaching either directly from their observations, from student outcomes, or from outside perspectives, with the intent to shift their practice based on feedback and reflection.

## Manifestation

One's ability to integrate aspects of teacher knowledge in relation to the teaching act with the goal of improving outcomes while responding to their specific contexts.

One's ability to recognise meaningful patterns quickly, allowing one to attend to deeper-level problem solving and in turn perform at a higher level.

One's ability to engage in reflection, conscious deliberation, and regulation processes.

# Research Design

Year	1		2		3	
School Terms	1 & 2	3 & 4	1 & 2	3 & 4	1 & 2	3 & 4
Human Research Ethics Application						
Finalising lesson sequences, interview protocols, online video survey tool, observation schedule						
Participant recruitment						
Development and validation of instrument						
Initial interview		RQ1				
Pre- and post-video survey		RQ1				RQ1&2
Teachers' half-day orientation workshop						
Co-planning, co-teaching and co-reflecting interdisciplinary lesson sequence			LS1	LS2	LS1-R	LS2-R
Data collection: video-recording lessons, lesson observations, post-lesson sequence video-stimulated interviews, student data			RQ1 & 3	RQ1,2 & 3	RQ1,2 & 3	RQ1,2 & 3
Data analysis		RQ1	RQ1 & 3	RQ1,2 & 3	RQ1,2 & 3	RQ1,2 & 3
Dissemination						



## Interdisciplinary maths and science lesson sequences

- Two sequences of 3 lessons for Year 5/6. Co-designed by teachers and teacher educators/researchers
- ***Keeping your finger on the pulse*** uses the context of ‘heart rate’ as an adaptation for human survival to engage students with important mathematical and scientific ideas, in particular, proportional reasoning and scientific inquiry skills.  
This sequence has been piloted and filmed in July-August in one school.
- ***Journey Through Space*** encourages students to explore the solar system, in particular focusing on distances and times it would take to travel between planets and bodies within the solar system.  
This sequence has been implemented in Oct/Nov by 4 teachers in two schools.

Overview of learning tasks	Learning focus
<p><b>Lesson 1</b></p> <ul style="list-style-type: none"> <li>▪ <b>Name and rank the order of the planets of our solar system.</b></li> <li>▪ <b>Recognise the relative size of each planet by assigning diameter values to each planet in words, rather than numbers.</b></li> </ul>	<p>Mathematics focus: Relative size and distance of the planets and making sense of large numbers.</p> <p>Science focus: The Earth is part of a system of planets orbiting around a star.</p>
<p><b>Lesson 2</b></p> <ul style="list-style-type: none"> <li>▪ <b>Calculate relative speeds of different modes of transport, in particular: walking, driving, flying in an airplane or a space probe between Sydney and Melbourne</b></li> </ul>	<p>Mathematics focus: Estimating, proportional reasoning e.g., speed can be measured in km/hour and metres/seconds, comparing units.</p> <p>Science focus: Using concrete experiences to act as a <u>spring board</u> to more abstract ideas</p>
<p><b>Lesson 3</b></p> <ul style="list-style-type: none"> <li>▪ <b>Review estimates of travelling to the moon</b></li> <li>▪ <b>Estimate the distance and speed it would take in a plane and probe to travel to your chosen place.</b></li> <li>▪ <b>Calculate the distance and speed of the probe between Melbourne and Sydney and Earth and the moon.</b></li> <li>▪ <b>Create timeline to compare distance between earth and moon.</b></li> </ul>	<p>Mathematics focus: Working with big numbers to develop an appreciation for differences in magnitude e.g., the moon is 384 million metres from the Earth</p> <p>Science focus: Relative distances between the planets. The relative distances between planets <u>is</u> a different scale to the relative diameters of the planets. Order of the planets. Size of the solar system in terms of distances or how long it takes to travel across it.</p>



## ***Guidelines for planning interdisciplinary lesson sequences:***

1. Prepare for the planning process: Design a planning framework
2. Use the curriculum as a guide for planning and thinking creatively
3. Connect concepts and skills using an iterative process
4. Use instructional processes to guide integration
5. Develop a collaborative culture
6. Enable flexibility to allow the content and process to evolve.

“Beginning and ending with the science learning, and adopting an iterative process to planning, meant that the ‘science was acting in the service of mathematics’ and vice versa.” (Hughes et al., 2022, p. 72).



# Data sources

1. Initial teacher interviews:  
During initial workshop, each teacher was interviewed about their experiences of co-teaching and collaboration, their expectations in relation to participation in the project, experiences with mathematics, science and interdisciplinary teaching, and more general aspects of their school context.
2. Adaptive Expertise Video Survey Tool (Pre- and post)
3. For each lesson sequence:
  - Annotated lesson plans & student artefacts
  - Video recording (360 Video) of classroom
  - Teacher reflection on classroom videos (individual), teacher interviews (in pairs)

# Video survey instrument



- Identify variation in teachers' adaptive expertise.
- Compare their adaptive expertise over the two-year period, that is at the beginning and end of their engagement in the project.
- Responses will be analysed to identify evidence of the three characteristics of adaptive expertise – flexibility, deep-level of understanding and deliberate practice.

# Design process for AE-VS instrument

## Step 1

Independently viewing the (pilot) videos to identify students' mathematical and scientific thinking that challenges teachers' ability to respond to students.

## Step 2

Using a spreadsheet to record our critical/challenging moments, connection to theoretical framework.

## Step 3

Team meeting to compare selected challenging moments and discuss and relate these moments to theoretical framing of AE.

## Step 4

Compiling possible video extracts to a common list for final discussion.

## Step 5

Team meeting to discuss question structure: MC vs Open-ended.  
Drafting of multiple-choice items with audio explanation (Phonic) for the video extracts.

## Step 6

Team meeting to make final selection of video items and the wording of MC options for each item.

# An example of the final version of an item

After students measured their resting heart rate, they had to predict and measure the change in their heart rate as they undertook various activities such as walking, star jumping, and running. In this video clip, the teacher is responding to a student who has just calculated their bpm after walking for a minute, before doing star jumps for a minute. Please **watch the video**.



# An example of the final version of an item

What response or question would you have used when interacting with this student? Choose **one response** from the list below.

- A. "What did you find out?"
- B. "What do you think about your prediction for heart rate for star jumps?"
- C. "Do you think your heart rate for star jumps will be higher or lower than for walking? Why?"
- D. "I think you should change your prediction for star jumps, don't you?"
- E. Other questions you may ask (please describe below).

Why did you choose this response and not the other responses? Please audio record your **verbal explanation**.

RECORD



SUBMIT

# Back to the aims & research questions...progress to date

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THANK YOU!

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More information about the project  
can be found at:

<https://www.monash.edu/education/research/projects/primary-teachers-adaptive-expertise-in-interdisciplinary-maths-and-science>

