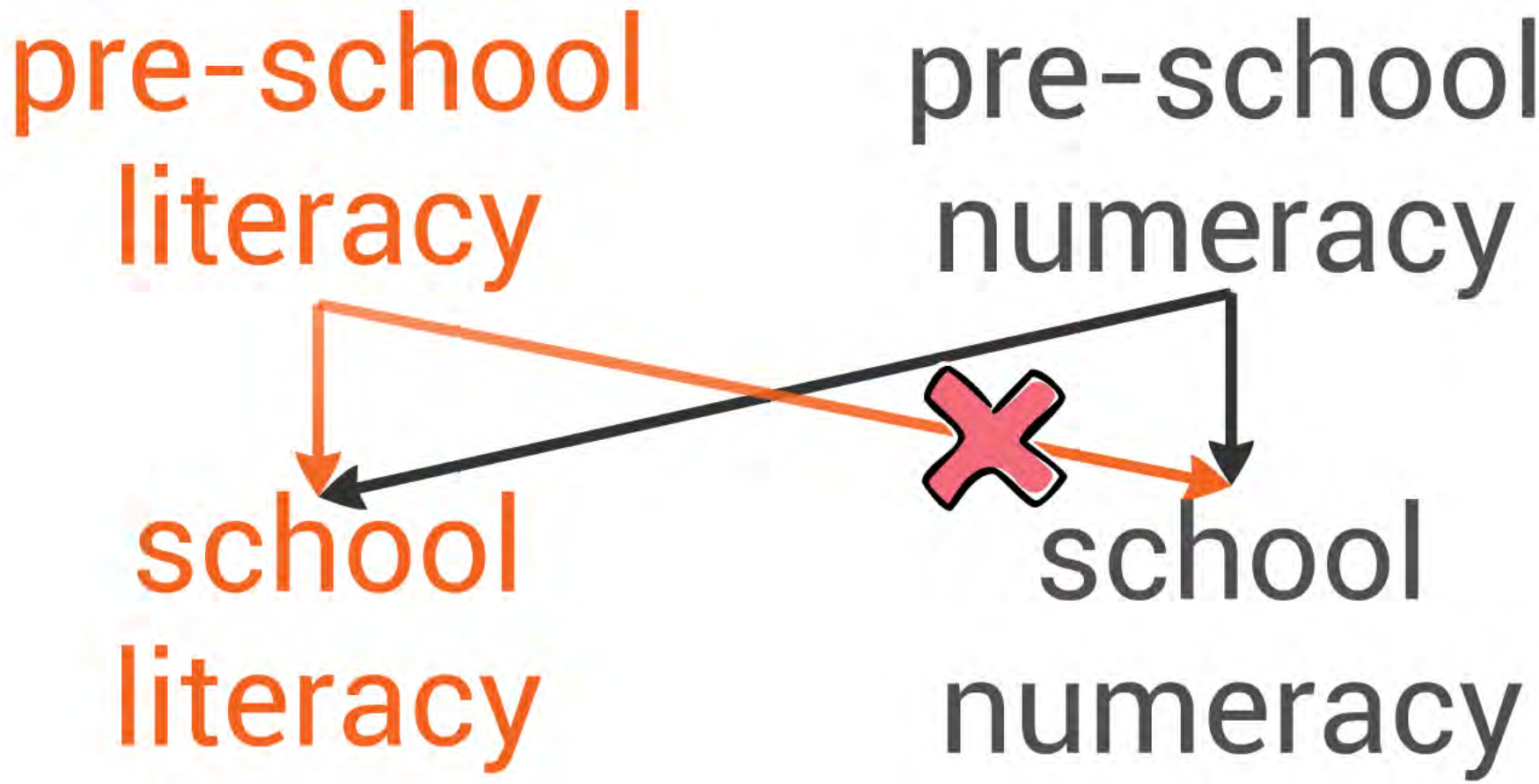
If mathematics is the key, what should it unlock?

hard thinking

SACE BOARD
SOUTH AUSTRALIA

martin.westwell@sa.gov.au


pre-school literacy
pre-school numeracy
school literacy
school numeracy

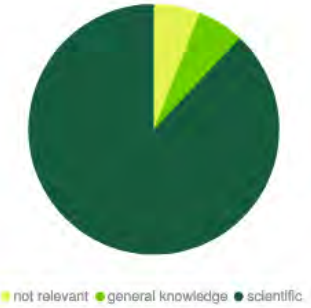
Peter Atkins
"Galileo's Finger: The Ten Great Ideas of Science"

"One of the finest creations of the human mind is mathematics, for not only is it the ***apotheosis of rational thought*** *but it is also the spine that* ***renders scientific speculation sufficiently rigid*** *to confront experience.*

Scientific hypotheses themselves are like jelly; they need the rigidity of mathematical formulation if they are to stand up to experimental verification and fit into the network of concepts that constitute physical science."

Anne Pillman: PhD research, prelim. data
6 classes; 120 students

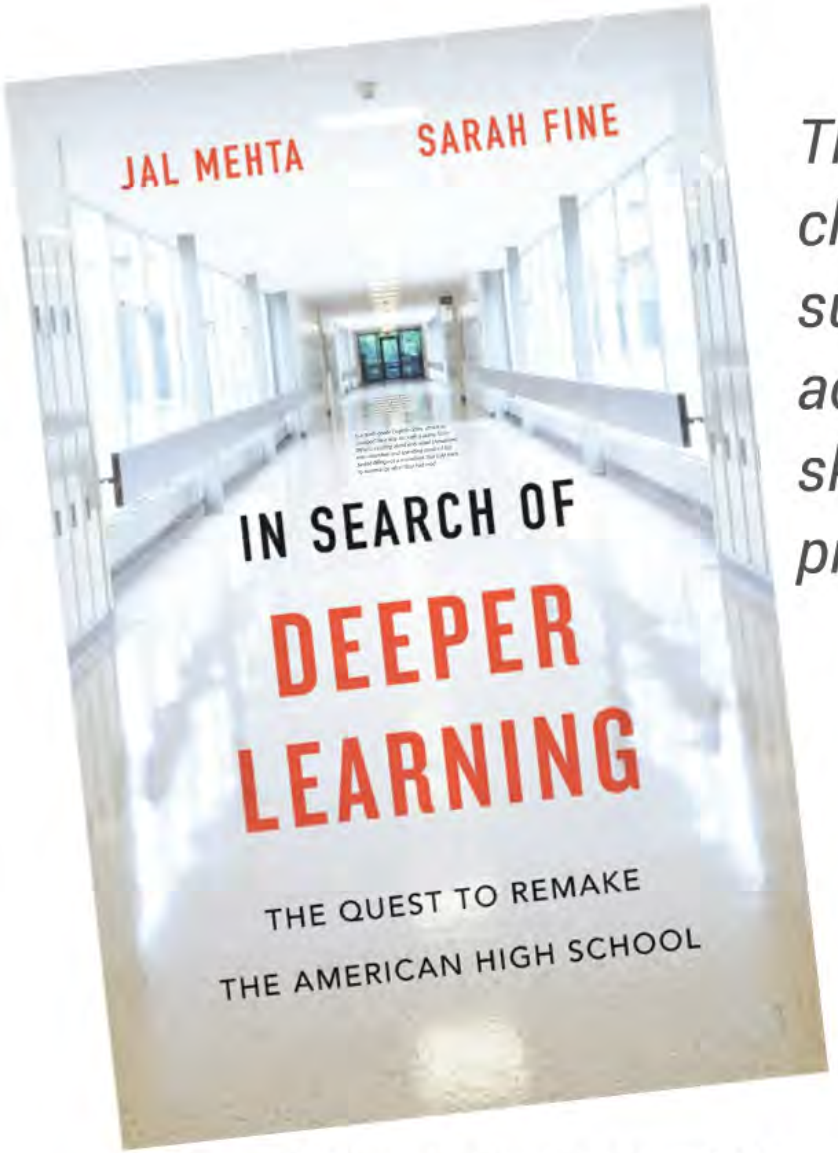
Q1 What causes earthquakes like this?



Q2 What what have tectonic plates got to do with damage like this?

Q3 Why might an earthquake cause power blackouts?

Q4 What have conductors, insulators and complete circuits got to do with power blackouts??



Harvard University Press; 9 April 2019

Their school, they told us, was was leading the charge... - using project-based learning to support students in developing both deep academic knowledge and "twenty-first century skills" such as collaboration and creative problem solving.

integrated values

mastery

"students had opportunities to develop knowledge and skill"

identity

"students came to see their core selves as vitally connected to what they were learning and doing"

creativity

"opportunities to enact their learning by producing something rather than simply receiving knowledge."

Ad
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unlocked for maths
unlocked by maths

Australian Government
Chief Scientist

OFFICE OF THE CHIEF SCIENTIST – OCCASIONAL PAPER, JULY 2018

IMPROVING THE MATHEMATICS PERFORMANCE OF AUSTRALIA'S STUDENTS

Phillippa Smith, Matthew Ladewig and Roslyn Prinsley

Our most improved schools show that rapid progress is possible

INTRODUCTION

The state of mathematics in Australian schools is a widely shared concern. Parents, educators, industry groups and governments all query why a prosperous country, placed second on the United Nations' Human Development Index, is sliding down the global education rankings.[1]

The trend is clear: Australia's mathematics performance has stalled or declined in NAPLAN (the National Assessment Program – Literacy and Numeracy), TIMSS (the Trends in International Mathematics and Science Study), and PISA (the Programme for International Student Assessment) whilst government funding per student has increased.[2,3,4]

In TIMSS, strong international performers like Singapore and Japan continue to extend their lead.[5,6] Canada, a nation to which we are often compared, now significantly outperforms us in all PISA and Year 8 TIMSS domains, despite its similar levels of per-student expenditure.[3,4,7]

At a glance

Australia's schools can turn around stalling mathematics results in two years.

A mastery-focused classroom and teachers enthusiastic about teaching mathematics are key.

Additional discipline-specific training and professional development of teachers improves conceptual understanding.

Principals can lead a culture of improvement from the top.

Professional learning communities are important for success.

Principals and teachers need support to develop data analysis skills.

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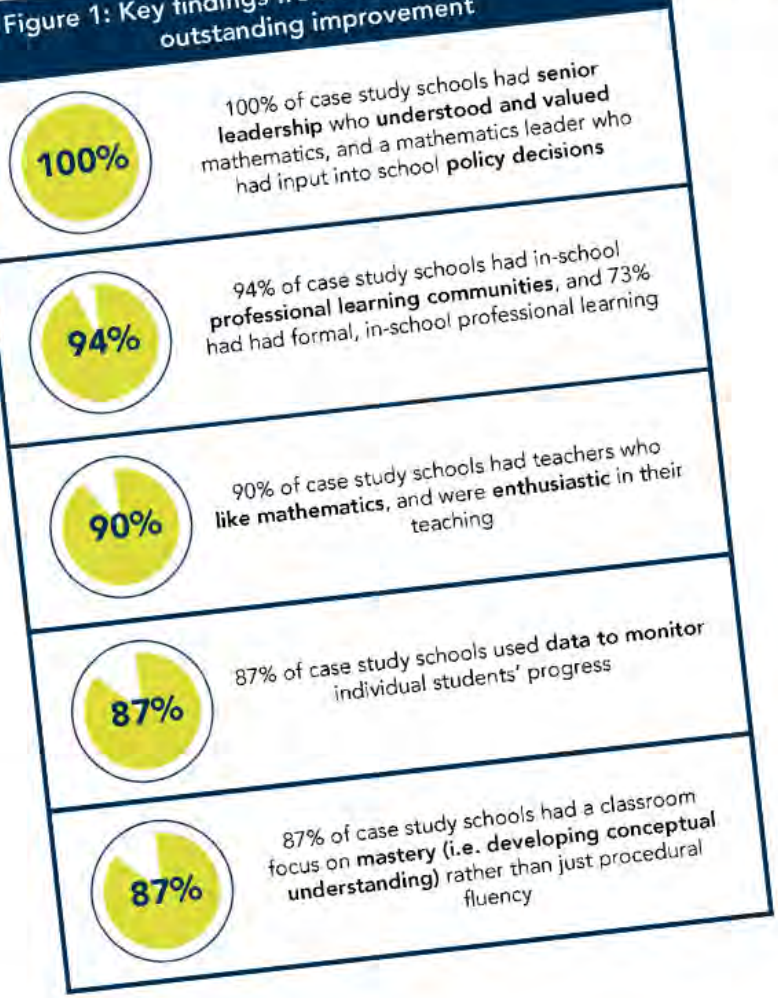
Figure 1: Key findings from case study schools with outstanding improvement



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Box 1: Examples of 'mastery oriented' and 'performance oriented' learning goals

MASTERY	PERFORMANCE
Developing competence	Demonstrating competence
Focus on learning, understanding and developing skills	Focus on ability and performance
Orient students to strive to acquire and improve skills and understanding	Orient students to strive to demonstrate superior, or mask inferior, ability relative to others[16,17]

in performance oriented classrooms were more likely to find mathematics difficult. Almost 90% of the high-improvement case study schools displayed a focus on conceptual understanding, not just procedural fluency.

The classroom focus should be on mastering concepts—not competing with other students or schools—and improved performance will follow.

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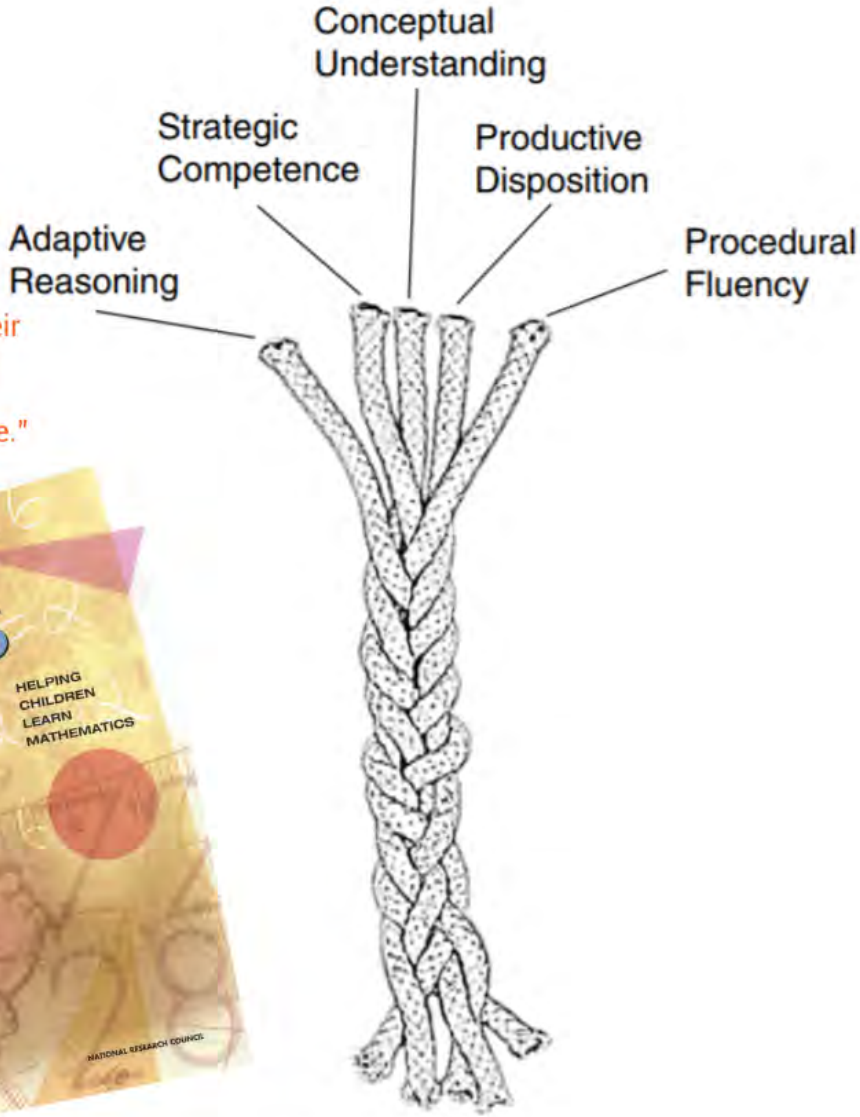
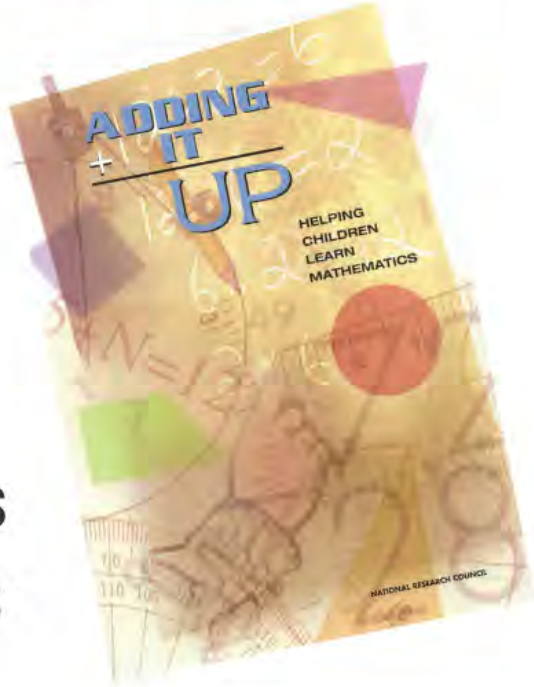


unlocked for maths
unlocked by maths



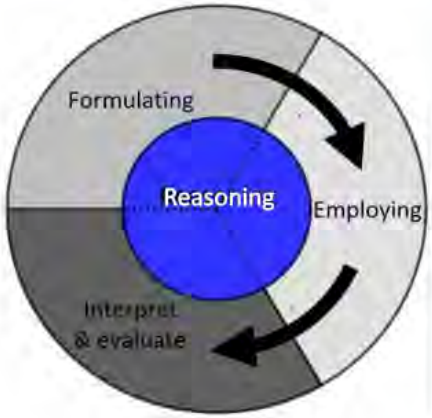
integrated mathematics proficiencies

PISA Mathematical literacy

Dr Peggy Carr,
Vice Chair PISA Governing Board
US Centre for Educational Statistics

learning entitlement

Defining Mathematical Literacy in 2021



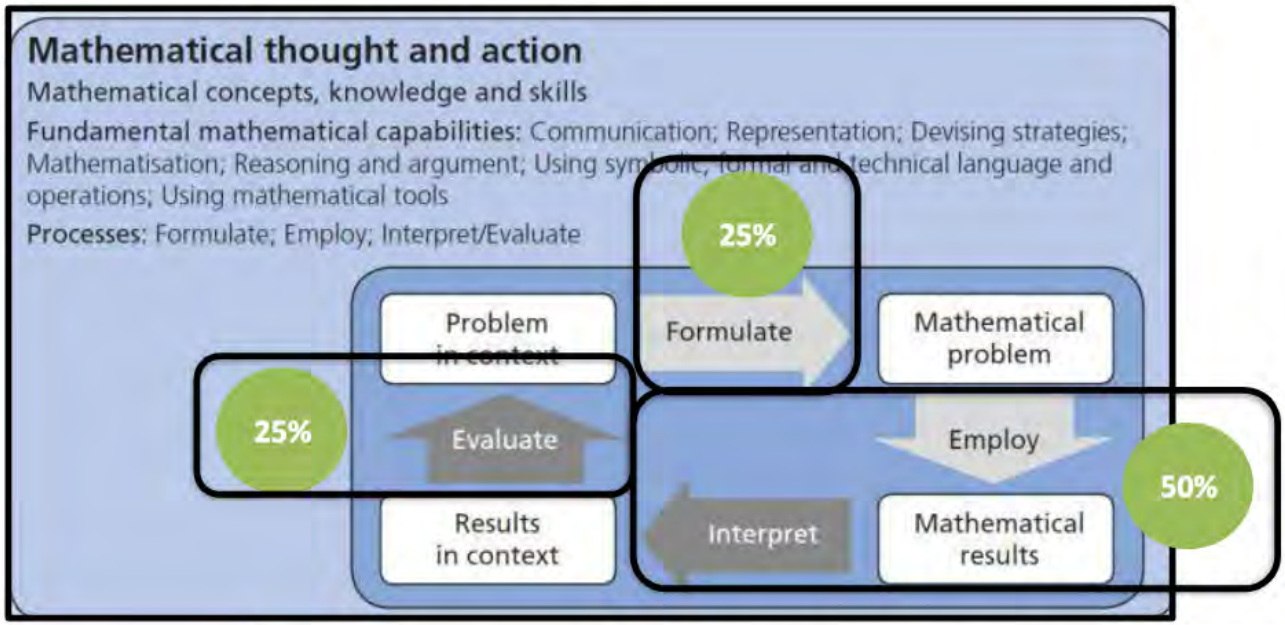
*Mathematical literacy is an individual's capacity to **reason mathematically** and to **formulate, employ,** and **interpret mathematics** to solve problems in a variety of real-world contexts.*

It includes concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to know the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective 21st century citizens.

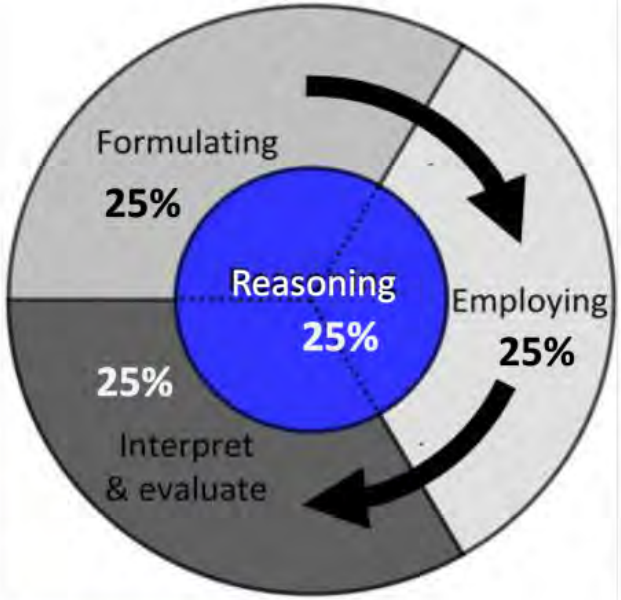
https://curriculumredesign.org/wp-content/uploads/Mathematics-in-the-21st-C_Geneva-Presentation_animated_v15.pdf

Development of the PISA 2021 Mathematics Framework

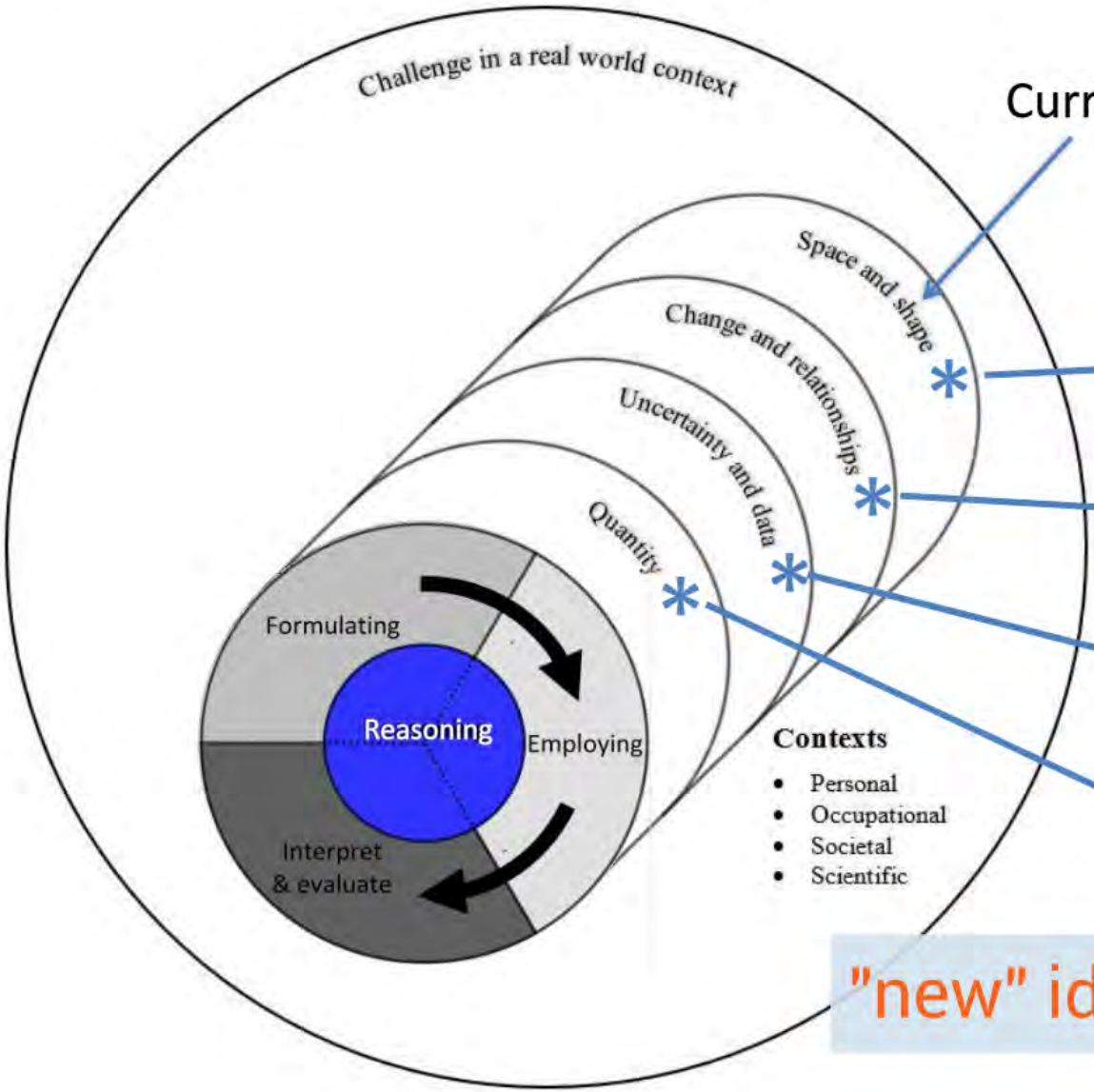
2012



2021



Preserving the underlying problem solving processes ensures that trend is maintained while the framework is expanded to include reasoning.



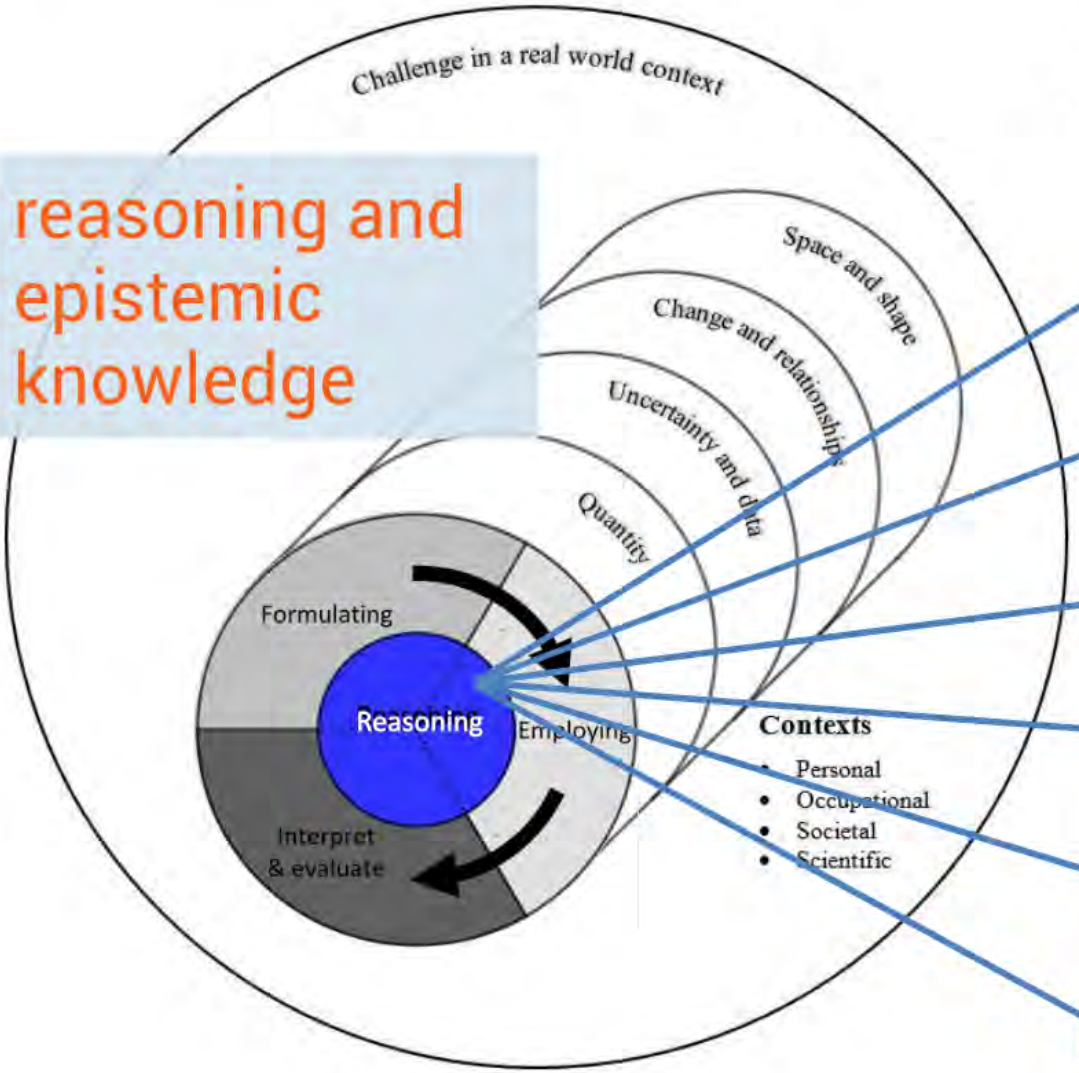
Current PISA mathematics subscales

Additions to PISA math subscales for 2021

- Geometric approximation
- Growth phenomena
- Conditional decision making
- Computer simulations

"new" ideas in traditional frame

reasoning and epistemic knowledge



Addition of PISA Reasoning

- Number systems and algebraic properties
- Mathematics as a system based on abstraction and symbolic representation
- Structure of mathematics and its regularities
- Functional relationships between quantities
- Mathematical modeling as a lens to the real world
- Variance at the heart of statistics

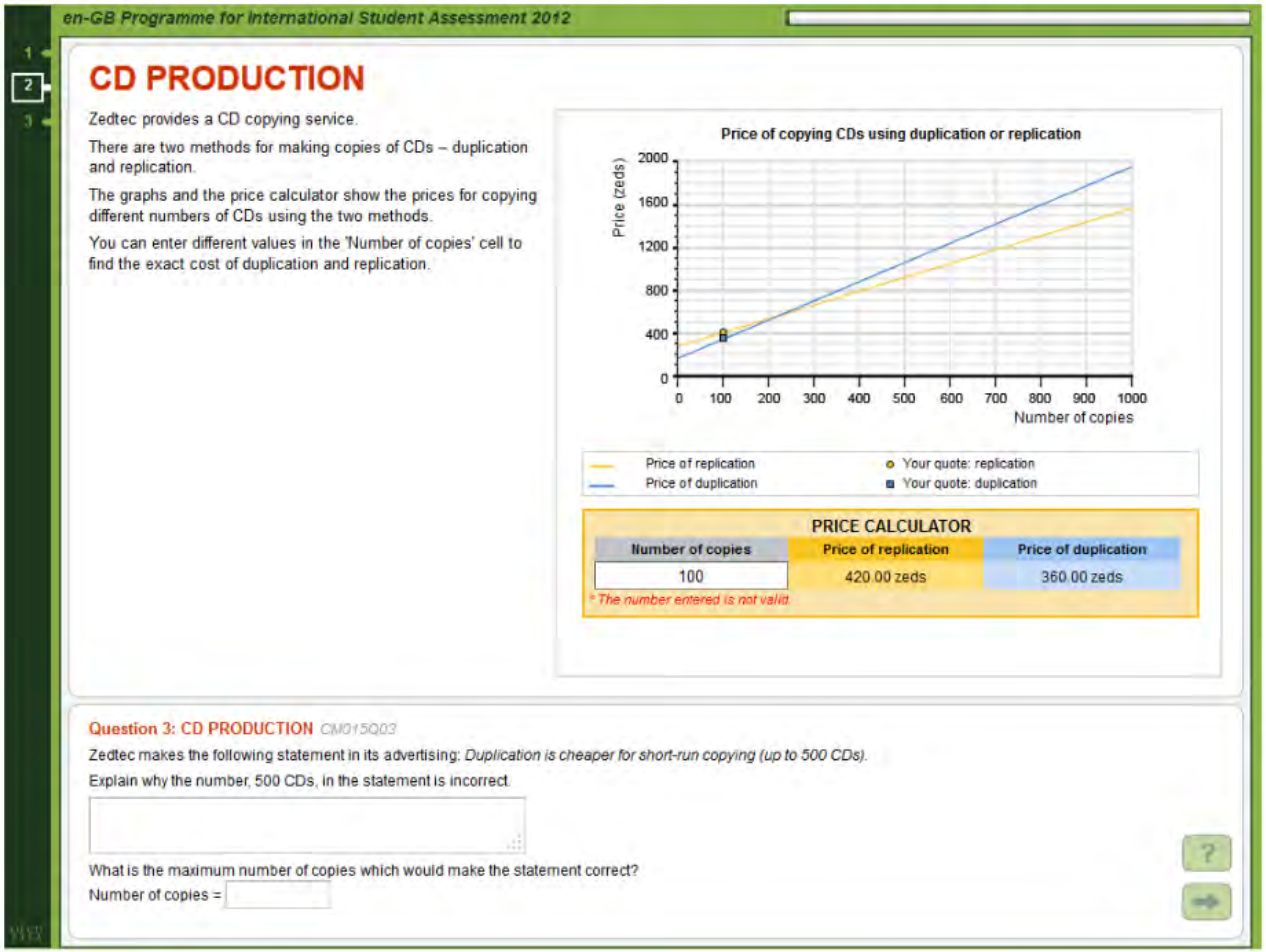
Take Advantage of the Digital Delivery System

Digital-based assessment (DBA) allows for measurement of skills and processes that cannot be accomplished through traditional paper-and-pencil assessments

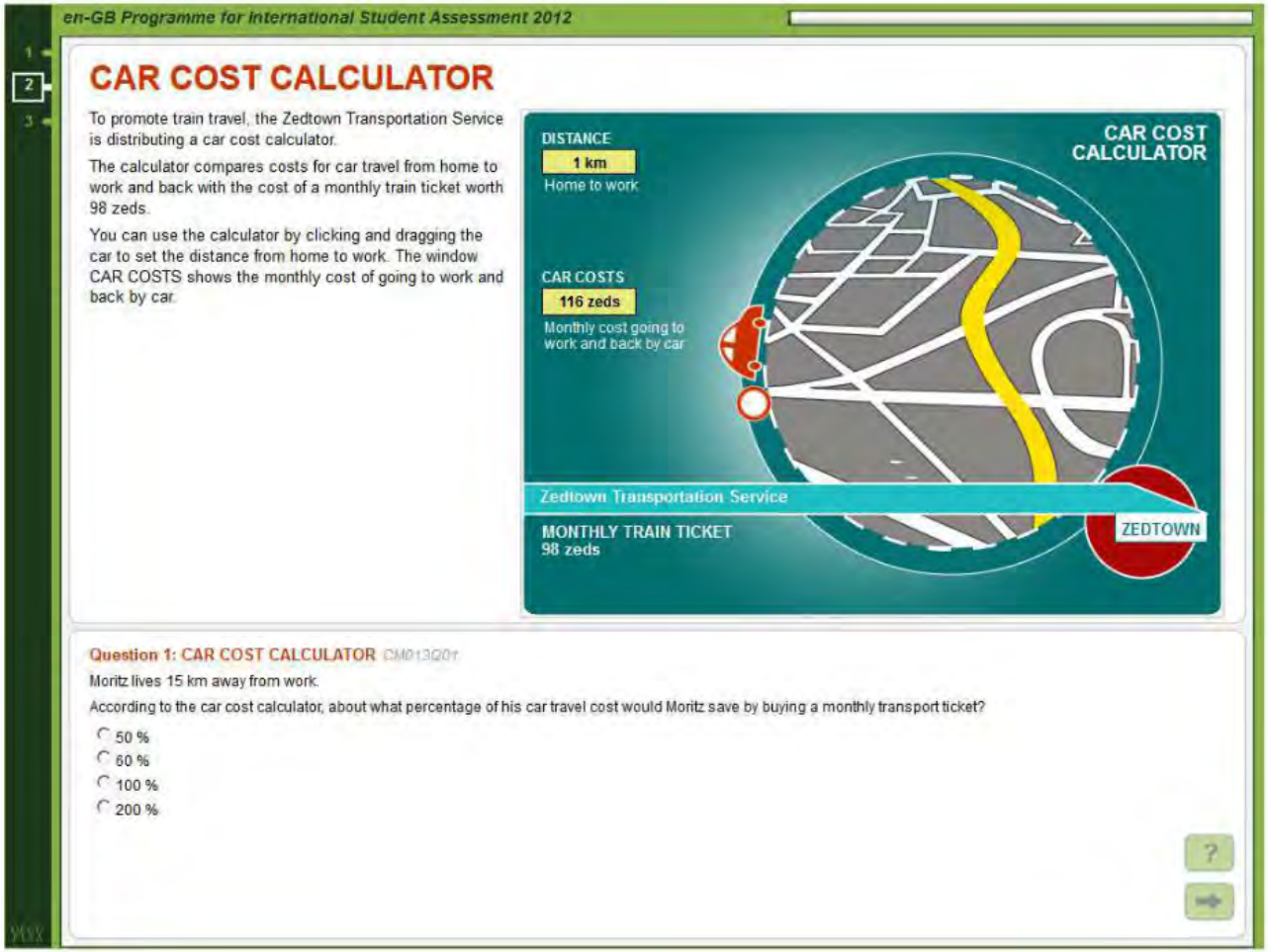
Examples

- Allows for simulations, which with captured log data, may be used to measure processes of mathematical reasoning

Sample Reasoning Item from 2012



Sample Reasoning Item from 2012

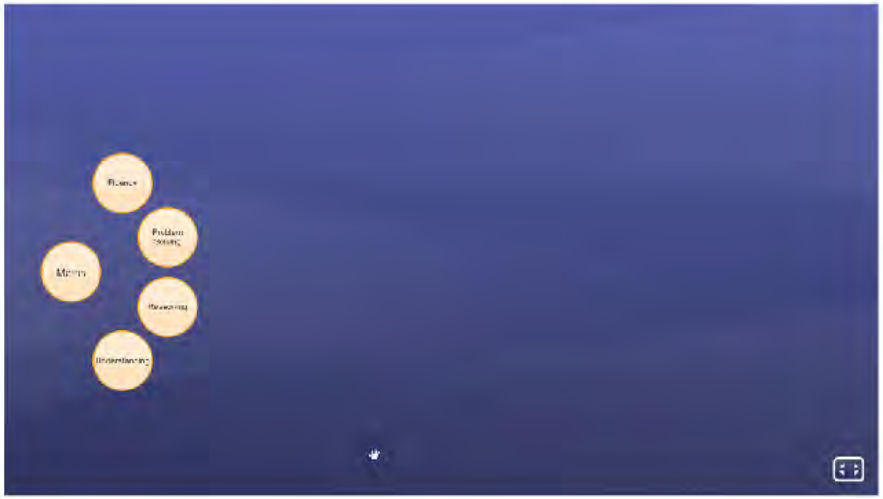


OECD/PISA: "The problem needs to simulate the real-world in its messy, complex way requiring the student to conceptualize, organize, and extract the relevant information before formulating and employing."

How to?
e.g., dialogue & questioning

hard thinking
strategic competence

https://acleadersresource.sa.edu.au/



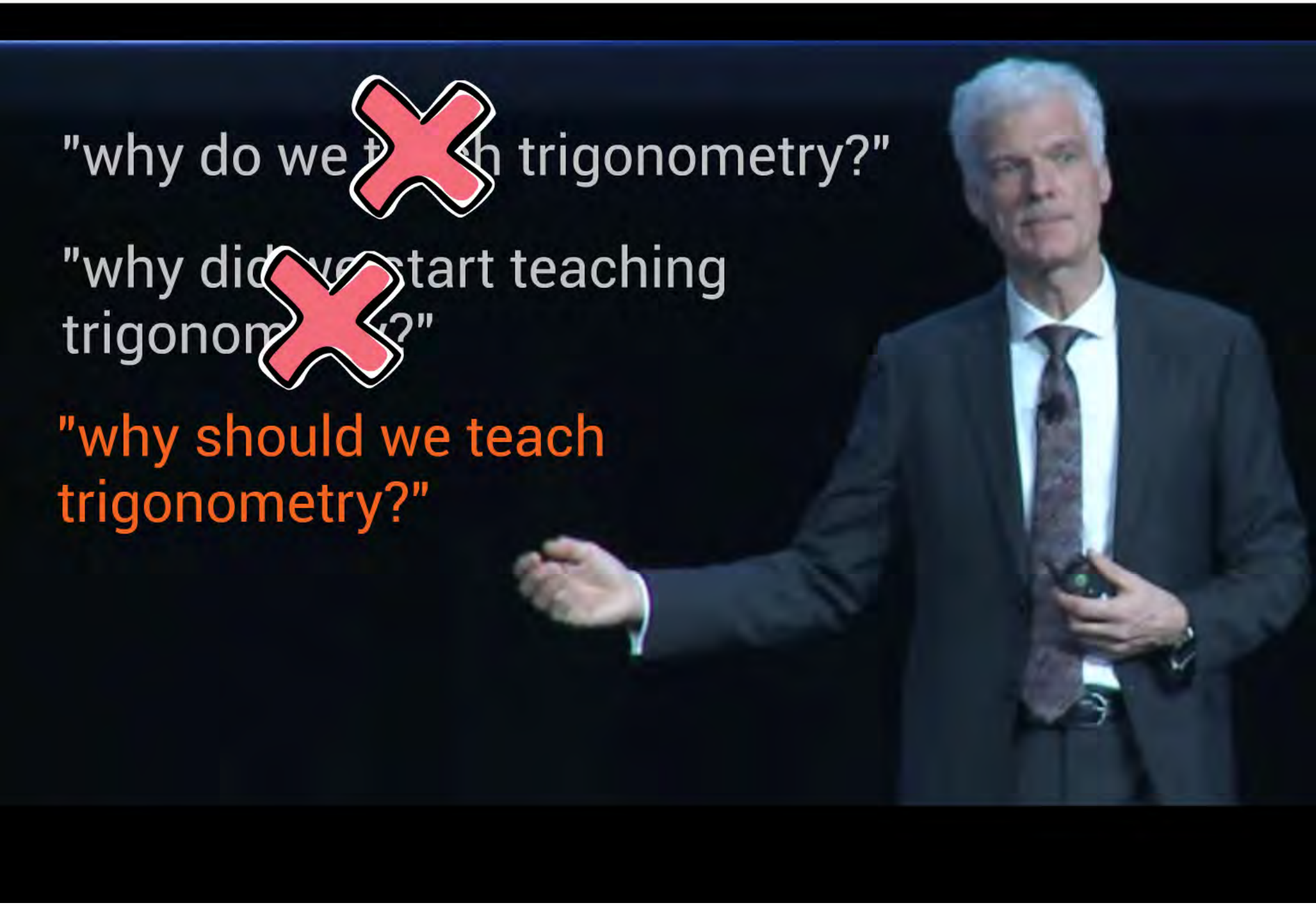
Transforming tasks | Designing tasks where students do the thinking

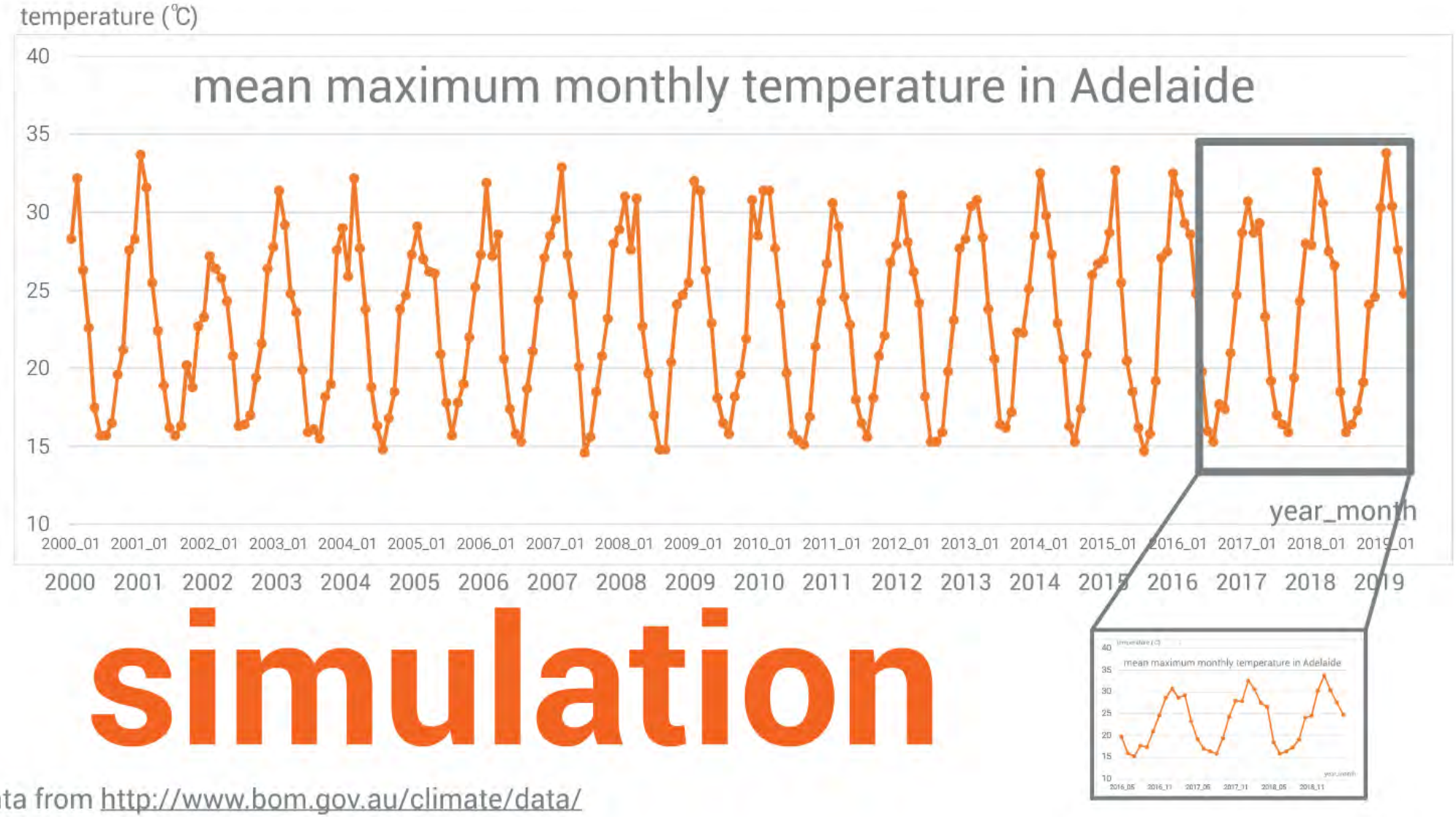
Overview chart

Strategies	Techniques			
From **closed** to **open**	Different perspectives Have students explore different points of view in the task.	Many entry points Have students work backwards by beginning with the outcome.	Many pathways Ask for one problem to be solved in multiple ways.	Many solutions Ask questions which have many solutions. Add or remove constraints.
From **information** to **understanding**	Many ways of knowing Ask students to show what/how they know in more than one way.	Compare and contrast Ask students to identify similarities and differences.	Make connections, find relationships Have students make meaning by asking them to connect pieces of information.	Generalise Ask students to construct general rules by identifying patterns.
From **tell** to **ask**	Socratic questioning Ask questions that help students dig deeper.	Explore before explain Ask students to try their ideas first.	Use dialogue Ask students to interact and build meaning through learning conversations.	Student voice Ask students to decide how they might do this best.
From **procedure** to **problem solving**	Students identify the 'problem to solve' Present a provocation and ask students to determine the problem to solve.	Provide insufficient information at first Give a perplexing problem and slowly provide information as needed.	Don't give all of the steps Provide multi-step problems and do not state all the steps.	Include some irrelevant information Give additional information that is not required to do the task.

OECD/PISA: *"Quantitative reasoning goes beyond solving problems in the traditional word problem sense in which all the relevant information is given and the student must simply decide on the mathematics to be used"*

Dan Myer DESMOS


"why do we t h trigonometry?"
"why did we start teaching trigonom ?"
"why should we teach trigonometry?"



simulation

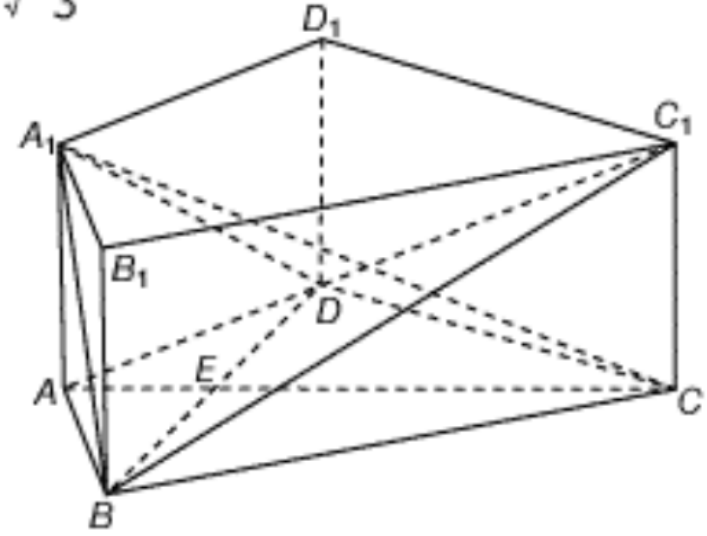
data from http://www.bom.gov.au/climate/data/

As shown in the figure, in square prism $ABCD—A_1B_1C_1D_1$, $AB=AD=2$, $DC=2\sqrt{3}$, $AA_1=\sqrt{3}$ $AD\perp DC$, $AC\perp BD$, and foot of perpendicular is E,

(i) Prove: $BD\perp A_1C$:

(ii) Determine the angle between the two planes A_1BD and BC_1D:

(iii) Determine the angle formed by lines AD and BC_1 which are in different planes.



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Mathematics, the name of the game

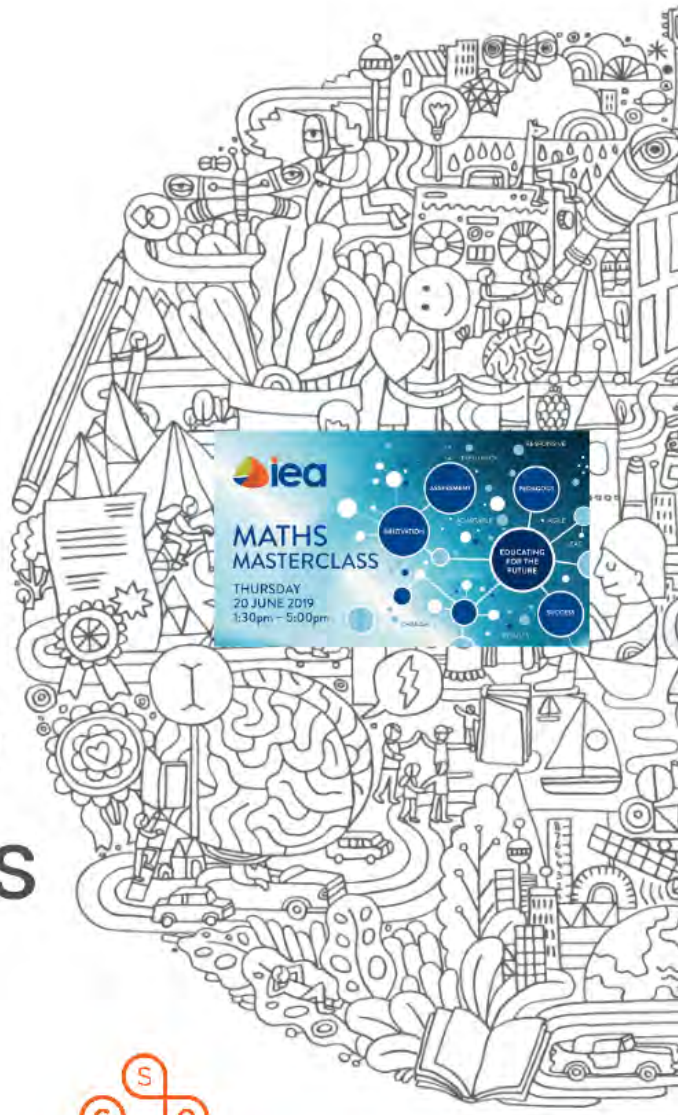
LOKESHWARRI SK VINAY KAMATH

"The older companies such as IBM, Intel, most of GE, United Technologies all have no choice but have to convert sooner or later. Google, FB and Amazon were created as mathematical corporations and, in some sense, born digital. Apple became a math corporation after Steve Jobs returned as CEO. Nokia failed to convert, so did Motorola. ***These math houses are going to change every other industry.***"

If mathematics is the key, what should it unlock?

hard thinking
transfer
mastery identity creativity
AC/*"Adding It Up"* proficiencies

understanding the story
(careers in AI)



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SOUTH AUSTRALIA

martin.westwell@sa.gov.au


iea
MATHS
MASTERCLASS
THURSDAY
20 JUNE 2019
1:30pm – 5:00pm
RESPONSIVE
INFLUENCE
IMPROVE
ASSESSMENT
PEDAGOGY
INNOVATION
ADAPTABLE
AGILE
LEAD
EDUCATING FOR THE FUTURE
OUTCOMES
SUCCESS
CHANGE
RESULTS