

# Evidence into action - mathematics

Dr Tanya Vaughan, Webinar, 11 September 2018



**EVIDENCE  
FOR LEARNING**

# Acknowledgement of Country

We acknowledge and pay respect to the past, present and future traditional custodians and elders of this country on which we meet.



# Outline of webinar

- What does the evidence tell us about the effectiveness of different ways to teach mathematics?
- Evidence ecosystem
- Thinking Maths results
- What does the evidence tell us about effective teaching approaches?
- Tailored Toolkits
- Measuring mathematics outcomes
- Questions



QUIZ



# True or false?

The current state of the evidence base suggests that...

1. Feedback on how students complete a task is more effective than general praise.
2. Calculators should not be used within classrooms.
3. Manipulatives lead to students reduced conceptual understanding in mathematics.



# Evidence-based mathematics

There are eight evidence based recommendations when thinking about mathematics:

- Use assessment to build on learners existing knowledge and understanding
- Use manipulatives (physical objects) and representations (such as number and line graphs)
- Teach learners strategies for solving problems
- Enable learners to develop a rich network of mathematical knowledge
- Develop learners independence and motivation
- Use tasks and resources to challenge and support learners' mathematics
- Use structured approaches to provide additional support
- Support students to make a successful transition between primary and secondary school.



# Use assessment to build on learners existing knowledge and understanding

Assessment to provide teachers with information about what learners do and not know.

Effective feedback crucial for student growth. Knowledge of misconceptions can be invaluable in planning lessons. A misconception is an understanding that leads to a 'systematic pattern of errors'.

Provide effective feedback:

- Be specific
- Accurate and clear
- Give feedback sparingly so that is meaningful
- Compare what a pupil is doing right now with what they have done wrong before, encourage and support further effort
- Provide specific guidance on how to improve.



Education Endowment Foundation. (2018). Improving Mathematics in Key Stages Two and Three. Retrieved from <https://educationendowmentfoundation.org.uk/tools/guidance-reports/maths-ks-two-three/>

Education Endowment Foundation. (2018). Evidence for Learning Teaching & Learning Toolkit: Education Endowment Foundation. Retrieved from <http://evidenceforlearning.org.au/the-toolkit/>

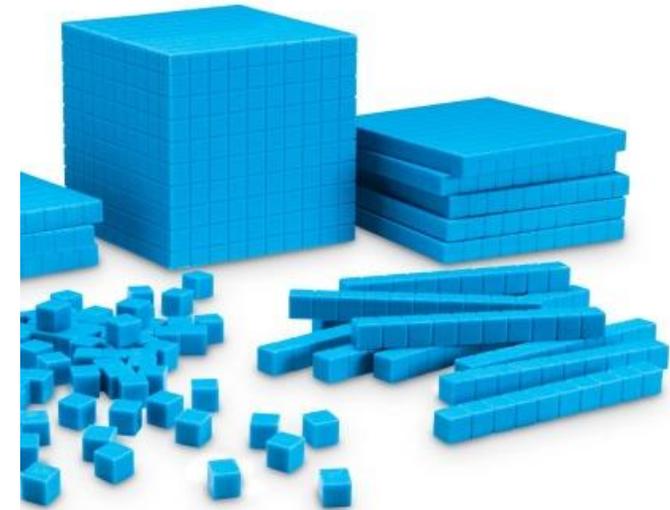
# Use manipulatives and representations

Need a clear rationale for the use of the particular manipulative (physical object) or representation (such as number and line graphs).

Manipulatives should be temporary to act as a scaffold that can be removed once independence is shown.

The evidence suggests some key considerations:

- Ensure there is a clear rationale, enables learners to understand the links between the manipulatives and the mathematical ideas they represent.
- Try to avoid learners becoming reliant on manipulatives, manipulatives should act as a 'scaffold', which can be removed.



# Teach learners strategies for solving problems

Select problem-solving tasks for which learners do not have ready-made solutions. Use worked examples to enable them to analyse the use of different strategies.

Teach learners to use and compare different approaches. Use worked examples to enable learners to analyse the use of different strategies.

Encourage learners to monitor, reflect on and communicate their reasoning and choice of strategy.

Education Endowment Foundation. (2018). Improving Mathematics in Key Stages Two and Three. Retrieved from <https://educationendowmentfoundation.org.uk/tools/guidance-reports/maths-ks-two-three/>

Education Endowment Foundation. (2017a). Evidence for Learning Teaching & Learning Toolkit: Education Endowment Foundation. Retrieved from <http://evidenceforlearning.org.au/the-toolkit/>

# Teach learners strategies for solving problems

A 'worked example' is a problem that has already been solved for the learner, with every step fully explained and clearly shown.

Novice learners who are given worked examples to study perform better on subsequent tests than learners who are required to solve the equivalent problems themselves.

The reason for this is that unguided problem-solving places a heavy burden on working memory, inhibiting the ability of the learner to transfer the information into their long-term memory.

## Example and Question

### Example 1

Solve  $2x - 3 = 1$  for  $x$

Add 3 to both sides

$$2x - 3 + 3 = 1 + 3$$

$$2x = 4$$

Divide both sides by 2

$$\frac{2x}{2} = \frac{4}{2}$$

$$x = 2$$

### Question 1

Solve  $3x - 2 = 7$  for  $x$

Centre for Education Statistics and Evaluation. (2017) Cognitive load theory: Research that teachers really need to understand. Retrieved from [https://www.cese.nsw.gov.au/images/stories/PDF/cognitive\\_load\\_theory\\_report\\_AA1.pdf](https://www.cese.nsw.gov.au/images/stories/PDF/cognitive_load_theory_report_AA1.pdf)

Source: Ashman, G (2016). Example-problem pairs. Retrieved from: <https://gregashman.wordpress.com/2016/02/09/example-problem-pairs/>

# Enable learners to develop a rich network of mathematical knowledge

- Emphasis the many connections between mathematical facts, procedures and concepts. Ensure that learners develop fluent recall of facts.
- Ensure the learners develop fluent recall of number facts.
- Teach learners to choose between mathematical strategies.
- Teach learners to recognise and use mathematical structure.

Education Endowment Foundation. (2018). Improving Mathematics in Key Stages Two and Three. Retrieved from <https://educationendowmentfoundation.org.uk/tools/guidance-reports/maths-ks-two-three/>

Education Endowment Foundation. (2017a). Evidence for Learning Teaching & Learning Toolkit: Education Endowment Foundation. Retrieved from <http://evidenceforlearning.org.au/the-toolkit/>

# Enable learners to develop a rich network of mathematical knowledge

Teach learners to choose between mathematical strategies:

- The evidence suggests that using a calculator does not generally harm learners' mental or pencil-and-paper calculation skills. In fact, studies have shown using a calculator can have positive impacts, not only on mental calculation skills, but also on problem-solving and attitudes towards mathematics.
- The aim is to enable learners to self-regulate their use of calculators consequently making less (but better use of them).



# Enable learners to develop a rich network of mathematical knowledge

Teach learners to recognise and use mathematical structure:

- Encouraging learners to read numerical and algebraic expressions as descriptions of relationships, rather than simply as instructions to calculate.
- For example, learners often regard the equals sign as an instruction to calculate rather than an indicator of an equivalence, understanding a relationship as an equivalence would mean thinking of:

$$17 \times 25 = 10 \times 25 + 7 \times 25$$

as

$$17 \times 25 \text{ is the same as } 10 \times 25 + 7 \times 25$$

# Develop learners independence and motivation

Learners need to develop metacognition – the ability to independently plan, monitor and evaluate their thinking and learning. Provide regular opportunities for learners to develop their metacognition by encouraging them to describe their own thinking.

Teachers need to model metacognition by simultaneously describing their own thinking or asking questions as they complete a task.

## Metacognition and self-regulation

High impact, very low cost, based on extensive evidence

Average cost

\$ \$ \$ \$ \$

Evidence security

🔒 🔒 🔒 🔒 🔒

Months' impact

+7

Metacognition and self-regulation approaches have consistently high levels of impact.

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# Develop learners' independence and motivation

Develop learners' metacognition through structured reflection on their learning.

While demonstrating the solving of a problem, a teacher could model how to plan, monitor, and evaluate their thinking by reflection aloud on a series of questions. These could include:

- What is the problem asking?
- Have I ever seen a mathematical problem like this before?
- What approaches to solving it did I try and were they successful?
- Could I represent the problem with a diagram or graph?
- Does my answer make sense when I re-read the problem?
- Do I need help or more information to solve this problem?
- Where could I find this?

Education Endowment Foundation. (2018). Improving Mathematics in Key Stages Two and Three. Retrieved from <https://educationendowmentfoundation.org.uk/tools/guidance-reports/maths-ks-two-three/>

Education Endowment Foundation. (2017). Evidence for Learning Teaching & Learning Toolkit: Education Endowment Foundation. Retrieved from <http://evidenceforlearning.org.au/the-toolkit/>

# Mathematics anxiety

Mathematics anxiety is a type of anxiety that specifically interferes with mathematics, and is not the same as general anxiety. It can have a large detrimental impact on learners' learning by overloading their **working memory** or causing them to avoid mathematics.

**Working memory** is the memory system where small amounts of information are stored for a very short duration. Working memory roughly equates with what we are conscious of at any one time.

Mathematics anxiety tends to increase with age, but there are signs of it appearing in children in Years 4, 5 and 6. Gaining an awareness of, and ability to recognise the problem is the first step. Teachers can look out for learners avoiding mathematics or displaying signs of anxiety ('freezing', sweating, fidgeting) when using mathematics, and use their knowledge of their learners and professional judgement, to support them to overcome their anxiety.

Centre for Education Statistics and Evaluation. (2017) Cognitive load theory: Research that teachers really need to understand. Retrieved from [https://www.cese.nsw.gov.au/images/stories/PDF/cognitive\\_load\\_theory\\_report\\_AA1.pdf](https://www.cese.nsw.gov.au/images/stories/PDF/cognitive_load_theory_report_AA1.pdf)

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Education Endowment Foundation. (2017). Evidence for Learning Teaching & Learning Toolkit: Education Endowment Foundation. Retrieved from <http://evidenceforlearning.org.au/the-toolkit/>

# Reducing students' maths anxiety

‘Sometimes it will take me a whole month of working with students and actually telling them it’s okay to be slow with mathematics. The most important thing in mathematics is not speed, it’s the ability to slow down and ask the right questions. It’s okay to make mistakes. Actually, mistakes are so wonderful because you make a mistake, you learn from it and that’s the most important thing ... my students have actually gone through their entire schooling, 10 to 15 years, being taught that both of those things are wrong.

‘So, helping students grapple with that, and not judging them and helping them see that they’re accepted in the classroom and it’s safe. It’s really important to help students know you’re not going to jump on them, you’re not going to make them feel belittled because they can’t get an answer. Every day that I’m in the classroom, I do that.’ Eddie Woo, Head Teacher Mathematics



# Use tasks and resources to challenge and support learners' mathematics

Use assessment of learners' strengths and weaknesses to inform your choice of task.

Use assessment of learners' strengths and weaknesses to inform selection and use of tasks.

Discuss and compare different solution approaches.

The evidence suggests that the choice of one particular task or resource over another is less important than the way that teachers set about using them in the classroom.

Discuss and compare different solution approaches:

A teacher asked a class to come up with different ways of calculating  $5 \times 18$ .

Here are some of their approaches:

I can multiple 5 by 20, then take two 5s away:

$$5 \times 18 = 5 \times 20 - 5 \times 2 = 100 - 10 = 90$$

To multiple by 5, it's easy. I can multiply by 10 then halve the answer'.

$$10 \times 18 = 180, 180 / 2 = 90$$

18 is 9 times 2, so I can multiply 5 by 9 , then multiply the answer by 2.

$$5 \times 9 = 45, 45 \times 2 = 90$$

Education Endowment Foundation. (2018). Improving Mathematics in Key Stages Two and Three. Retrieved from <https://educationendowmentfoundation.org.uk/tools/guidance-reports/maths-ks-two-three/>

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# Use structured approaches to provide additional support

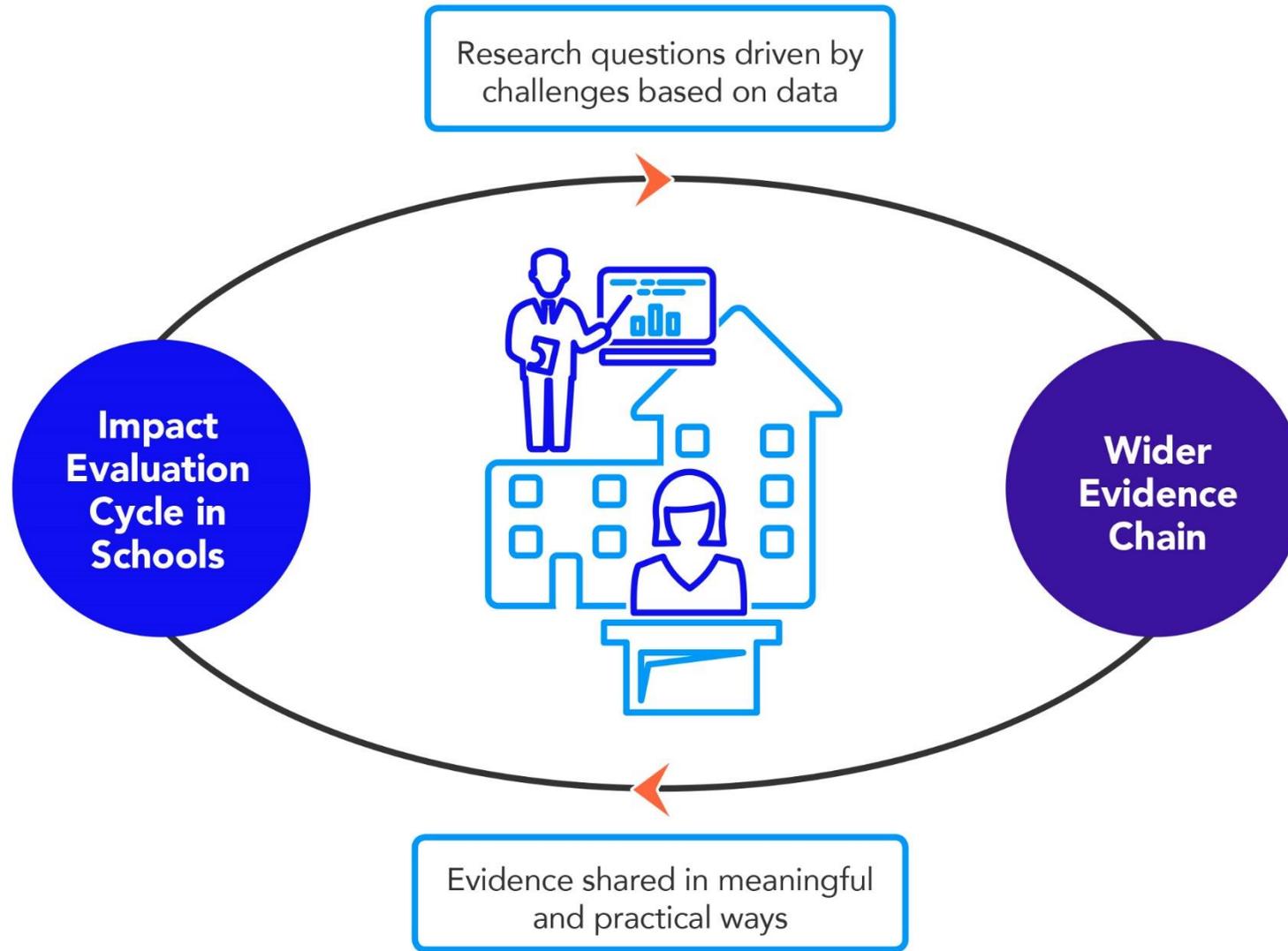
- Selection should be guided by student assessment.
- Approaches should start early, be evidence-based and be carefully planned.
- Approaches/programmes should include explicit and systematic instruction.



Education Endowment Foundation. (2018). Improving Mathematics in Key Stages Two and Three. Retrieved from <https://educationendowmentfoundation.org.uk/tools/guidance-reports/maths-ks-two-three/>

Education Endowment Foundation. (2017). Evidence for Learning Teaching & Learning Toolkit: Education Endowment Foundation. Retrieved from <http://evidenceforlearning.org.au/the-toolkit/>

# Evidence ecosystem

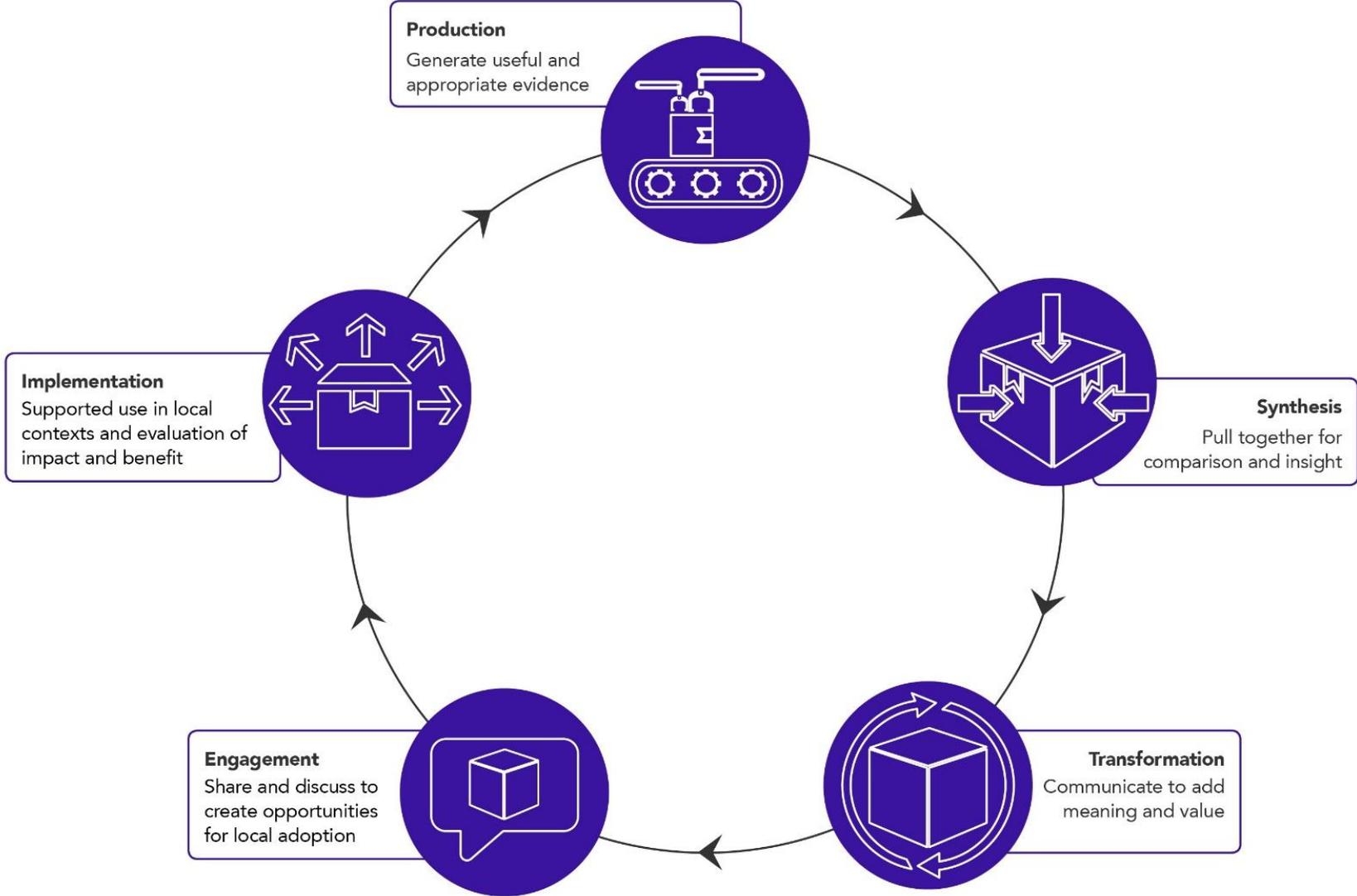


# Barriers to engaging with the wider evidence chain?

Three common barriers to accessing and using research:

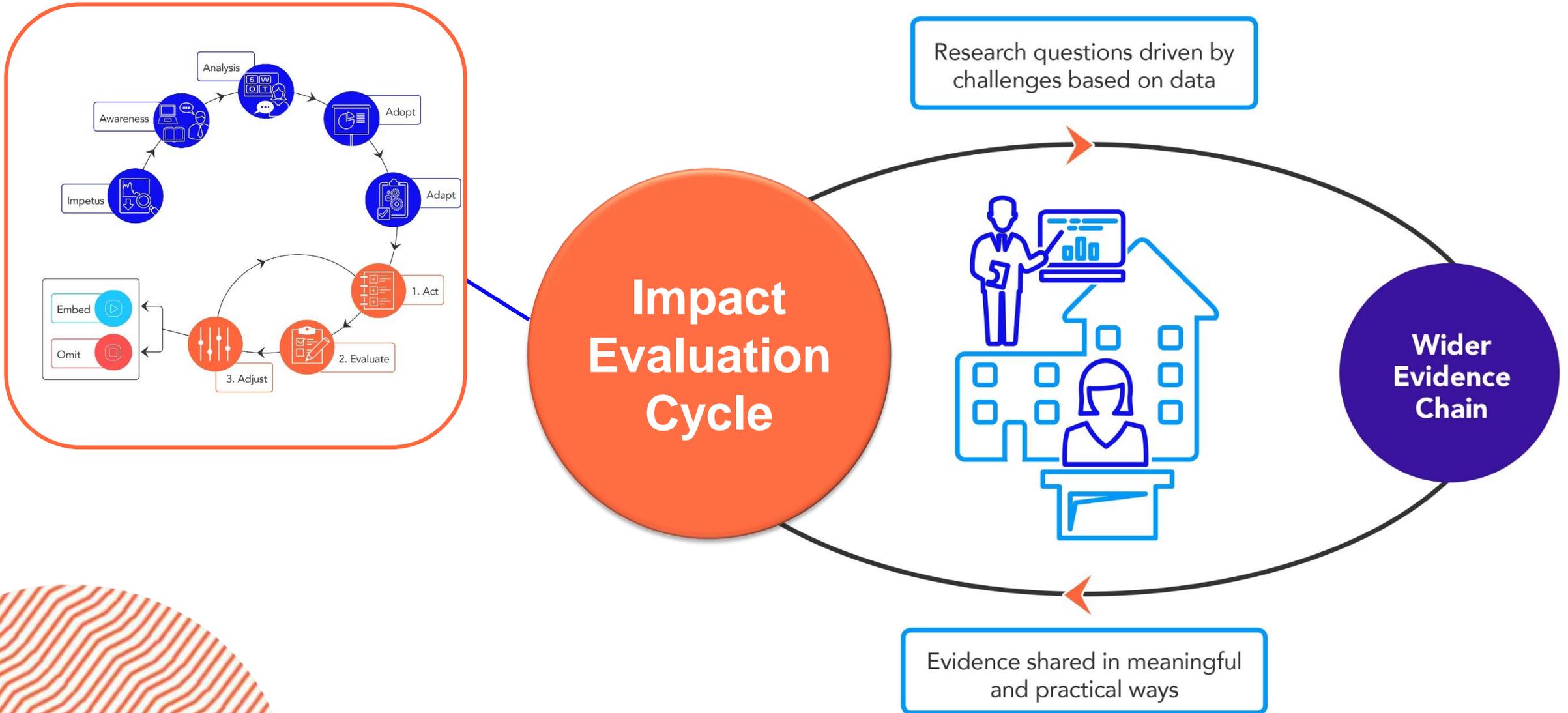
- Shortage of time to engage with research
- Overload of information to process
- Insufficient contextualised information for practice.

# Wider Evidence Chain - external

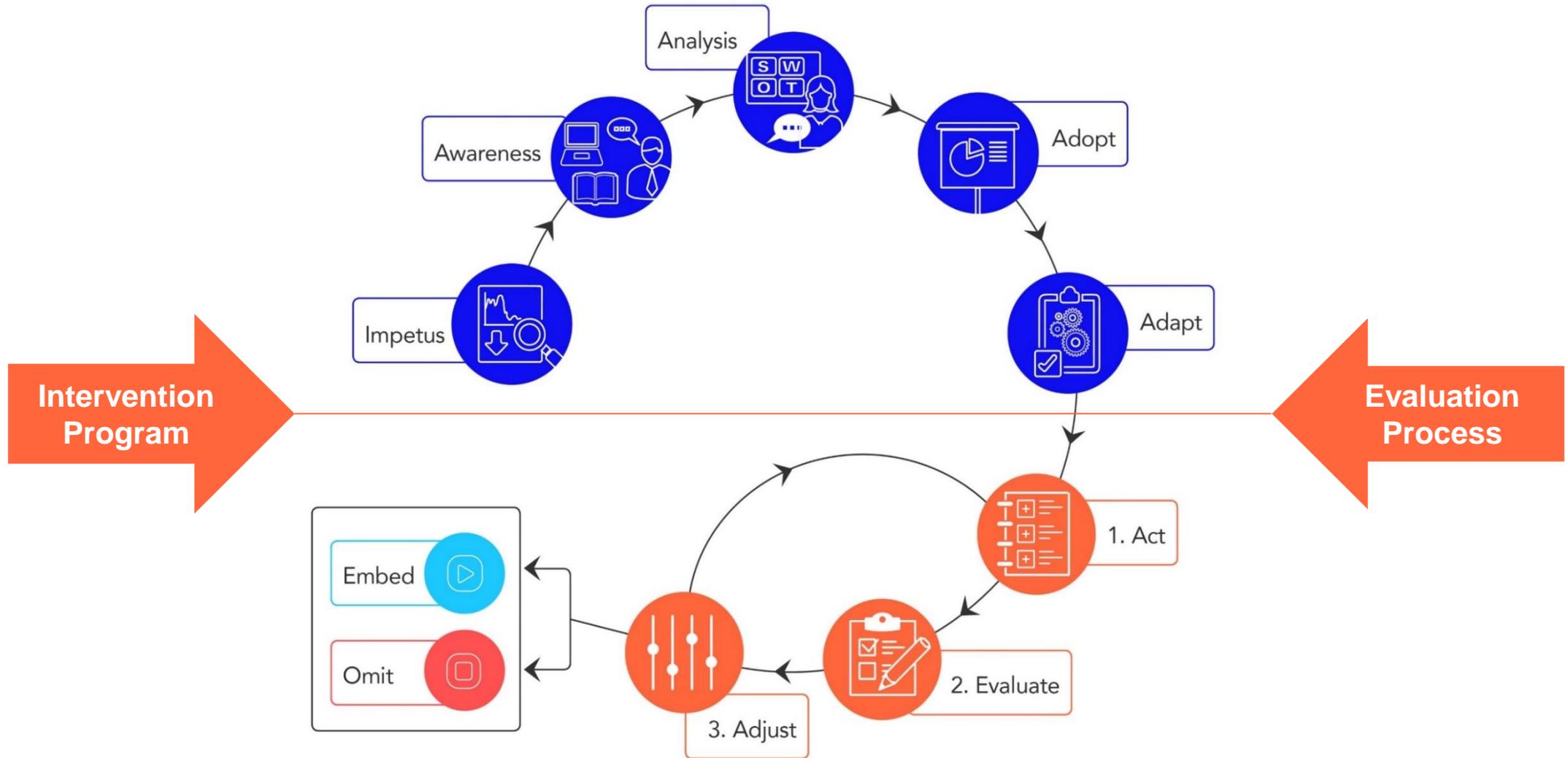


Adapted from Sharples J Evidence Chain for the Frontline (2013).  
[evidenceforlearning.org.au/evidence-informed-educators/evidence-ecosystem](http://evidenceforlearning.org.au/evidence-informed-educators/evidence-ecosystem)

# Evidence ecosystem



# Evidence for Learning Impact Evaluation Cycle

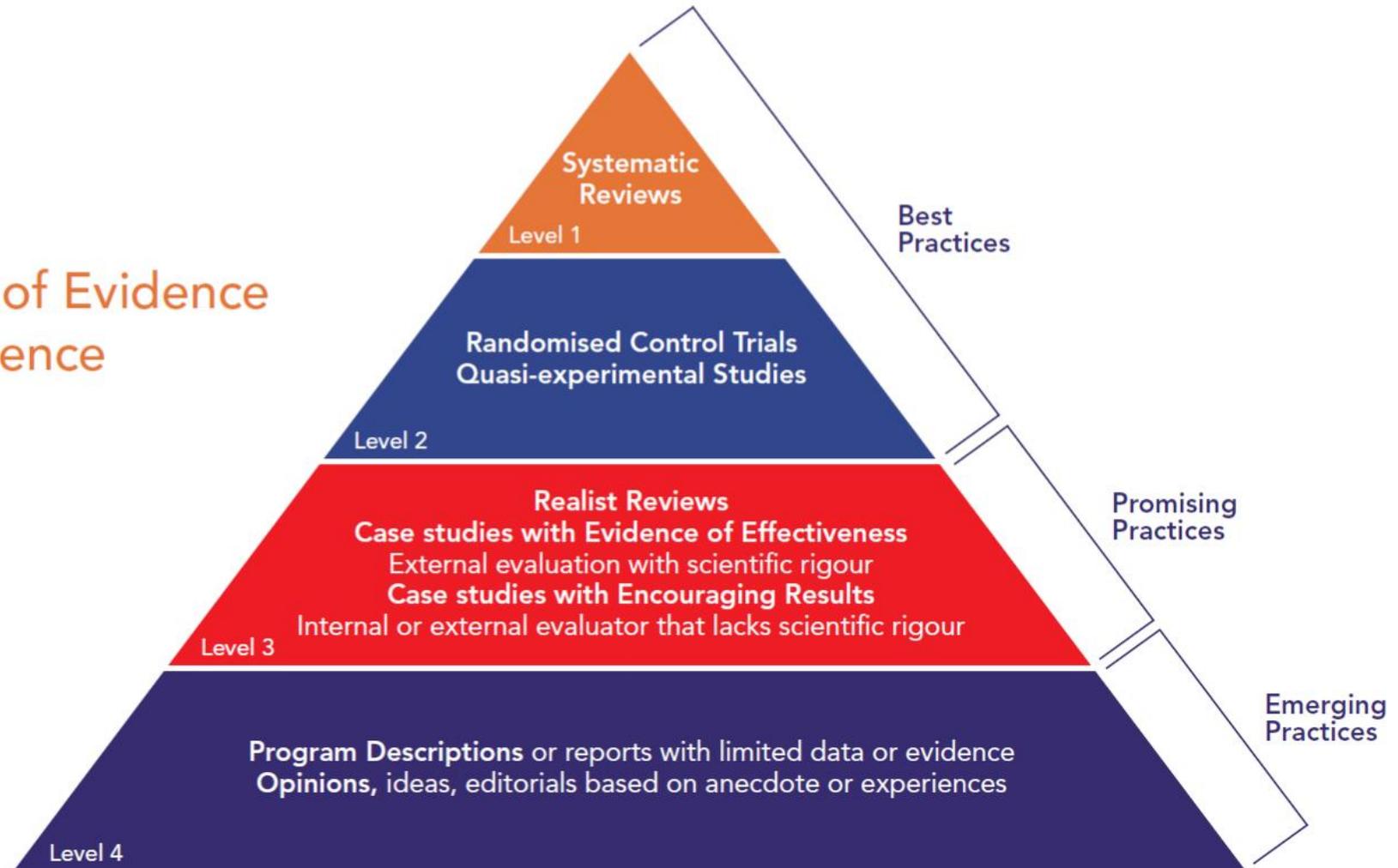


# What is evidence-informed decision making?

Evidence informed decisions are about '*integrating professional expertise with the best external evidence from research to improve the quality of practice*' (Sharples, 2013, p. 7). This is not about '*prescribing what goes on from a position of unchallenged authority*' (Sharples, 2013, p. 7).

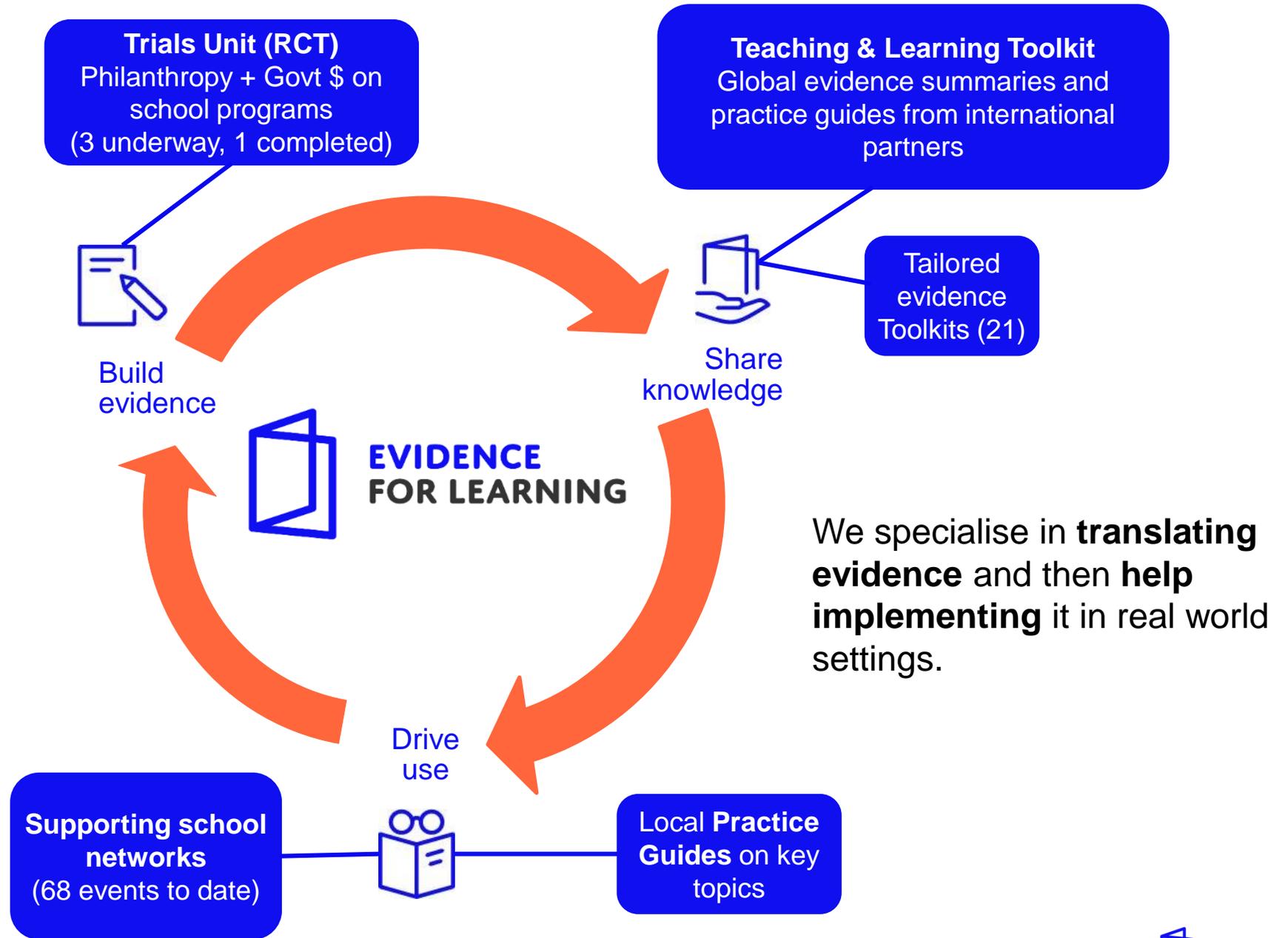
# Hierarchy of evidence

## Levels of Evidence Confidence



# Better school decisions informed by evidence

We are an **Evidence Intermediary**; we play a brokering role between research and practice



# Current progress in Learning Impact Fund

## MiniLit

Active

Small-group reading intervention for struggling Year 1 students.

Developer  
Multitit

Type of trial  
Efficacy

Project progress



## QuickSmart Numeracy

Active

Small-group student tutoring intervention to increase fluency and automaticity in maths.

Developer  
SiMERR National Research Centre at the  
University of New England

Type of trial  
Effectiveness

Project progress



## Resilient Families

Active

School-based social-emotional learning program involving parental engagement.

Developer  
Deakin University

Type of trial  
Developmental

Project progress



## Thinking Maths

Completed

Teacher professional learning for middle school maths teachers (Years 6-9).

Developer  
South Australian Department for Education

Type of trial  
Efficacy

Cost

\$\$\$\$\$

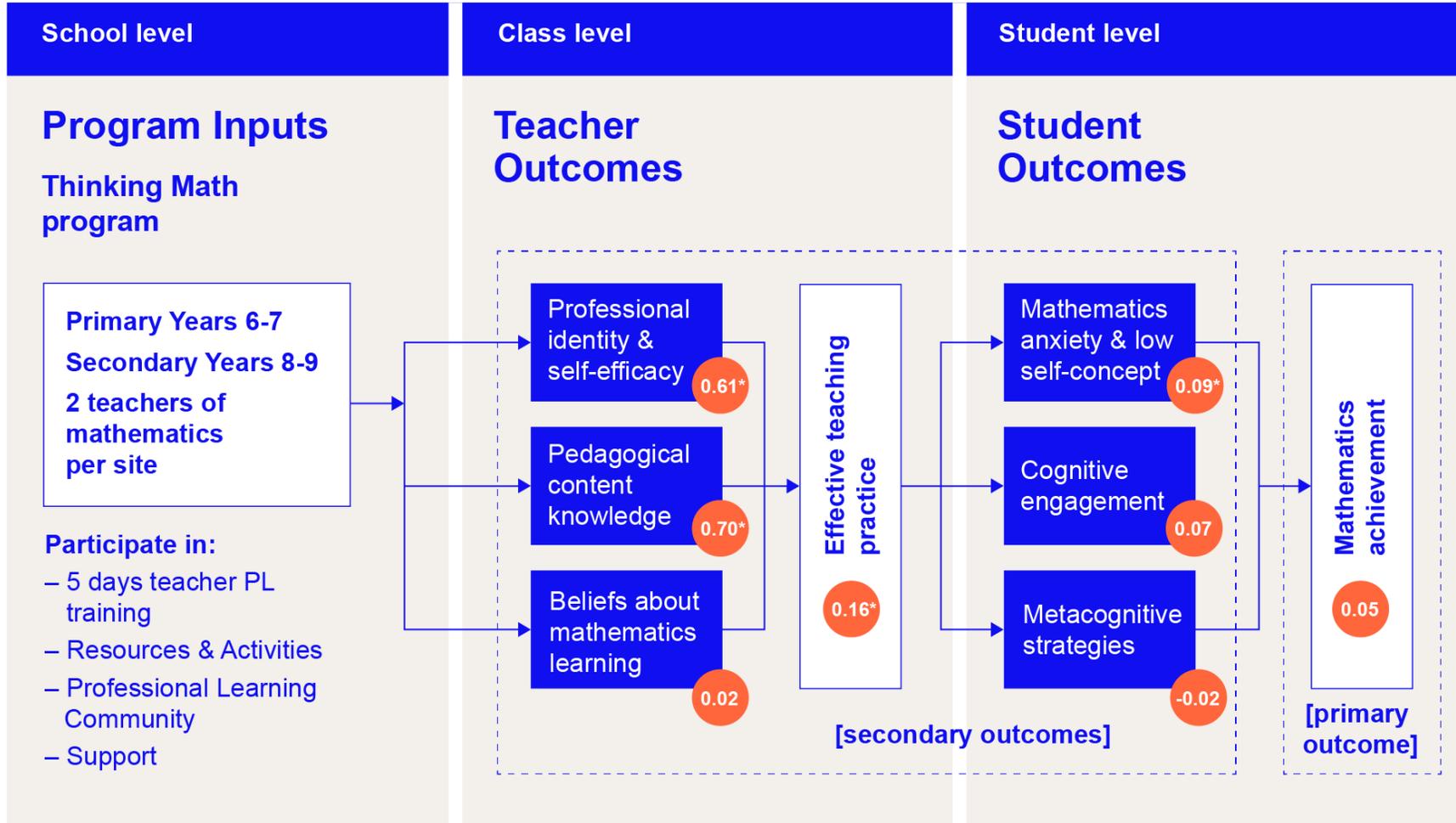
Security



Months' impact

+1

# What was measured: Thinking Maths



# What E4L reports

Intervention vs control	Effect size [95% CI]	Estimated months progress*	E4L security rating+	Number of students	P value	E4L cost rating
All students	0.05 [0.00 – 0.10]	+1		7068 students in 158 schools	0.38	\$\$\$\$\$
Primary Years 5-7	0.14 [0.08 – 0.19]	+2	N/A	5013 students in 119 schools	0.05	\$\$\$\$\$
Secondary Years 8-10	-0.16 [-0.25 – -0.07]	-2	N/A	2055 students in 56 schools	0.05	\$\$\$\$\$
School Card holders	0.11 [-0.04 – 0.27]	+1	N/A	666 students in 118 schools	0.21	\$\$\$\$\$



# Findings – primary research question

Did the Thinking Maths program enable middle-school students to improve their mathematics achievement above typical learning growth?

- Small positive effect on Years 5-10 students' maths achievement
- More positive effect in Primary context than Secondary context
- Small positive effect on sub-sample of School Card holder students (both Primary and Secondary) of Thinking Maths teachers
- Largest effect found on teachers' maths pedagogical content knowledge, professional identity and self-efficacy
- Lesser gains on students' cognitive engagement, no additional gains in students' metacognition. Increased students' maths anxiety, particularly for Secondary students
- Barriers to effective implementation in Secondary schools included timetabled lessons, common tests, set text-books, and lack of time to plan

# Support students to make a successful transition between primary and secondary school

- Structured intervention support may be required for Year 7 pupils who are struggling to make progress.
- Both primary and secondary teachers are likely to be more effective if they are familiar with the mathematics curriculum and teaching methods outside of their age that they are teaching.
- The research evidence suggests that allocating students to their mathematics classes based on prior achievement does not on average lead to increases achievement.

## Setting or streaming

Negative impact, very low cost, based on limited evidence

Average cost

\$ \$ \$ \$ \$

Evidence security

🔒 🔒 🔒 🔒 🔒

Months' impact

-1

Evidence suggests that regrouping and streaming has a very small negative impact for low and mid-range attaining learners.

Education Endowment Foundation. (2018). Improving Mathematics in Key Stages Two and Three. Retrieved from <https://educationendowmentfoundation.org.uk/tools/guidance-reports/maths-ks-two-three/>

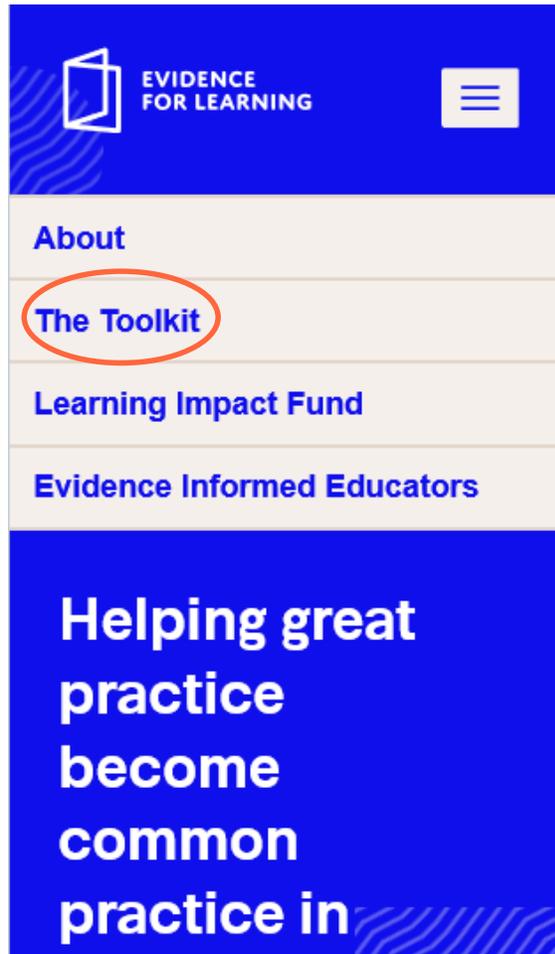
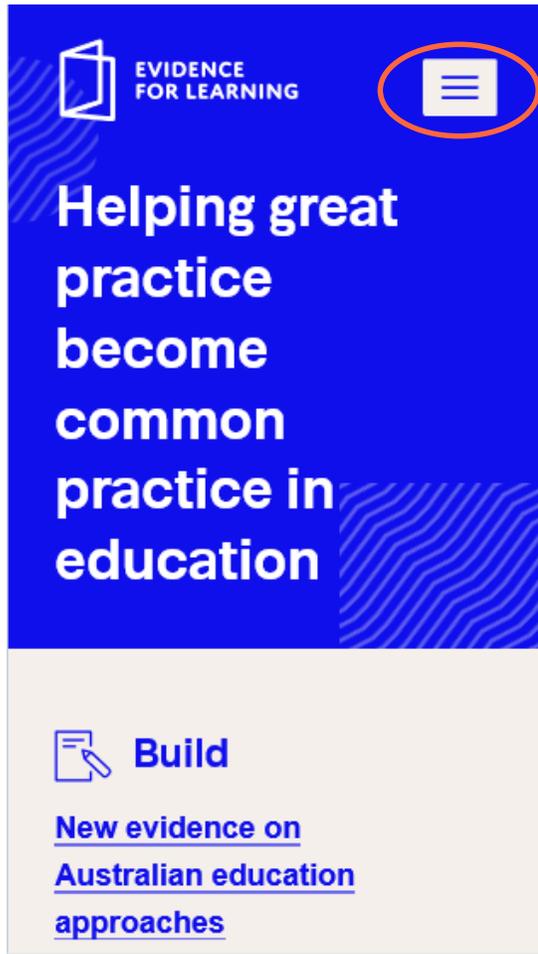
Education Endowment Foundation. (2017). Evidence for Learning Teaching & Learning Toolkit: Education Endowment Foundation. Retrieved from <http://evidenceforlearning.org.au/the-toolkit/>

# Summary of effective teaching approaches

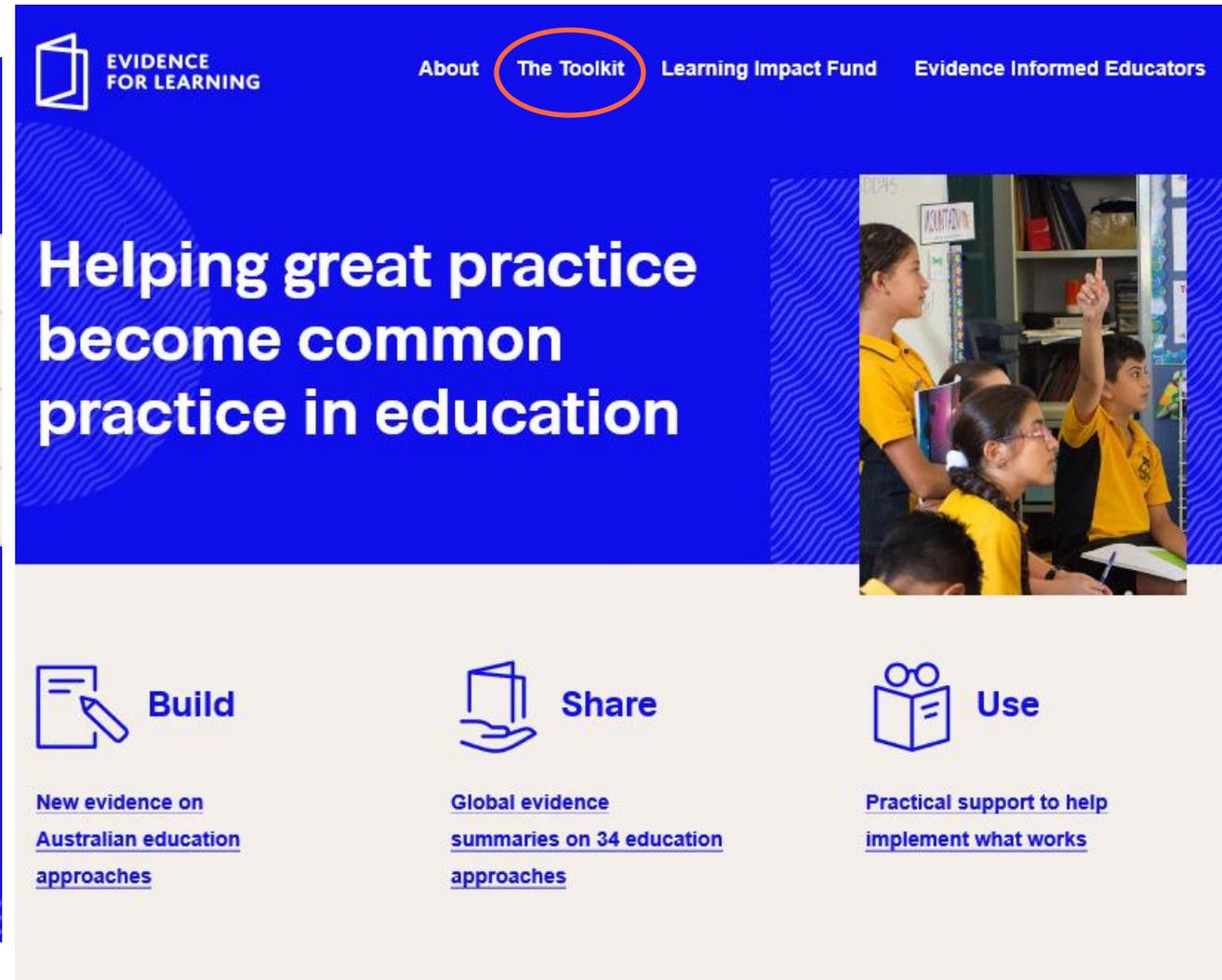
Approach	Months worth of learning progress	Cost	Evidence security
Metacognition and self regulation	+7	Very low – less than \$160 per student per year	Extensive
Feedback	+8	Very low – less than \$160 per student per year	Moderate
Setting and streaming	-1	Very low – less than \$160 per student per year	Limited

# Accessing the Teaching & Learning Toolkit

Tablet or phone



Laptop



# The Teaching & Learning Toolkit

Tablet or phone

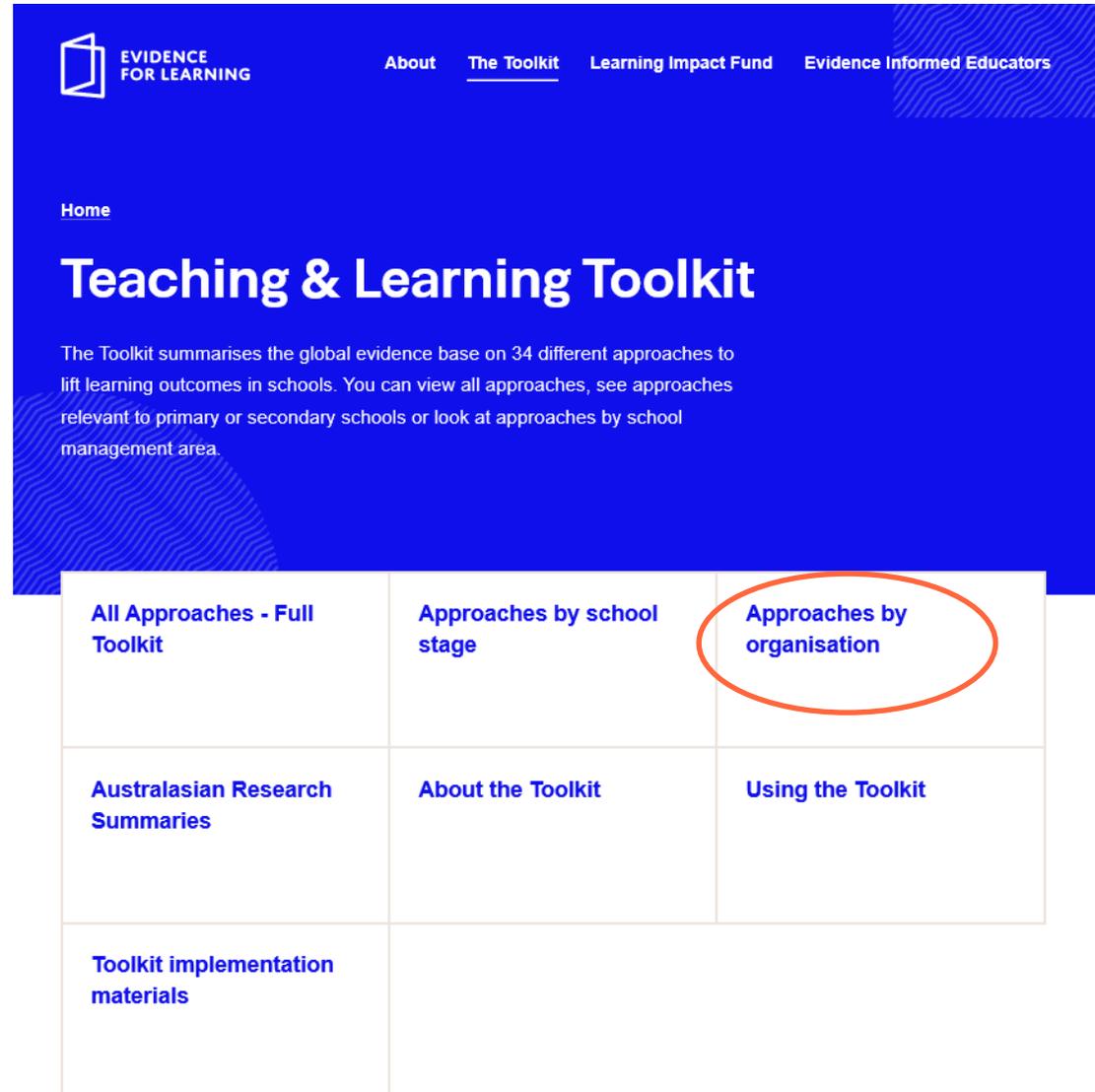


All Approaches - Full Toolkit

Approaches by school stage

Approaches by organisation

Laptop



# Approaches by organisation

## Tablet or phone



Agile Schools
Australian Institute for Teaching and School Leadership (AITSL)
Association of Independent Schools of ACT

Australian Council for Educational Research
CITEL Curriculum Conference
Education Changemakers
EduInfluencers
Education State: Victorian Department of Education and Training
Independent Schools Queensland
Loop

The LearnFast Group
MInd Lab/Acellum
Murdoch University
NSW Department of Education
Principals Australia Institute
Science of Learning Research Centre (SLRC)
The Australian Association of Mathematics Teachers (AAMT)

## Laptop



Agile Schools	Australian Institute for Teaching and School Leadership (AITSL)	Association of Independent Schools of ACT
Australian Council for Educational Research	CITEL Curriculum Conference	Education Changemakers
EduInfluencers	Education State: Victorian Department of Education and Training	Independent Schools Queensland
Loop	The LearnFast Group	MInd Lab/Acellum
Murdoch University	NSW Department of Education	Principals Australia Institute
Science of Learning Research Centre (SLRC)	The Australian Association of Mathematics Teachers (AAMT)	Teach for Australia
Watterston Consulting		

[evidenceforlearning.org.au/the-toolkit/approaches-by-organisation](https://evidenceforlearning.org.au/the-toolkit/approaches-by-organisation)

# Standards for Excellence in Teaching Mathematics in Australian Schools

These are the Evidence for Learning support pages for the Standards for Excellence in Teaching Mathematics in Australian Schools by AAMT.



Evidence for Learning works with organisations to map their improvement frameworks to The Teaching & Learning Toolkit.

The Australian Association of Mathematics Teachers (AAMT) is the peak national body of mathematics teachers from F-12 and beyond. AAMT represents teachers' professional interests and supports their work through journals and other publications, conferences and other professional learning programs, and developmental projects. There are branches in each state and territory that are integral to its extensive and active networks within the profession.

## Standards for Excellence in Teaching Mathematics in Australian Schools

[3.1 The learning environment](#)

[3.2 Planning for learning](#)

[3.3 Teacher in action](#)

[3.4 Assessment](#)

The complete Teaching & Learning Toolkit can be accessed [here](#).

This site is currently in draft form for feedback from members and the wider profession.

[evidenceforlearning.org.au/the-toolkit/approaches-by-organisation/aamt/](https://evidenceforlearning.org.au/the-toolkit/approaches-by-organisation/aamt/)

# The learning environment

Presented here is a range of different approaches that you might think about as you consider the learning environment.

Sort by Name ▾	Average cost –	Evidence security –	Months' impact –
Behaviour interventions	\$ \$ \$ \$ \$	🔒 🔒 🔒 🔒 🔒	+3
Collaborative learning	\$ \$ \$ \$ \$	🔒 🔒 🔒 🔒 🔒	+5
Digital technology	\$ \$ \$ \$ \$	🔒 🔒 🔒 🔒 🔒	+4
Feedback	\$ \$ \$ \$ \$	🔒 🔒 🔒 🔒 🔒	+8
Individualised instruction	\$ \$ \$ \$ \$	🔒 🔒 🔒 🔒 🔒	+3
Mastery learning	\$ \$ \$ \$ \$	🔒 🔒 🔒 🔒 🔒	+5
Metacognition and self-regulation	\$ \$ \$ \$ \$	🔒 🔒 🔒 🔒 🔒	+7
Peer tutoring	\$ \$ \$ \$ \$	🔒 🔒 🔒 🔒 🔒	+5
Small group tuition	\$ \$ \$ \$ \$	🔒 🔒 🔒 🔒 🔒	+4
Social and emotional learning	\$ \$ \$ \$ \$	🔒 🔒 🔒 🔒 🔒	+4

# How can we measure learning?

The important thing is that they help the teachers to become disciplined and informed observers of *what students are doing, saying, making or writing*. Teachers then have a base for inferring the students' levels of proficiency or competence.

Patrick Griffin



# How do we know if we've made a difference?

## Primary

- Learners progress in their ability to demonstrate place value
- Learners progress in their ability in multiplication and division

## Primary and Secondary

- How are the students' progressing in their ability to interpret statistical information?
- NAPLAN results in numeracy
- Class grades in reports
- Progressive Achievement Tests (PAT) – Mathematics

Numeracy continuum. Retrieved from: <http://www.numeracycontinuum.com/index.php/continuum-chart>

General capabilities numeracy learning continuum. Retrieved from:

<https://www.australiancurriculum.edu.au/media/1077/general-capabilities-numeracy-learning-continuum.pdf>

Evaluating impact: multiple measures and sources of data. Retrieved from: [aitsl.edu.au/feedback](https://aitsl.edu.au/feedback)

# Questions?



# Where to now?

- Join our Evidence Informed Educator Network  
[evidenceforlearning.org.au/evidence-informed-educators/join/](https://evidenceforlearning.org.au/evidence-informed-educators/join/)
- Subscribe to our newsletter for updates [evidenceforlearning.org.au/](https://evidenceforlearning.org.au/)
- Follow us on Twitter [@E4Ltweets](https://twitter.com/E4Ltweets) and Facebook [Evidence for Learning](https://www.facebook.com/EvidenceforLearning)
- Comments and feedback please [tvaughan@evidenceforlearning.org.au](mailto:tvaughan@evidenceforlearning.org.au)



Helping great practice  
become common practice in education



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