Bond® Blocks
TEACHER NOTES

The Evidence Base of Bond Blocks

Defining 'Evidence-Based'

"Is Bond Blocks evidenced-based?" This is a great question and one we are often asked. However, it is also a term that is often misunderstood. We describe Bond Blocks as being "research-informed" and "using evidence-informed practice". We do this because strictly speaking, "evidence-based" is a research term that requires rigorous controlled trials. This is common in the medical field.

To answer the question "Is this evidence-based?" in an educational setting we refer to Professor Geoff Masters the CEO of the Australian Council for Educational Research (2018).

> **Evidence-based teaching involves the use of evidence to: (1) establish where students are in their learning; (2) decide on appropriate teaching strategies and interventions; and (3) monitor student progress and evaluate teaching effectiveness. (p. 4)**

We recommend reading the entire article.
https://research.acer.edu.au/cgi/viewcontent.cgi?article=1335&context=research_conference

The salient points are that the medical profession, despite having access to controlled research studies also relies on other tests and evidence, including observations. Doctors try a course of treatment, monitor progress and alter the treatment according to observations. Masters explains that this comprehensive understanding of what an "evidenced based" approach is should also be applied to education.

> **"Policies and discussions of 'evidence-based teaching' sometimes overlook the importance of this broader, more integrated understanding of the role of evidence in teaching and learning." (p. 4)**

Collecting Evidence

Bond Blocks has several tools built in to do what Masters (2018) defines as evidence-based teaching.
That is, collect data as evidence to:

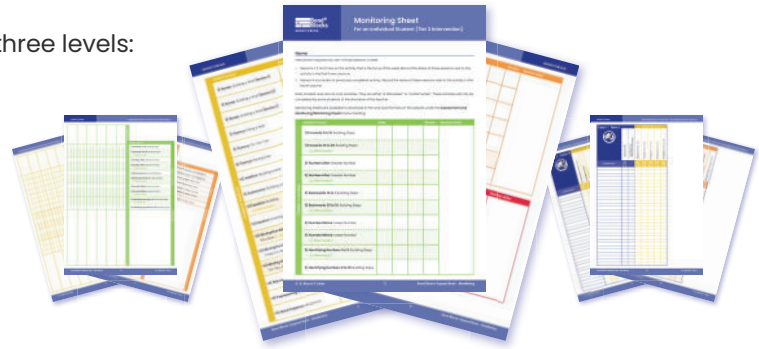
- Establish where student are in their learning
- Monitor student progress
- Evaluate teaching effectiveness.

All Bond Block resources include assessment and monitoring resources to evaluate the effectiveness of teaching and learning.

The Bond Blocks Core Kit Test is used to identify specific areas of difficulty and is colour coded to relevant chapters of activities. It is re-administered annually to track progress over time. Results are entered into the Excel Results and Tracking Tool to monitor the progress of every student over time, identify school wide gaps in teaching and inform decision making.

All Bond Blocks resources contain monitoring tools at three levels:

- Tier One whole class.
- Tier Two small group.
- Tier Three individual student.



Evidence-Informed Mathematics Teaching

Masters (2018) highlights that general, non-subject specific, evidence-based strategies "must be interpreted and implemented in the contexts of the subjects teachers teach… Teachers require evidence about the best ways to implement effective teaching strategies and interventions in subject-specific contexts" (p.5).

The following section outlines evidence informed principles that are embedded in both the "Bond Blocks Counting to 10 & 20" Kit and the "Bond Blocks Core Kit".

Mathematics Specific Evidence-Infromed Teaching Strategies

Bond Blocks incorporates the following key principles that have been identified by Sullivan (2001), and Anthony and Walshaw (2009), as effective for the teaching of **mathematics**.

Articulating Learning Goals*	The learning goals of every activity are provided.
Making Mathematical Connections	Connections are made between the concrete, representational and abstract elements of learning basic addition and subtraction facts through to pre-algebra and word questions.
Differentiated Teaching*	Activities are differentiated 'a little harder' and 'a little easier' alternatives.
Structuring Lessons*	The Bond Blocks session fits into standard lesson structures
Promote Fluency and Transfer	The goal of the system is to do away with the Bond Blocks in favour of automatic recall. Activities are structured to move from using the blocks, to diagrams, to finally using numbers only.
Mathematical Language	Mathematical language is specified in the teacher notes for every activity and is modelled in the teaching videos.
Assessment for Learning	Tools include a placement test that is used to ascertain prior knowledge and monitor progress and a variety of recording sheets to document observational notes.
Improving Teacher Knowledge	Clear succinct teacher notes are provided for every activity and concept along with Professional Learning opportunities.

***Key principles that are also identified as general High Impact Teaching Strategies (Victoria Department of Education, 2020).**

Bond Blocks incorporates these **general** High Impact Teaching Strategies:

Explicit Teaching	Explicit teaching is modelled in the videos that are provided for every activity.
Multiple Exposures	Bond Blocks activities are organised in cyclical chapters so that students return to the same concept, spaced over the teaching period.

Proficiency Strands

Sullivan's (2011) paper "Teaching Mathematics: Using research-informed strategies" is a review of research in the subject specific context of Mathematics. He draws on the work of Kilpatrick, Swafford and Findell (2001) who identify five intertwined strands of proficiency required for effective learning in mathematics.

It is from these five strands that four of the proficiency strands of the Australian Mathematics Curriculum (Australian Curriculum, Assessment and Reporting Authority 2022) https://v9.australiancurriculum.edu.au/ are based:

- Understanding
- Reasoning
- Fluency
- Problem Solving

Bond Blocks activities systematically incorporates each of these proficiencies into sequenced content as is illustrated in the **'Sequential Curriculum'** section.

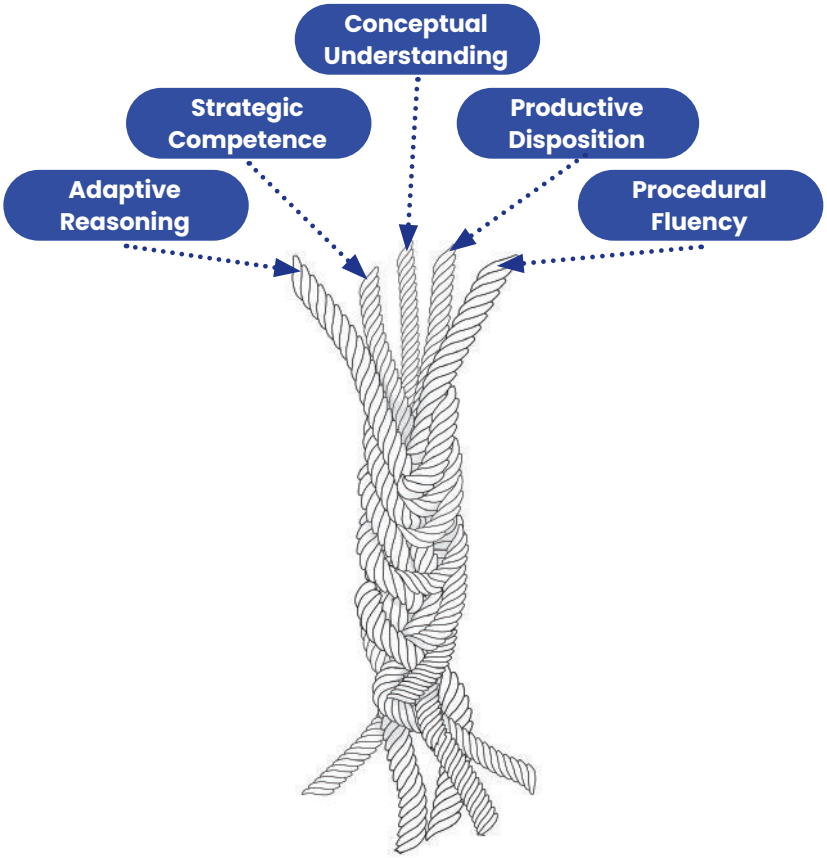


Figure 1. Five intertwined strands of mathematical proficiency.

Original diagram from "*Adding it up: Helping children learn mathematics*" by Kilpatrick, J., Swafford, J., & Findell, B.

The strand of **"productive disposition"** was not included in the Australian Curriculum however we believe it is essential for mathematics education. Sullivan (2011) quotes Watson and Sullivan (2008) in defining ***"productive disposition as a habitual inclination to see mathematics as sensible, useful and worthwhile, coupled with a belief in diligence and one's own efficacy"***. This is essential for both teachers and students. Sullivan (2011) stresses the importance of this for low-achieving students. The following features of Bond Blocks were built in to foster the development of productive disposition in teachers and students:

- Multiple activities highlight the innate beauty of mathematics as the **science of pattern**.
- Addition and subtraction are taught through understanding and making connections, so as students can **make sense** of them.
- The **mathematics** in every activity is clearly identified. Students know **why they are doing the activity**.
- The Bond Block test identifies what students do and don't know. Student then **set goals for their own learning**.
- The activities have been designed to have levels of engagement. Three-quarters of the activities are two player games. **Maths can be enjoyable.**
- Every topic has a set of Teacher Notes. These can be used by **teachers** to increase their **understanding of the mathematics**.
- Every activity is modelled in a video to support **teachers** in how to teach maths, increasing their **confidence teaching it**.

Sequentially Built, Cyclically Reviewed

Bond Block activities are sequenced based on prerequisite knowledge to ensure students have the required prior knowledge to build new understandings. Doing this reduces the risk students will rely on counting to calculate which is a major indicator that students will be at risk in mathematics. The activities are cyclically reviewed every chapter.

Mathematical Focus of each Core Kit Activity

Activity Chapter	Bonds	Fluency	Addition	Subtraction	Equation Building	Missing Number Equations	Word Problems	Calculating Strategies
2) Bonds of 5	6	7, 8, 9	10	11	12	13	14, 15	
3) Doubling and Halving to 10	16	17, 18						19, 20
4) Five Plus Bonds	21, 22	23	24	25				
5) Bonds of 10	26	27, 28	29	30	31	32	33	
6) Bonds of 6, 7, 8, 9	34	36, 37		35	38	39	40	
7) Ten Plus Bonds	41, 42, 43		44, 45, 47	48 (Set A)	46	48 (Set B), 49		50, 51, 52, 53, 54, 55, 56
8) Doubling and Halving to 20	57	58, 59, 60, 61						62, 63
9) Bonds of 11 to 20			64	65	66	67	68	69, 70, 71

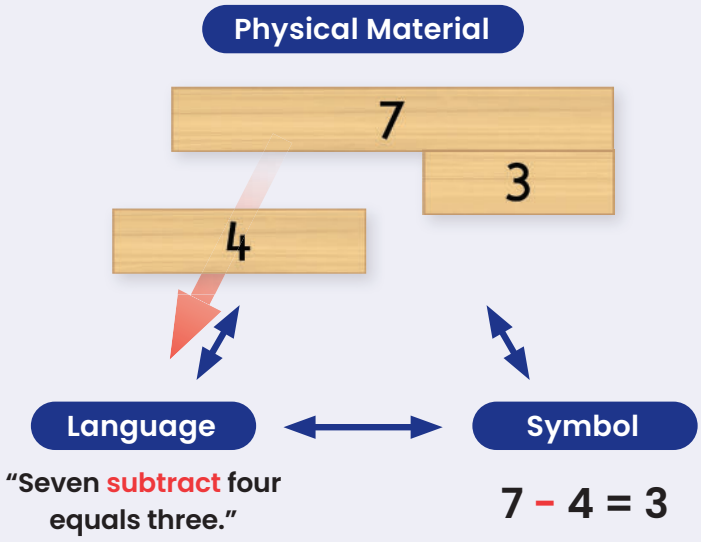
Numbers represent activity board numbers.

Mathematical Language and Connections

Mathematical understanding is strengthened when connections are made between the physical materials, mathematical language and symbols.

Core Kit

The way Bond Blocks are **positioned** (part-part-whole) and **moved** represents the operations of addition and subtraction. Students match the operation word, such as "subtract", with a corresponding action.



Concrete-Representational-Abstract

The Bond Block system is built using the **Concrete-Representational-Abstract approach**. This stems from the work of Bruner (1966). Bond Blocks are a **representational manipulative** that bridge the gap from concretely counting by ones to abstractly working with numbers and symbols.

Core Kit

Concrete

Most manipulatives can be counted by ones.

Many students don't progress from counting by ones.

Bridging the Gap

Representational

Bond Blocks are a physical manipulative to support bar-model maths.

The Missing Link to Abstract Calculation

Bond Blocks cannot be counted by ones.

- Learn number bonds (facts) in a self-correcting way.
- Represent and relate addition and subtraction using Part-Part-Whole.

Abstract

Adding and subtracting using numbers and symbols.

Part + Part = Whole

3 + 2 = 5

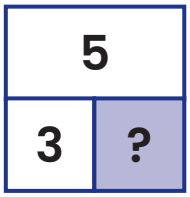
2 + 3 = 5

Whole - Part = Part

5 - 3 = 2

5 - 2 = 3

Extend with algebraic thinking.



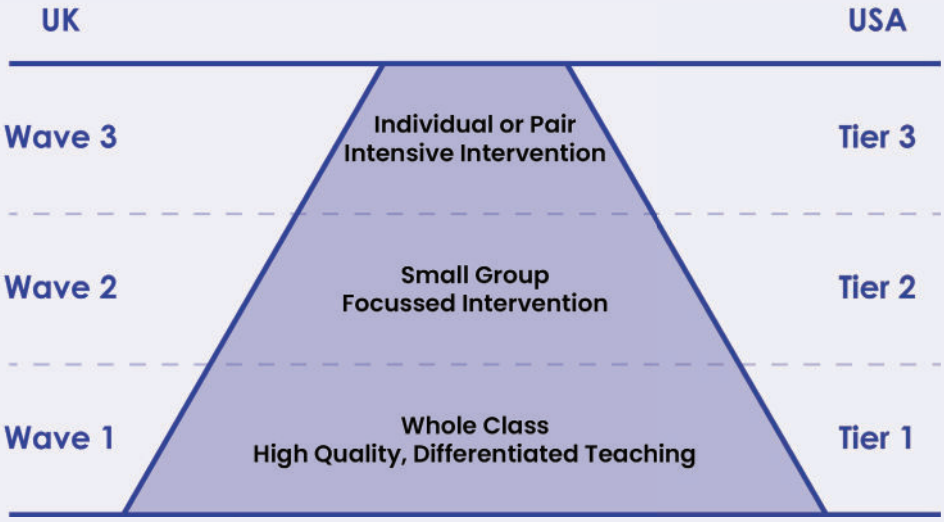
5 - ? = 3

3 + ? = 5

Evidence-Informed Intervention

Implementing Bond Blocks using Response to Intervention

The Bond Blocks System has been designed to be implemented at a whole school level. Implementation occurs at three different levels in line with a Response To Intervention process of instruction.



Bond Blocks is implemented at three different levels in line with a **Response To Intervention** process of instruction.

Firstly, the Bond Blocks Core Kit is implemented at a **tier one whole class** level as part of a whole school approach to teaching counting, addition and subtraction, including word problems and related algebraic thinking, from **Year 1 to Year 3**. Using Bond Blocks in these early years as a high-quality, differentiated teaching resource will reduce the numbers of students who require intervention.

Secondly, the Bond Blocks Core Kit is implemented at **tier two and three** as an **intervention program** for students from **Year 1 to 6** who have specific difficulties with foundational addition and subtraction. For example, students who count to add or subtract.

The GRATTAN Institute

For more information about implementing Bond Blocks refer to the implementation guides. The GRATTAN Institute's report (2023) ***"Tackling under-achievement: Why Australia should embed high-quality small-group tuition in schools"*** strongly endorses using tier two intervention in small groups of four students, as is recommended in the Bond Blocks implementation guide, as a cost effective way to help reduce the gap between advantaged and disadvantaged students. The report also recommends intervening as early as possible, before the gap increases. Bond Blocks targets the skills that are predictors of difficulty in maths from the first years of schooling, identified by research, and provides a high-quality differentiated resource to help close the gap.

Learning Difficulties Information Guide Numeracy

Using an **Response to Intervention** approach is endorsed by the State of Victoria Department of Education and Training (2019) *"Learning Difficulties Information Guide Numeracy"*. You can download this guide free from their site. One of our favourite quotes from this guide is, "***There is no 'one size fits all' approach to supporting students with learning difficulties in numeracy"*** (p. 14). Instead Intervention needs to be differentiated based on the needs of the learner. For this reason every Bond Block activity has differentiation options. This quote is also in line with Masters (2018) definition of evidenced-based teaching. The effectiveness of the intervention needs to be constantly evaluated for every student. This is why the Bond Block recording sheets for monitoring progress at a tier two and three level have significant space for recording anecdotes.

Response to Intervention Recommedations

Implementation of Bond Blocks for tier two and three intervention enacts the top four recommendations of the Institute of Education Sciences for RTI in Maths (Gersten et. al., 2009, p. 5).

Recommendation	Level of Evidence	Bond Blocks
Instruction during the intervention should be explicit and systematic. This includes providing models of proficient problem solving, verbalization of thought processes, guided practice, corrective feedback, and frequent cumulative review.	**Strong**	• Explicit, video modelled teaching of every activity. • Systematically sequenced activities based on required prior knowledge and curriculum standards. • Verbalisation of mathematical process and content specified for every activity. • Mathematics is cyclically reviewed every chapter of activities. • Guided practice using gradual release model.
Interventions should include instruction on solving word problems that is based on common underlying structures.	**Strong**	• Word problem instruction uses underlying additive structures of part-part-whole and comparison problems, solved using Polya and the bar model. In depth teacher notes provided for professional learning.
Intervention materials should include opportunities for students to work with visual representations of mathematical ideas and interventionists should be proficient in the use of visual representations of mathematical ideas	**Moderate**	• Bond Blocks are a representational manipulative that is proportional. In each chapter students move from using the using physical Bond Blocks, to drawings of Bond Blocks, then to non-proportional part-part-whole diagrams.
Interventions at all grade levels should devote about 10 minutes in each session to building fluent retrieval of basic arithmetic facts.	**Moderate**	• Bond Blocks intervention specifies a minimum of four, ten minute sessions per week.

Research Informed

Each Bond Block resource has been designed to target the major predictors of maths difficulties, identified by research, with evidence-based teaching strategies. Therefore, Bond Blocks doesn't cover every area of the curriculum but focuses on:

- initial counting (Pre-Foundation and Foundation) using the "Bond Blocks Counting to 10 & 20" Kit and
- addition and subtraction (Year 1 to 3 level) using the "Bond Blocks Core" Kit.

> "Critical early quantitative competencies that children must possess to learn mathematics include an understanding of the relation between number words, Arabic numerals, and the underlying quantities they represent, as well as skill at fluently manipulating these representations; knowledge of the mathematical number line; and basic skills in arithmetic (i.e., skilled use of counting procedures, decomposition, and fact retrieval in problem solving). These skills are easily assessed in young children and many have been shown to be highly responsive to instructional interventions." (Geary, 2011, p. 15-16)

Core Kit

For students in Years 1 to 3 the major predictors of difficulties in maths are (Geary et al., 2009):

1. Persistent use of finger counting to add.
2. Lack of recall of basic facts (bonds).
3. Inefficient addition strategies such counting all.

The Bond Block Core Intervention Kit sequentially targets the teaching of all basic facts (bonds) used for addition and subtraction and the related strategies.

Intervention

The Core Kit can be used for Intervention with students who are not fluent with addition and subtraction of basic facts. It has been designed to support students with learning difficulties.

For more information please read these Bond Blocks Teacher Notes:

- "Developing Calculation, Not Counting". This outlines how to help students move on from counting when adding and subtracting to calculating without counting. This Teacher Note also contains information about characteristics of students with a specific learning difficulty in mathematics (Dyscalculia). bondblocks.com/tn-developing-calculation-not-counting
- "Supporting Students with Learning Difficulties". This Teacher Note outlines the range of features have been built into the Bond Block System to support students with learning difficulties.

Geary et al. (2009 p.4) states that when looking at students with a mathematical learning disability the "most consistent finding is that [they] show a deficit in the ability to use retrieval-based processes... and rarely use decomposition." He states that these students "rely on finger counting for more years" than students who do not have a disability in maths. Students who hold onto counting to solve addition and subtraction are at risk. These students do not move past the concrete stage of development for additive thinking.

The Core Kit systematically targets fluency with two-part bonds of wholes up to twenty and the development of partitioning based calculating strategies to help student move on from counting by one to add and subtract.

Prevention

It is worth noting that it is not only students with a mathematical learning disability who hold onto counting by ones to add and subtract. It is also mainstream students. Hopkins, Russo and Siegler in their 2022 paper "Is counting hindering learning?" found that over 30% of the Year 3 and 4 students they studied relied on counting to solve basic addition.

We found accurate min-counters [counting on from the largest number] represented over 30% of participants. These children were often incorrect when they were required to use retrieval for simple addition and were less flexible than most of the peers with mental computation strategies. (Hopkins et al., 2022, p. 52)

Their study involved 166 students "from three public primary schools in Melbourne, Australia…one school community was relatively advantaged… and two schools were similar to the Australian average" (p. 55). They surmised that "the percentage of children who do not consistently use retrieval to solve simple addition problems might well be even higher in lower-income areas" (p. 64).

This study involved simple addition. Whilst the number of students in Year 3 and 4 counting for addition is concerning, the number of students using counting for subtraction is even higher. In a different study Hopkins et al. (2023, p. 267) found "the prevalent use of decomposition strategies for single-digit problems that sum to between 10 and 20 and the use of counting strategies for corresponding subtraction problems".

Australian curriculums expect students to recall basic facts for addition and subtraction as well apply these to missing number problems in Years 2 and 3. The specific year varies from state to state depending on which version of the curriculum is being used.

The authors hypothesize that the following two factors are contributing to the significant number of tier one students not achieving the curriculum standard for addition and subtraction and are instead requiring intervention because they are dependent on counting:

- An overuse of discrete manipulatives at the Concrete stage of addition and subtraction that can be counted with one-to-one correspondence. Our observations are that when students are experiencing difficulty with addition and subtraction they are given more (albeit often different) manipulatives that can still be counted. This amplifies the problem. Our recommendation is the use of representational manipulatives, that cannot be counted by one, to bridge the gap from the concrete stage to the abstract stage of fluently adding and subtracting with numbers and symbols alone. This was the primary motivation for the creation of Bond Blocks.
- The importance of mathematical language at each of the Concrete-Representational-Abstract stages. Literacy has effectively upskilled teachers to use consistent whole school language when teaching English. Mathematics has failed to do this at a system wide level. For example, when asking what numbers that add to ten are called the following answers are often given in the same school: Bonds of 10, basic facts, compatible numbers, friendly numbers, friends of ten, rainbow facts. The lack of consistent school wide mathematical language contributes to ineffective teaching and learning. This is why every Bond Blocks activity states the mathematical language and models the correct use of it in explicit teaching on video.

Using the Core Kit are part of whole class, tier one teaching in Years One to Three will reduce the number of students who are stuck counting to solve addition and subtraction of basic facts. It also focuses on relationships between addition and subtraction to solve missing number and word problems. Prevention is better than cure.

We will conclude with our favourite quote from John Hattie (2016).

"Almost everything in published research works at least some of the time with some students. Our challenge as a profession is to become more precise in what we do and when we do it. Timing is everything, and the wrong practice at the wrong time undermines efforts." (p. 103)

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