

# Report of the Building Numeracy Leadership in Early Action for Success Schools Impact Analysis Study

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## Executive Summary

### 1. Introduction

Building Numeracy Leadership [BNL] is an extended professional learning experience that was first implemented in 2017 for teachers in *Early Action for Success* [EAFS] schools. BNL's purpose is "to extend participants' knowledge and capabilities to enhance the numeracy outcomes of students in *Early Action for Success* schools" (BNL expression of interest, 2018).

The aim of this study was to analyse and evaluate BNL's impact on teacher participants' knowledge and teaching practices.

### 2. Background to BNL

Prior to 2017, mathematics and numeracy were generally not key foci of EAFS schools despite the majority of ILs employed to develop both literacy and numeracy. BNL was developed and offered to EAFS schools to help develop their mathematics and numeracy.

#### 2.1. Approach and Underpinning Theories of BNL

BNL aims to enable transformative change in teachers. The professional learning of BNL is based on research about mathematics and numeracy related to the pedagogical content knowledge and mathematical knowledge of teachers. It draws from a wide research base. Its major theoretical underpinnings stem from social constructivism, educational psychology and variation theory but it also draws upon a range of other epistemologies according to the research base relevant to the aspect of mathematics teaching and learning in question.

#### 2.2. Conceptual Framework

The conceptual framework for this study was informed by two theoretical models. The first was an adaption of Clark and Peterson's (1986) model of teacher thought and action of instructional planning. The second, was Ball, Thames and Phelps' (2008) mathematical knowledge for teaching (MKT) model.

### 3. Methodology

Quantitative and qualitative methodology using mixed-method data sources including a questionnaire, open-ended response tasks, interviews and classroom observations.

#### 3.1. Participants

Study participants included 563 teachers of K-6 (5-12 years of age) students and their teacher leaders (Instructional leaders and principals) from 110 school teams across NSW who participated in BNL professional learning.

#### 3.2. Data Gathering: Instruments and Procedure

##### 3.2.1. Questionnaire

A questionnaire was used to collect data on specific aspects of teachers' mathematical knowledge, conceptions, teaching practices and confidence to teach mathematics prior to and at the conclusion of the BNL professional learning experience. The questionnaire's reliability was obtained using Cronbach's  $\alpha$ . Results indicate that the questionnaire

demonstrated strong reliability with an internal consistency co-efficient of  $\alpha = .732$ . The entire questionnaire took participants approximately 25 minutes to complete.

### *3.2.2 Scenario Task*

Following completion of the questionnaire at both Time 1 and Time 2, teachers were asked to provide responses to a classroom scenario task. The task was adapted from the game, *Four Strikes and You're Out* (Tank & Zolli, 2008).

### *3.2.3. Interviews*

Interviews were conducted in the final term of the school year between late October and early December. They were conducted at participants' schools in a private office and lasted approximately 30 to 40 minutes. The purpose of the interviews with teachers was to gain an understanding of how BNL had impacted their beliefs, knowledge and practices for teaching mathematics. Interviews with Principals and Instructional Leaders focused on reasons for decisions about the school's involvement in BNL and for the selection of particular teachers, arrangements at the school level for on-going support for their involvement in BNL and their perspective on the uptake of the practices and beliefs underpinning BNL by teachers.

### *3.2.4. Observations*

Observations of mathematics lessons normally occurred prior to teacher interviews but on two occasions this was reversed due to school timetable constraints. Observations of 16 lessons across K-6 classrooms in six different schools took place that ranged in duration from 15 minutes to one hour. The purpose of the observations was predominantly to provide a context for the interviewer to initiate discussion with each teacher at their interview.

## *3.3. Analysis*

Data from the questionnaire was analysed quantitatively, using SPSS Statistics, Version 25. A combination of correlational analysis and analysis of variance to determine differences between participants' item scores between Time 1 and Time 2. All other data were analysed qualitatively using a combination of deductive and inductive approaches.

## *4. Results*

### *4.1. Questionnaire*

Higher scores at Time 2 indicate that there was an overall shift in teachers' commitment towards the conceptions of teaching and learning mathematics and the instructional practices emphasised in BNL at the end of 2018 than reported by teachers prior to their involvement in the professional learning. Teachers reported significant and positive changes to every dimension measured on the questionnaire except for Assessment. Results also indicate that there was an increase in the percentage of teachers using a variety of sources to inform their teaching of mathematics and shifts occurred in the organisational structures used to instruct students in mathematics.

### *4.2. Scenario*

Overall shifts in participants' responses on the scenario task revealed:

- Increased specialised content knowledge (SCK);
- Enhanced knowledge of content and students (KCS);
- A greater emphasis on Working Mathematically;
- Increased use of teacher questioning to elicit student thinking;
- Shifts in the type of questions asked by teachers to include more ‘what if’ type questions; and
- Increased emphasis on students representing and sharing their reasoning.

### 4.3 Interviews with Principals and Instructional Leaders

#### 4.3.1. *Opportunities and Constraints*

Principals and ILs considered the invitation to participate in BNL as an opportunity to address a number of existing contextual constraints perceived to be inhibiting the advancement of students in mathematics and numeracy, including:

- disappointing student NAPLAN performances;
- the apparent lack of students’ capacities to solve non-routine and challenging problems;
- students’ under-developed capacities for higher-order thinking and for articulating their mathematical reasonings;
- teachers’ self-identified weaknesses in knowledge and pedagogy; and
- inconsistencies among groups of teachers’ pedagogies or between school philosophical approaches and teacher pedagogies for teaching mathematics.

#### 4.3.2. *Affect*

The major changes noted by principals and ILs included:

- overall positive shifts in teacher and student mathematical mindsets towards a growth mindset;
- increase in teachers’, ILs’ and students’ interest, enjoyment and enthusiasm for mathematics;
- increased use of mathematical language by teachers and students; and
- increased sense of pride in principals for the achievements of their teachers and students.

#### 4.3.3. *Knowledge of mathematics and pedagogy*

Prevalent aspects of teacher knowledge inferred by principals and instructional leaders included:

- increased use of specialised mathematical language;
- development of teacher specialised content knowledge (SCK) especially around the ‘big ideas’ of mathematics;
- development of teacher knowledge of students’ thinking (KCS);
- development of teacher knowledge about sequencing of learning and making links between concrete and abstract representations (KCT).

#### 4.3.4. *Planning intentions*

Interview data from principals and instructional leaders were interpreted in two ways as part of the planning component of Clark and Peterson’s framework:

- Purposeful executive-level plans to achieve teacher buy-in, ensure sustainability and dissemination to other staff; and
- intentional strategies to assist teachers incorporate BNL ideas into their programs.

#### *4.3.5. Classroom actions*

The major changes to teachers' classroom actions reported by principals and instructional leaders included:

- changes to classroom organisation and resources such as the use of ability-groupings or textbooks;
- increased use of student talk;
- use of challenging problems; and
- increased emphasis on all working mathematically processes.

#### *4.3.6. Student responses*

Student responses were gleaned via a general 'sense' or 'feeling' from a range of anecdotal evidence. Such responses included:

- changes to students' conceptions of and attitudes towards mathematics; and
- improvements in NAPLAN (for schools involved in BNL for two years).

### *4.4. Teacher interviews and observations*

#### *4.4.1. Opportunities and Constraints*

Commonly, teachers referred to the BNL opportunity:

- as an approach to teaching; and
- as positively impacting their knowledge, beliefs, practices for, and enjoyment of, teaching mathematics.

Teachers referred to a small number of obstacles surrounding the implementation of approaches and ideas emphasised in BNL, including:

- the amount of content and the pace at which it was presented;
- the relatively short period of time for individual teacher involvement in formal BNL sessions;
- feelings of isolation (mostly for teachers from rural/remote areas) and uncertainty about the quality of their enactment; and
- the need for school-level strategies to alleviate the effects of 'resistors' and 'blockers'.

#### *4.4.2. Affect*

Affective changes reported by teachers:

- included increased interest, enjoyment and confidence for teaching mathematics; and
- resulted from different experiences for different teachers.

#### *4.4.3. Knowledge of mathematics and pedagogy*

The salient aspects of teacher knowledge evident from interviews included:

- increases in teachers' knowledge of students' thinking strategies (KCS);

- increases in teachers' knowledge of specialised content knowledge (SCK); and
- changes to teachers' knowledge of content and teaching (KCT).

#### *4.4.4. Planning intentions*

Teachers' planning intentions:

- heavily relied on formative assessment with planning for the next week (or even day) dependent on student responses from immediate previous lessons;
- involved structural changes to the way students were grouped for instruction;
- involved structural changes to the way they planned and programmed with increased use of collaborative planning strategies;
- involved a slower pace of progress than typical of programs planned prior to BNL with the intention that concepts be treated in more depth; and
- involved a greater variety of resources to inform planning than prior to BNL.

#### *4.4.5. Classroom actions*

The most notable changes to teachers' practices included:

- More time for students to talk with each other and as a whole class,
- More opportunities for students to investigate, explore and struggle without teacher intervention or 'telling';
- Greater use of teacher questioning to elicit student thinking;
- More noticing, listening and responding to student strategies by teachers;
- Greater emphasis on students noticing the structure of number; and
- More opportunities for students to record and represent their thinking in a variety of forms.

#### *4.4.6. Student responses*

Student responses included:

- Shifts towards growth mindsets;
- Increased use of mathematical language;
- Increased enjoyment of, and confidence to do, mathematics
- Enhanced capacity to explain their reasoning; and
- Greater persistence to work on challenging problems.

## 5. Summary of Results and Recommendations

The aim of this study was to analyse and evaluate BNL's impact on teacher participants' knowledge and teaching practices.

What impact does BNL have on participating teachers' pedagogical and mathematical knowledge?

Increases in the amount and quality of teacher specialised content knowledge of mathematics (SMK), their knowledge of content and students (KCS) and knowledge of content and teaching (KCT) were evident from and (to a lesser degree) participants responses to the scenario task. Generally, the introduction of the vast majority of ideas and concepts, and the theoretical underpinnings of those ideas and concepts, were new to nearly all participants. Teachers differed in their prior knowledge, which meant that their



readiness to accommodate this knowledge also differed. Many participants felt that they needed a longer timeframe to fully take on board all the benefits of BNL. Nevertheless, all teachers who participated in the data collection demonstrated positive growth in their mathematical knowledge for teaching to some degree.

#### Recommendation 1

The NSW Department of Education consider strategies to extend the length of time in which either individual teachers and/or their schools can participate in formal BNL sessions for at least two years, and ideally, three year.

#### What impact does BNL have on teachers' instructional practices in mathematics?

Changes to teachers' instructional practices in mathematics were evident from questionnaire responses, interviews with principals, instructional leaders, teachers themselves, and from the lesson observations. Most notable changes involved:

- More opportunities for students to investigate, explore and struggle without teacher intervention or 'telling';
- Greater use of teacher questioning to elicit student thinking;
- More noticing, listening and responding to student strategies by teachers;
- Greater emphasis on students noticing the structure of number;
- More opportunities for students to record and represent their thinking in a variety of forms.
- Greater emphasis on formative assessment with planning for the next week (or even day) dependent on student responses from immediate previous lessons;
- Structural changes to the way students were grouped for instruction;
- Structural changes to the way they planned and programmed with increased use of collaborative planning strategies;
- A slower pace of progress than typical of programs planned prior to BNL with the intention that concepts be treated in more depth; and
- A greater variety of resources to inform planning than prior to BNL.

Changes to instructional practice were immediate and quite often profound. Teachers noted that the implementation of their new knowledge was the most challenging aspect of BNL. Knowing what these practices looked like in the classroom and whether they were "on the right track" was an on-going concern for many teachers.

#### Recommendation 2

The NSW Department of Education consider strategies to increase the time allocated to instructional leaders to allow more 'in-class' support and that the expertise of past BNL participants be utilised as mentors or coaches to support new schools as they implement BNL.

#### What impact does BNL have on teachers' confidence to teach mathematics?

Positive changes to all aspects of teachers' affective states were noted throughout the study. The increase in teacher confidence to teach mathematics was accompanied by increase in enjoyment, growth mindsets and renewed interest in learning about

mathematics pedagogy and content. Confidence was further stimulated when teachers witnessed positive responses by students. The positive affective impact was often contagious, with principals experiencing a sense of pride in their teachers and students particularly when visitors from outside the school could share and witness the impact.

#### Recommendation 3

The NSW Department of Education consider strategies for sharing of practices, possibly through a teacher showcase or open-door/classroom event specifically designed to share the positive impact of BNL on teachers and students.

#### Conclusion

There is overall evidence that BNL has had, and continues to have, a positive impact on teachers' knowledge of mathematics and pedagogy, their instructional practice and their confidence levels for teaching mathematics. It is important to explore the reasons for its effectiveness in finer detail to better inform teacher professional learning initiatives of the NSW Department of Education in the future.

#### Recommendation 4

The focus on future impact analyses of BNL shift from *whether* it works to HOW and WHY it works.

# Report of the Building Numeracy Leadership in Early Action for Success Schools Impact Analysis Study

## 1. Introduction

Building Numeracy Leadership [BNL] is an extended professional learning experience that was first implemented in 2017 for teachers in *Early Action for Success* [EaFS] schools. EaFS is the New South Wales [NSW] Department of Education's strategy for implementing the State government's State Literacy and Numeracy Plan (2017-2020), which aims to improve the literacy and numeracy skills of students in the early years of schooling. BNL's purpose is "to extend participants' knowledge and capabilities to enhance the numeracy outcomes of students in *Early Action for Success* schools" (BNL expression of interest, 2018).

BNL was implemented again in 2018, in which year the current study took place. The aim of this study was to analyse and evaluate BNL's impact on teacher participants' knowledge and teaching practices. The specific research questions guiding the study were:

1. What impact does BNL have on participating teachers' pedagogical and mathematical knowledge?
2. What impact does BNL have on teachers' instructional practices in mathematics?
3. What impact does BNL have on teachers' confidence to teach mathematics?

Findings of the study will inform recommendations for future development of BNL.

## 2. Background to BNL

EaFS commenced in 2012 with 50 schools. It expanded in 2015 to include 310 schools (Phase 1) based on the Family Occupation and Education Index (FOEI) – a school measure of socio-economic status. It expanded in 2017/18 (Phase 2) to include 555 schools, some of which were self-funded and chose to participate in EaFS.

In Phase 2 all EaFS schools were allocated an Instructional Leader (IL) for three years (2017-2019). ILs are allocated based on student enrolment numbers with allocations ranging between 0.2 (one day per week) to 2 full-time ILs. ILs have responsibilities for supporting literacy and numeracy in the early years (K-2). In Phase 2, ILs were employed by school principals. Prior to 2017, mathematics and numeracy were generally not key foci of EaFS schools despite the majority of ILs employed to develop both literacy and numeracy. BNL was developed and offered to EaFS schools to help develop their mathematics and numeracy.

### 2.1. Approach and Underpinning Theories of BNL

BNL aims to enable transformative change in teachers. It not only intends to change teacher knowledge and practices at superficial levels but to change participants' identities as

teachers of mathematics. Such transformations will have positive implications for how teachers position their students for learning and doing mathematics.

The professional learning of BNL is based on research about mathematics and numeracy related to the pedagogical content knowledge and mathematical knowledge of teachers. Specifically, it aims to support teachers in enhancing their knowledge and practice in:

- Embedding working mathematically (or mathematical proficiencies of the Australian Curriculum);
- Teaching through the big ideas and understandings in mathematics;
- Designing, implementing and evaluating rich tasks;
- Developing classroom environments that enhance student engagement; and
- Assessment for and of learning.

BNL draws from a wide research base, including (but not limited to):

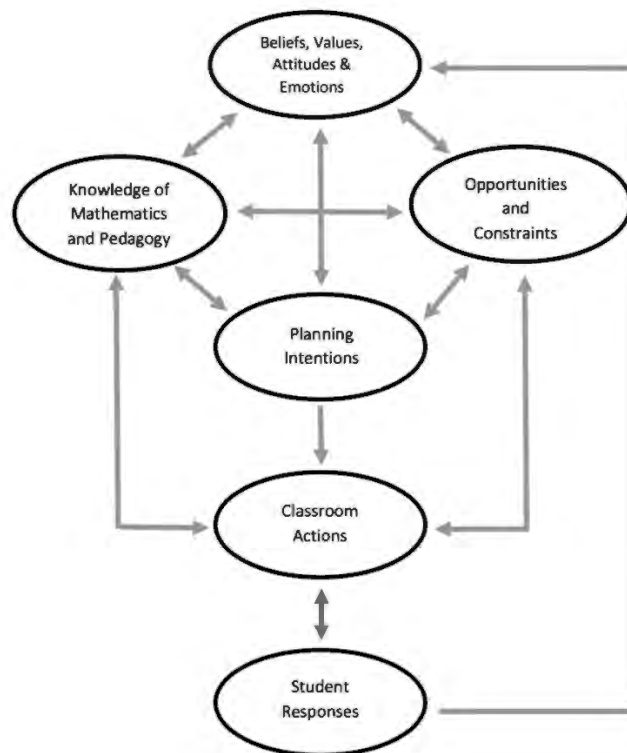
- Peter Sullivan (challenging and open-ended questions/tasks);
- Mike Askew (effective teachers of numeracy);
- Carol Dweck and Merylyn Goos (growth mindsets, dispositions);
- Jeremy Kilpatrick & Peter Sullivan (proficiencies/working mathematically);
- Leonie Burton, Mike Askew and Peter Grootenboer (Identity – ‘being a mathematician’);
- Elham Kazemi, Alison Hintz and Neil Mercer (Intentional talk, talk moves, dialogic talk);
- Andrew Martin, Geoff Munns, Wayne Sawyer and Fiona Ingram (Engagement and classroom climate);
- John Mason (teacher noticing);
- Dianne Siemon (big ideas);
- Alistair McIntosh and Robert Reys (number sense); and
- Margaret Walshaw and Glenda Anthony (rich tasks).

Its major theoretical underpinnings stem from social constructivism, educational psychology and variation theory but it also draws upon a range of other epistemologies according to the research base relevant to the aspect of mathematics teaching and learning in question.

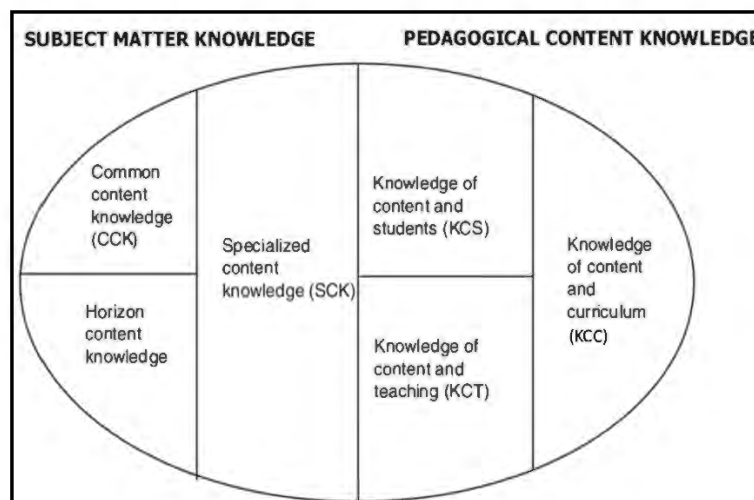
## 2.2. Conceptual Framework

The conceptual framework for this study was informed by two theoretical models. The first was an adaptation of Clark and Peterson’s (1986) model of teacher thought and action of instructional planning (see Figure 1). The model was adapted to match the theories and research base underpinning BNL. Adaptions to the model include the expansion of the ‘Beliefs, values and attitudes’ component to incorporate ‘emotions’. The model represents bi-directional relationships between teachers’ thoughts and actions as they are influenced by the opportunities and constraints afforded by their participation in BNL and the context in which they teach. A student responses component was also added to the model and is represented as a bi-directional relationship with teacher classroom actions. Finally, student responses are linked back to teacher affective components (beliefs, attitudes, values and emotions).

Ball, Thames and Phelps' (2008) mathematical knowledge for teaching (MKT) model was used to interpret specific changes in the teacher knowledge component of the adapted Clark and Peterson model (see Figure 2).



**Figure 1.** Adapted model of teacher thought and action of instructional planning (Clark & Peterson, 1986, p. 257)



**Figure 2.** Domain map for Mathematical Knowledge for Teaching (Ball et al., 2008)

A brief definition for each of the sub-domains is provided in Figure 3. The sub-domains of direct relevance to the current study (marked with an asterisk in Figure 3) are the sub-domains of specialised content knowledge (SCK), knowledge of content and students (KCS) and knowledge of content and teaching (KCT).

**Common content knowledge (CCK)** – The mathematical knowledge and skill used in settings other than teaching. Recognising a student error involves CCK.

**Horizon content knowledge (HCK)** – This knowledge allows a teacher to look forward to how mathematical topics are related to other topics taught later in the curriculum.

**Specialized content knowledge (SCK)** – The mathematical knowledge and skill unique to teaching. Understanding an error is SCK but beyond that of the average person and different to a mathematician’s understanding.

**Knowledge of content and students (KCS)** This knowledge combines knowing about students and knowing about mathematics. Teachers need to anticipate what students are likely to think and what they will find confusing. It involves teachers knowing how best to build on students’ thinking and address their errors.

**Knowledge of content and teaching (KCT)** This knowledge combines knowing about teaching and knowing about mathematics. Many of the mathematical tasks of teaching require a mathematical knowledge of the design and sequencing of instruction and assists teachers evaluate particular representations in instructional decisions.

**Knowledge of content and curriculum (KCC)** – Knowledge that enables decisions to be made about appropriate resources for teaching specific aspects of mathematics.

**Figure 3.** Brief definition for each of the sub-domains of Mathematical Knowledge for Teaching

Ball et al. (2008) recognised the subtleness of the divisions between the types of knowledge in their model and emphasised the importance of teachers having connected mathematical knowledge.

### 3. Methodology

Quantitative and qualitative methodology using mixed-method data sources including a questionnaire, open-ended response tasks, interviews and classroom observations. Ethics approval was obtained from the University of Sydney Human Ethics Committee (see Appendix A) along with SERAP from the NSW Department of Education (see Appendix B).

#### 3.1. Participants

Study participants included 563 teachers of K-6 (5-12 years of age) students and their teacher leaders (Instructional leaders and principals) from 110 school teams<sup>1</sup> across NSW who participated in BNL professional learning<sup>2</sup>. Prior to commencing the PL (Time 1), participants were invited to complete an on-line questionnaire and respond to a classroom scenario task. At Time 1, 360 participants (90.3% female) completed both data-gathering instruments anonymously, and at the final PL session (Time 2), 331 completed the same data gathering instruments (90.6% female). A unique identification code created at Time 1 was used to match participant responses at Time 1 with their responses at Time 2. The

<sup>1</sup> A ‘school team’ includes groups of teachers from a single school and teachers from a number of small and/or remote schools who combine to form a ‘team’ based on some aspect of convenience, such as proximity.

<sup>2</sup> While the majority of teachers attending BNL PL were new participants in 2018, a few school teams who were involved in a 2017 trial of BNL also participated in 2018.

responses of 239 participants could be matched for both Time 1 and Time 2. Demographic data collected via the questionnaire at Time 2 is summarised in Table 1. Of note is the high proportion of participants with more than 15 years teaching experience (46.5 %), which is probably a result of the large number of teachers in leadership roles (Instructional Leaders and Assistant/Deputy Principals) attending the PL. While BNL targeted the early years of primary school, teachers of K-6 were involved.

**Table 1**  
Demographics of questionnaire respondents at Time 2

<b>Demographic</b>	<b>Frequency (n=331)</b>	<b>Percentage (%)</b>
<b>Location</b>		
Rural/remote	135	40.8
Metropolitan	196	59.2
<b>Teacher Classification Level</b>		
Classroom Teacher	129	39.0
Assistant/Deputy Principal	78	23.6
Principal	9	2.7
Instructional Leader	107	32.3
Other (Learning Support Teacher)	8	2.4
<b>School Enrolment Number</b>		
<51	21	6.3
51-100	14	4.2
101-200	41	12.4
>201	255	77.0
<b>Teaching Experience (years)</b>		
First Year	2	0.6
2-3	22	6.6
4-5	30	9.2
6-10	68	20.5
11-15	55	16.6
Over 15	154	46.5
<b>Current Grade Level Taught *</b>		
Kindergarten	153	46.2
Year 1	157	47.4
Year 2	157	47.4
Year 3	98	29.6
Year 4	103	31.1
Year 5	93	28.1
Year 6	85	19.0
<b>Highest Academic Qualification</b>		
Diploma	20	6.0
Bachelor	257	77.7
Masters	43	13.0
2-3 Year Teacher Diploma	5	1.5
Other (Graduate Diploma/Certificate)	6	1.8

\* Some teachers taught multi-grade classes, so percentages do not total 100%

While responses to both instruments were anonymous, questionnaire respondents were asked to provide their name and contact details if they wished to be included in an interview and classroom observation phase of the study. Approximately 58% of participants at Time 1 agreed to be contacted and provided their details. To maximise the number of interviews and classroom observations in the time available, participants were invited to



interview when at least three or more from the same school indicated their willingness to participate in this phase of the study. A balance between participants from rural and metropolitan schools was also desired. A total of 25 interviews were conducted, including 15 classroom teachers, five Instructional Leaders (one of whom was acting principal at the time of interview) and five principals from six different primary schools from across NSW (three metropolitan and three rural).

## 3.2. Data Gathering: Instruments and Procedure

### 3.2.1. Questionnaire

A questionnaire was used to collect data on specific aspects of teachers' mathematical knowledge, conceptions, teaching practices and confidence to teach mathematics prior to and at the conclusion of the BNL professional learning experience (see Appendix C for a copy of the questionnaire). Part A of the questionnaire was used to collect teacher biographical information that was reported earlier. Additional background questions asked teachers about prior attendance at professional development courses, the sources they used for teaching ideas and grouping structures used for mathematics instruction.

Part B was adapted from the Ross, McDougall, Hogaboam-Gray, and LeSage (2003) instrument for measuring the extent to which teachers were committed to instructional practices in mathematics that were supportive of reform-oriented and inquiry-based approaches. Items were adapted to reflect the underlying principles (e.g. student struggle time on challenging mathematics problems is important) and practices (the use of enabling and extending prompts can be used to differentiate student learning) emphasised in BNL. It contained 20 Likert-type items with a 5-point response scale ranging from *strongly disagree* (1) to *strongly agree* (5). The questionnaire items were designed to help describe teachers' perspectives about mathematics learning, their confidence teaching mathematics and their instructional approach across seven dimensions: namely, *Tolerance for Struggle* (e.g. Item 3: I allow students to struggle before I intervene), *Teacher Confidence* (Item 6: I feel confident in my understanding of the mathematics content I am about to teach), *Nature of Tasks* (e.g. Item 14: I often provide the same task for all students and then offer enabling and extending prompts), *Teacher's Role* (e.g. Item 19: I teach students how to explain their mathematical ideas), *Instructional organisation* (e.g. Item 11: In my classes, students learn maths best when they can work together to discover mathematical ideas), *Assessment* (e.g. Item 10: I integrate maths assessment into most maths activities), and *Teacher's Conception of Mathematics* (e.g. Item 16: A lot of things in maths must simply be accepted as true and remembered). As a check for agreement bias, five items (Items 8, 9, 12, 16, and 20) were negatively worded so that their scoring would be reversed (Creswell, 2003).

Appendix D presents each questionnaire item grouped according to its relevant dimension (or subscale) measured by the BNL Questionnaire. The questionnaire's reliability was obtained using Cronbach's  $\alpha$ . Results indicate that the questionnaire demonstrated strong reliability with an internal consistency co-efficient of  $\alpha = .732$ . Further details about the questionnaire's reliability is presented in Section 4 Results.

The entire questionnaire took participants approximately 25 minutes to complete.

### 3.2.2 Scenario Task

Following completion of the questionnaire at both Time 1 and Time 2, and following a short break, teachers were asked to provide responses to a classroom scenario task (see Appendix E for a copy of the task). The task was adapted from the game, *Four Strikes and You're Out* (Tank & Zolli, 2008). Its purpose was to elicit teachers' capacities to:

- i. determine the learning intention of the task;
- ii. anticipate and interpret student strategies and knowledge evident in the scenario;
- iii. suggest strategies to differentiate the task for different student capacities (e.g. use enabling and extending prompts);
- iv. suggest variations to suit different grades/stages and leverage learning from this task to other topics in the syllabus; and
- v. make meaningful decisions as to what and how student learning should progress.

In terms of Ball et al.'s model of MKT, the scenario task addressed teacher knowledge of content and students (KCS), knowledge of content and teaching (KCT) and, to a lesser degree, specialised content knowledge (SCK). The task was conducted on-line and took approximately 10 minutes for teachers to complete.

### 3.2.3. Interviews

Interviews were conducted in the final term of the school year between late October and early December. They were conducted at participants' schools in a private office and lasted approximately 30 to 40 minutes. Interviews with classroom teachers usually took place immediately, or soon, after a classroom visit to allow observation of a mathematics lesson taught by the teacher and to elicit conversations about the nature of the lesson and tasks observed. Schools were provided with relief-teacher funding to ensure teachers were available for interview during school hours.

The purpose of the interviews with teachers was to gain an understanding of how BNL had impacted their beliefs, knowledge and practices for teaching mathematics. Semi-structured interviews were considered most appropriate to achieve this purpose. They allowed the interviewer the freedom to follow-up on aspects of the lesson recently observed and to adjust questions to suit the particular context of each teacher. In particular, teachers were asked to talk about the strategies they used in the lesson just observed, and to elaborate upon reasons for selecting particular activities and strategies as well as commenting on how and why any of these aspects had changed as a result of their involvement in BNL. Teachers were encouraged to bring documents to the interview to support their explanations. Approximately half the teachers brought along some documentation, including student work samples from the lesson just observed, influential articles that had informed changes to their practice, and lesson plans.

Interviews with Principals and Instructional Leaders focused on reasons for decisions about the school's involvement in BNL and for the selection of particular teachers, arrangements at the school level for on-going support of their participation in BNL and their perspective on the uptake of the practices and beliefs underpinning BNL by teachers.

All interviews were audio recorded and transcribed for analysis. To maintain the anonymity of participants, no references to teachers' names and their schools are made in this report.

#### *3.2.4. Observations*

Observations of mathematics lessons normally occurred prior to teacher interviews but on two occasions this was reversed due to school timetable constraints. Observations of 16 lessons across K-6 classrooms in six different schools took place that ranged in duration from 15 minutes to one hour. One teacher was observed but was not available for interview. Prior to and during the lessons, photographs were taken of the classroom environment and particularly of wall displays containing student's work from previous mathematics lessons. Photographs during the lessons focused on capturing students' visual representations to problems posed (individual and small group responses) and to stimulus material provided by teachers and displayed to all students. Field notes were taken during the observations that served mostly as a reminder to follow-up on specific questions about the lesson during the follow-up interview. The purpose of the observations was predominantly to provide a context for the interviewer to initiate discussion with each teacher at their interview. However, the observations and data generated via the photographs also conveyed a sense of the nature of tasks provided to students on a regular basis and the instructional practices employed by teachers.

#### *3.3. Analysis*

Data from the questionnaire was analysed quantitatively, using SPSS Statistics, Version 25. A combination of correlational analysis and analysis of variance to determine differences between participants' item scores between Time 1 and Time 2.

All other data were analysed qualitatively using a combination of deductive and inductive approaches. Data generated from the scenario task was analysed according to the five aspects of teacher capacities it was designed to elicit (see Section 3.2.2). Twelve participants' responses (one principal, two assistant/deputy principals, six classroom teachers, and three instruction leaders) for both Time 1 and Time 2 to the scenario, were randomly selected for analysis.

Interviews were analysed via an iterative process using the adapted Clark and Peterson (1986) model to guide interpretations of changes at the school and/or individual teacher level (see Figure 3). It will be recalled that adaptations to the framework included the expansion of the 'Beliefs, values and attitudes' component to incorporate 'emotions', the addition of 'Student responses' emanating from 'classroom actions', and extra arrows to indicate connections between components as new themes and links between them emerged inductively during analysis. Ball et al.'s (2008) MKT model was used to interpret specific changes in the teacher knowledge component of the framework with a focus on the subdomains SCK, KCS, KCT and KCC. It was anticipated that principals and instruction leaders would provide different perspectives on the impact of BNL and because they were not observed directly teaching a lesson as part of this study, data from their interviews were analysed together and dealt with separately from classroom teachers' interview data.

Observational data, including data generated from classroom visits and photographs taken before and during lessons, were used to support teacher interview data. Namely, the

observational data provided evidence and elaborations of what teachers described as newly adopted practices.

## 4. Results

### 4.1. Questionnaire

Demographic information gathered from Part A of the questionnaire is presented in Table 1 and summarised as part of the participant information in Section 3.1. Descriptive statistics for data generated from the remaining items in Part A are presented in Tables 2 and 3.

Question 9 asked teachers to indicate the sources they used most regularly for teaching ideas and tasks. Responses to this question for Time 1 and Time 2 are summarised in Table 2. Of note is the high proportion of teachers using the internet to help them plan their instruction (83% at Time 1 and 88.8% at Time 2). The next most frequently cited sources for teaching ideas were 'PD' (Time 1: 76.9% and Time 2: 77.3%) and 'other staff' (Time 1: 72.8% and Time 2: 78.2%). Both these responses indicate the value of professional learning opportunities provided formally and informally, and the importance of having school-based knowledgeable staff from whom teachers can seek advice and teaching ideas. The largest increase from Time 1 to Time 2 occurred for 'conferences' as a source of teaching ideas. This result likely reflects the two Sydney-based conferences organised as part of BNL. Overall, there was an increase in the percentage of teachers using a variety of sources to inform their teaching of mathematics.

**Table 2**

Source of teaching ideas selected by BNL participants at Time 1 and Time 2

Source of Teaching Ideas	Time 1 Percentage* ( <i>n</i> = 360)	Time 2 Percentage* ( <i>n</i> =331)
Specific Textbook	12.2	13.6
Conferences	47.8	73.7
A Variety of Texts	59.4	65.9
Mathematics Teaching Journal	15.0	18.4
Internet	83.0	88.8
Research Articles	59.9	64.4
Other Staff	72.8	78.2
PD (other than conferences)	76.9	77.3
Other	8.1	10.9

\* Teachers selected more than one response

Table 3 summarises participants responses to Question 10. Participants were asked to indicate all the class organisational structures they routinely used to instruct students in mathematics. Of particular interest is the decrease in the percentage of teachers employing class ability grouping (60.6% down to 47.7%) and within-year ability grouping or streaming (20.3% down to 14.8%). The use of mixed-ability grouping, friendship grouping, and flexible needs-based grouping structures all increased from Time 1 to Time 2. Overall, responses indicate shifts in the organisational structures used to instruct students in mathematics.

**Table 3**

Organisational structures participants used for teaching mathematics at Time 1 and Time 2

Class Organisation Structures	Time 1 Percentage* (n= 360)	Time 2 Percentage* (n=331)
Whole Class Introduction	79.4	78.2
Within-Class Ability Grouping	60.6	47.7
Within-Year Ability Grouping	20.3	14.8
Mixed-Ability Grouping	68.9	79.8
Partner/Friendship Grouping	44.2	55.9
Flexible/Needs-Based Grouping	79.2	84.3
Other	3.6	2.4

\* Teachers selected more than one response

Part B of the questionnaire intended to measure the extent to which teachers were committed to teaching practices and conceptions of mathematics that were supportive of instructional approaches emphasised in BNL PL. As previously mentioned, this part of the questionnaire demonstrated strong reliability with an internal consistency co-efficient of  $\alpha = .732$ . As expected, mean scores on individual questionnaire items appeared to be positively correlated with the mean scores of the subscales they were proposed to capture. Hence, mean scores on Items 1, 3 and 15 were positively correlated with the mean score of the *Struggle* subscale ( $r = .727, p < 0.01$ ;  $r = .652, p < 0.01$ ;  $r = .644, p < 0.01$ ). Mean scores on Items 2, 6 and 17 predicted the mean score on the *Confidence* subscale ( $r = .760, p < 0.01$ ;  $r = .742, p < 0.01$ ;  $r = .760, p < 0.01$ ). Similarly, mean scores on Items 4, 5, 12 and 14 were positively correlated with the mean score of the *Nature of Tasks* subscale ( $r = .635, p < 0.01$ ;  $r = .647, p < 0.01$ ;  $r = .624, p < 0.01$ ;  $r = .553, p < 0.01$ ). Furthermore, mean scores on Items 7 and 19 were strongly positively correlated with the mean score of the *Teacher's Role* subscale ( $r = .847, p < 0.01$ ;  $r = .728, p < 0.01$ ). Mean scores on Items 8 and 11 appeared to predict the mean score on the *Instructional Approach* subscale ( $r = .832, p < 0.01$ ;  $r = .760, p < 0.01$ ). Similarly, mean scores on Item 13 were positively correlated with the mean score of the *Assessment* subscale ( $r = .762, p < 0.01$ ). Finally, mean scores on Items 9, 16, 18 and 20 were positively correlated with the mean score of the *Conceptions of Mathematics* subscale ( $r = .559, p < 0.01$ ;  $r = .621, p < 0.01$ ;  $r = .751, p < 0.01$ ;  $r = .564, p < 0.01$ ).

Table 4 presents the total score and subscale score means across Time 1 and 2 for the 239 teachers who completed the questionnaire at both times and who could be identified from their unique ID code. A repeated measures Analysis of Variance (ANOVA) on continuous variables (total score, subscale and item scores) revealed that total questionnaire scores significantly differed between Time 1 and Time 2,  $F(1, 238) = 323.64, p < 0.001, \eta^2_p = .576$ , with Time 2 scores higher than Time 1. A higher score at Time 2 indicate that there was an overall shift in teachers' commitment towards the conceptions of teaching and learning mathematics and the instructional practices emphasised in BNL at the end of 2018 than reported by teachers prior to their involvement in the PL.

More specifically, individual participants achieved higher total scores at Time 2 as compared to Time 1 ( $MD = 7.41, S.E. = 0.412, p < 0.001$ ). Additionally, participants reported higher scores at Time 2 for each of the subscales *Struggle*, *Confidence*, *Tasks*, *Role*, *Approach* and *Conceptions* ( $F(1, 238) = 247.55, p < 0.001, \eta^2_p = .510$ ;  $F(1, 238) = 106.23, p < 0.001, \eta^2_p = .309$ ;  $F(1, 238) = 163.24, p < 0.001, \eta^2_p = .407$ ;  $F(1, 238) = 80.53, p < 0.001, \eta^2_p = .253$ ;  $F(1,$

238) = 44.86,  $p < 0.001$ ,  $\eta^2_p = .159$ ,  $F(1, 238) = 102.58$ ,  $p < 0.001$ ,  $\eta^2_p = .301$ , respectively). However, no significant difference was found between participants' scores for the Assessment subscale between Time 1 and Time 2,  $F(1, 238) = .002$ ,  $p = .963$ ,  $\eta^2_p = .000$ ). This means that teachers reported significant and positive changes to every dimension measured on the questionnaire except for Assessment.

**Table 4**

Means of questionnaire scores across Time 1 and Time 2 for each subscale and individual items ( $n=239$ )

Questionnaire Score	Time 1 <i>Mean (standard error)</i>	Time 2 <i>Mean (standard error)</i>
Total Score	74.34 (.416)	81.75 (.393)
Subscale Scores*		
Struggle	10.03 (.118)	11.94 (.093)
Confidence	11.78 (.087)	12.77 (.082)
Tasks	15.46 (.116)	17.17 (.101)
Role	7.82 (.076)	8.49 (.065)
Approach	8.50 (.076)	9.04 (.063)
Assessment	7.13 (.075)	7.13 (.079)
Conceptions	13.63 (.152)	15.25 (.155)
Item Scores		
Item 1	3.05 (.077)	4.02 (.056)
Item 2	3.92 (.037)	4.24 (.035)
Item 3	3.56 (.052)	4.04 (.038)
Item 4	4.28 (.038)	4.62 (.033)
Item 5	3.58 (.055)	4.03 (.042)
Item 6	3.91 (.043)	4.14 (.036)
Item 7	3.77 (.053)	4.11 (.048)
Item 8	4.42 (.051)	4.67 (.041)
Item 9	4.02 (.060)	4.40 (.050)
Item 10	3.73 (.052)	4.02 (.046)
Item 11	4.08 (.060)	4.38 (.038)
Item 12	4.12 (.056)	4.51 (.042)
Item 13	3.41 (.052)	3.10 (.063)
Item 14	3.48 (.057)	4.02 (.046)
Item 15	3.41 (.051)	3.88 (.047)
Item 16	3.55 (.056)	4.01 (.058)
Item 17	3.96 (.039)	4.39 (.035)
Item 18	2.72 (.064)	3.36 (.072)
Item 19	4.04 (.041)	4.39 (.036)
Item 20	3.35 (.063)	3.43 (.067)

\*Subscale scores = the total subscale score averaged across participants

A repeated-measures ANOVA also revealed a significant difference between participants' item scores between Time 1 and Time 2 for Items 1-19. In terms of Assessment items, Item 10 ("I integrate maths assessment into most maths activities") showed a significantly higher mean score at Time 2 than at Time 1. However, Item 13 ("Creating a set of criteria for

marking maths questions and problems is a worthwhile assessment strategy”) showed a significantly lower mean score at Time 2). No significant difference was found between participants’ scores for Item 20 (“If students use calculators, they don’t master the basic maths skills they need to know”),  $F(1, 238) = 1.31, p = .253, \eta^2_p = .005$ ). In summary, participants reported higher scores at Time 2 for all items apart from Item 13, in which participants reported lower scores at Time 2 ( $MD = -.305, S.E = 0.04, p < 0.001$ ).

To determine whether PL attendance and location (rural/remote or metropolitan) differentially influenced changes in total questionnaire scores between Time 1 and Time 2, a repeated measures ANCOVA was conducted. A main effect of PD attendance was observed on the difference between total scores at Time 1 and Time 2,  $F(1, 235) = 7.107, p < .05, \eta^2_p = .029$ ) indicating that PD involvement contributed to a higher overall score on the questionnaire. However, this was only found for PD reported at Time 1.

Pearson Correlations between the means of each subscale and participant demographics (PD, location, teaching experience and academic qualifications) were conducted to determine the extent to which they were linked. The results of the correlations are presented in Table 5 and indicate that for Time 2 data, attendance at PD was significantly related to teacher tolerance for student struggle, their confidence to teach mathematics and their conceptions about the teaching and learning of mathematics. Further, teaching experience was significantly and positively related to confidence teaching mathematics, assessment strategies and teachers’ conceptions of mathematics.

**Table 5**  
Pearson Correlations between mean subscale scores and demographics at Time 2

Demographics	Mean Subscale Scores						
	<i>Struggle</i>	<i>Confidence</i>	<i>Tasks</i>	<i>Role</i>	<i>Approach</i>	<i>Assessment</i>	<i>Conceptions</i>
PD	.135*	.138*	.035	.045	.004	.074	.189**
Location	.064	-.049	-.012	-.060	-.038	.012	.040
Teaching Experience	.078	.143*	.080	.010	.073	.168**	.287**
Highest Academic Qualification	-.077	.070	.028	.031	.028	.098	.025

N.B. Correlations are significant at the 0.05 level when marked with \* and significant at the 0.01 level when marked with \*\*

#### 4.2. Scenario

As previously indicated, the responses of twelve participants (one principal, two assistant/deputy principals, six classroom teachers, and three instruction leaders) to both Time 1 and Time 2 of the scenario task, were randomly selected for analysis. Interpretive analysis focused on detecting qualitative differences between Time 1 and Time 2 responses according to each of the five aspects of teacher capacities it was designed to elicit. A summary of individual participants’ responses accompanied by an interpretation of notable

qualitative changes for each aspect is presented in Appendix F. Overall shifts in participants' responses revealed:

- Increased specialised content knowledge (SMK);
- Enhanced knowledge of content and students (KCS);
- A greater emphasis on Working Mathematically;
- Increased use of teacher questioning to elicit student thinking;
- Shifts in the type of questions asked by teachers to include more 'what if' type questions; and
- Increased emphasis on students representing and sharing their reasoning.

#### *Participants' capacities to determine the learning intention of the task*

At Time 1, the majority of participants correctly identified mathematical content areas intended to be developed by the task reflected in the scenario. Five of the twelve participants identified "place value" and three referred to the addition operation involving two-digit numbers. Two responses did not directly address the question and could not be interpreted (e.g. "to ensure students are on task and are completing (sic) understanding the task").

At Time 2, responses revealed an overall shift in focus to working mathematically processes in addition to identifying the major content areas of place value and additive strategies. Nearly every respondent referred to some aspect of student reasoning, problem solving and/or communication of student strategies and suggested ways of eliciting these processes via talk, discussion and teacher questioning. The nature of teacher questioning, intended to stimulate deeper student thinking, shifted to 'what if'- type questions. Pedagogical moves to encourage student talk were more commonly suggested at Time 2 than at Time 1. Reference to mathematical content at Time 2 was indicative of increased SMK (e.g. "additive strategies", "trusting the count"). Suggestions for promoting student thinking strategies indicative of enhanced KCS.

#### *Participants' capacities to anticipate and interpret student strategies and knowledge*

At Time 1, responses were generally limited to "guessing" or "trial and error" strategies. Respondents indicating that students would get "stuck" offered little or no suggestions as to how to move their thinking forward except by 'telling' them what numbers to trial. Responses at Time 2 revealed greater knowledge of possible thinking strategies students could use (KCS) and referred to student capacities to "trust the count" and "partition" numbers based on their place value knowledge (SMK).

#### *Participants' capacities to suggest strategies to differentiate the task for different students*

Initially, three participants suggested students use "guess and check" or "estimation" strategies. Another three told them specific steps to follow (e.g. "Start with the last units number  $7+4$  then the tens") or use "real objects, popsticks and base ten blocks to make the numbers" if they were unable to progress on the task. Time 2 responses revealed two teachers still 'telling' specific steps to use ("Eliminate the numbers that could not possibly be used"), but the majority of responses indicated an increase in questions designed to elicit prior knowledge and stimulate thinking about "What do we already know?", "What won't work?". There was also an increase in respondents requiring students to justify their



reasoning (“Explain thinking to a partner”, “Support your reasoning”) indicating a greater integration of working mathematically.

*Participants’ capacities to suggest variations to suit different grades/stages and leverage learning from this task to other topics in the syllabus*

Changes to participants’ responses did not significantly vary from Time 1 to Time 2 in this aspect of teacher capacity with the majority of suggestions involving different operations, use of decimal fractions, larger numbers or numbers with a zero. This indicates that participants may need additional support in modifying tasks or creating tasks that are challenging for students. Given the brevity of most participants’ responses to this aspect, it is likely that a level of survey-fatigue also impacted the quality of their responses.

*Participants’ capacities to make meaningful decisions as to what and how student learning should progress*

This aspect was intended to reveal respondents’ capacities to make decisions about instruction that should follow-up on likely student responses. Time 1 responses were all quite brief, ranging from “I don’t know (yet)” to the common response “more examples” or a similar task of “increasingly difficulty”. Time 2 responses revealed a greater variety of suggestions about how to progress students’ learning. Most notable were the number of suggestions involving various forms of representation. Suggestions included “show their thinking, use some symbols to show your understanding”, “teach someone else your strategy”, “turn and talk” and “record their understanding...by drawing”. A shift in the nature and quality of responses between Time 1 and Time 2 was most notable in terms of students being asked to record and share their reasoning.

### 4.3 Interviews with Principals and Instructional Leaders

Principals’ (P1 rural, P2 metro, P3/IL3<sup>3</sup> metro, P4 metro, P5 rural, and P6 rural) and instructional leaders’ (IL1<sup>4</sup> rural, IL2 metro, P3/IL3 metro, IL4 metro, and IL6 rural) interview data is reported according to the main components of the adapted Clark and Peterson (1986) framework described in Section 2.2 and visually represented in Figure 1. Data categorised as belonging to the expanded component of ‘Beliefs, values, attitudes and emotions’ is reported under the main theme ‘Affect’. Data categorised as part of the ‘Knowledge of mathematics and pedagogy’ component is reported using the finer-grained categories of mathematical knowledge for teaching described by Ball et al. (2008).

#### 4.3.1. Opportunities and Constraints

Principals and ILs considered the invitation to participate in BNL as an opportunity to address a number of existing contextual constraints perceived to be inhibiting the advancement of students in mathematics and numeracy, including:

- disappointing student NAPLAN performances;
- the apparent lack of students’ capacities to solve non-routine and challenging problems;

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<sup>3</sup> Acting Principal at the metropolitan located School 3 was also the instructional leader and is referenced as P3/IL3.

<sup>4</sup> School 1 and School 5 were rural located schools who shared the same instructional leader (ie. IL1).

- students' under-developed capacities for higher-order thinking and for articulating their mathematical reasonings;
- teachers' self-identified weaknesses in knowledge and pedagogy; and
- inconsistencies among groups of teachers' pedagogies or between school philosophical approaches and teacher pedagogies for teaching mathematics.

Stagnated, low or falling Year 3 and 5 numeracy performances on NAPLAN were cited among the top reasons for initial interest in the BNL by all but one principal and IL. The most common response by principals was that there had been "...a focus on literacy, whereas our numeracy results hadn't had the same growth...so it was time to focus on the maths" (P1, rural). Principals considered that the previous literacy focus had seen "significant impact over time on student outcomes" (P3/IL3, metro) and were hoping for the same impact for mathematics from BNL — acknowledging that NAPLAN results "are not the only thing that we gauge success by for students" (P2, metro). The lack of sophisticated mathematical language, particularly amongst students in the higher grades, was regularly referred to by principals and ILs. It was perceived that "students didn't have the language to express their thinking very well" (P4, metro) and "even our top students didn't seem to be able to articulate their reasoning — they weren't being challenged" (P2, metro).

All principals and ILs considered that improved outcomes for students were linked to teacher professional learning. Participation in BNL was perceived as an opportunity where "we might be able to improve teacher capacity and confidence and practice around the teaching of mathematics" (P3/IL3 metro). Three principals (P1 rural, P3/IL3 metro, P2 metro) and two other ILs (IL1 rural, IL4 metro) identified inconsistencies in the way mathematics was taught amongst their teachers as a reason for their initial interest in BNL. In particular, "things were sort of falling down by Stage 2, Stage 3 ... we needed to rethink the way in which we were approaching our teaching of mathematics at the whole school level" (P3/IL3 metro). Inconsistencies in the way mathematics was taught between K-2 and Years 3-6 were also cited at a large metropolitan school. IL4 explained that "...the senior part of our school is heavily into project-based learning and for K-2, well, their project-based learning wasn't really happening...".

Two principals (P1 rural and P2 metro) cited mismatches between teacher pedagogy and the philosophical approaches advocated by the school as one of many reasons as to why they had initially supported BNL participation for their staff:

Part of our journey has also been Curiosity and Powerful Learning, where we wanted this idea of consistent teaching across the school. There was a very big mismatch between infants and the primary part of the school, where I think infants were starting to embrace new pedagogies in literacy. Numeracy, they were beginning to, but then primary was old-school... using streamed maths groups! The idea of an enquiring mindset in numeracy is important and BNL seemed to really grab that. (P1, rural)

Teachers at two schools had "heard about BNL from teachers who attended the previous year at other schools" (IL2 metro) and approached the principal with a request to participate in the BNL. Similarly, teachers at a large rural school "self-identified a need for PL in maths. Two of them had said to me, 'I really need this - I identify weakness'" (IL1 rural).

A few constraints to implementing the pedagogical approaches and philosophies emphasised in BNL were reported by principals and ILs. Constraints mentioned included:

- Parental concerns regarding new pedagogies;
- Staff turn-over;
- Funding shortfalls;
- Staff readiness to adopt new pedagogies; and
- Superficial understanding of the underlying principles of BNL leading to ineffective use of resources.

One principal (P2 metro) and one IL (IL1 rural) commented on the importance of “bringing the parents on-board...that’s something we have been trying to improve” (IL 1, rural). Helping parents understand the importance of “not always telling students...and allowing them time to struggle” (P2 metro) was an aspect of BNL considered challenging for most parents to grasp, with one school conducting “a lot of parent workshops on” (P2 metro) the approach to mitigate concerns voiced by a few parents.

Large turn-overs of teachers who had participated in BNL from one year to the next and even within the school year was a concern to a large metropolitan school who was participating in BNL for the second year. “I lost one of my best” BNL-trained teachers last year and “now seven out of nine teachers are casuals, and of those, most of them are in their first one, two or three years”. Large schools, in particular, found it challenging to maintain sufficient numbers of teachers familiar with BNL to ensure consistency of teaching approaches across whole year levels and stages. Coupled with this, was the fact that teachers “are on their own learning journey and some of them may not be ready for some of the things that we are saying to do” (IL4 metro).

Teacher readiness to adopt some of the central messages of BNL and their capacity for enacting them in their classrooms was a constraint mentioned by the principal (P5) of a rural school in its second year of BNL PL. A second year of BNL provided teachers with

...a better opportunity to embed it, and to make sure that it's right across the school. As opposed to when we first looked at it last year, we were just looking at one or two classes ... not really taking it on board. Whereas this year, there's been a lot more collaborative practice happening, .... we played around with the ideas last year and got our head around it in a couple of classrooms. Whereas this year we went right, we now see the value in this and have a better idea of what to do... (P5 rural)

Concerns were raised by one IL about teachers’ use of some resources “without really understanding the underpinning BNL knowledge and theory” (IL4 metro). She noticed that some of her teachers “did the number talks, but they didn't plan... they didn't make them purposeful”. The school purchased a range of resources recommended at BNL sessions, including the “*Number Talks* book ... But in hindsight, for people with limited BNL knowledge, I don't think they knew how to pick out of the book what their students were ready for”. IL4’s concerns resonated with those of P5. Namely, that the professional learning of teachers is an individual journey and that teachers will need different periods of time to develop deep understandings of some aspects of BNL and possibly longer periods of

exposure to its central messages before the same aspects can be enacted effectively in their classrooms.

Funding was an important constraint for one rural principal whose school was self-funding their participating in BNL. The travel to “Sydney for conferences for three teachers was a huge expense” (P6 rural) that was weighed against the benefits to teachers and students that the principal and instruction leader perceived. While he “did not mind spending the money, but I need *bang for my bucks* and so far, that has happened”. However, he conceded that future involvement will have to be very carefully scrutinised to ensure the funds “can’t be better placed elsewhere”.

#### 4.3.2. Affect

The affect theme captured comments by principals and ILs relating to changes they perceived in teachers’ beliefs, values, attitudes and emotions towards the teaching and learning of mathematics, including their self-belief and confidence for teaching mathematics. It also captured these same aspects as they related to principals and ILs themselves. The major changes noted by principals and ILs included:

- overall positive shifts in teacher and student mathematical mindsets towards a growth mindset;
- increase in teachers’, ILs’ and students’ interest, enjoyment and enthusiasm for mathematics;
- increased use of mathematical language by teachers and students; and
- increased sense of pride in principals for the achievements of their teachers and students.

Every principal commented on some form of affective change that teachers involved in BNL had undergone. A change in mindset to reflect “a growth mindset” was pleasing to P1 at a rural school because it matched the school’s underlying philosophy that was emphasised as part of the school’s focus on “curiosity and powerful learning”. Similarly, P2 at a metropolitan school considered “the teachers have undergone a change in mindset – a *transformational* kind of change!”. This view was echoed by the IL who added that BNL “has completely changed the teachers’ views around everything. In particular, it’s changed their views of how they teach maths. I think they thought in the past that our little people can’t do rich tasks” (IL2 metro).

IL4 at a large metropolitan primary school perceived the change in teachers’ “views of mathematics and what mathematics is” to be a longer-term prospect, “... it’s changed or changing. It takes some teachers longer to really understand the philosophy behind it”. The change in teachers’ beliefs and views about teaching mathematics were attributed to the “well-articulated and coherent underpinning philosophy, theory and research evidence-base that did not demand a prescriptive way of teaching” (P4 and IL4, metro). IL4 elaborated, saying that BNL

...hits you in your theory. You can't change practice unless you change your theory and beliefs, or you can't develop your practice unless you develop your theory. I think what BNL did was made us realise that there was so much theory out there. ... this maths knowledge, this maths understanding is actually really deep ... All of this is

underpinned by some really robust research and theories that work. What I like about it, is it makes you think. It makes you come to conclusions based upon what you're hearing and what you're reading and what you're seeing in the kids.

The “way BNL was implemented” was considered “a reason for teacher enthusiasm to implement” it in their classrooms. The fact that “small steps were encouraged and no pressure to complete tasks back at school....” (IL4, metro) meant that teachers did not feel overwhelmed experimenting with new practices because “they did what they understood and could see the value”.

Principals could “definitely see a massive improvement in their (teachers’) confidence in teaching mathematics” (P2 metro; P3 metro; P5 rural). The increased confidence was linked to the perceived increase in teachers’ enjoyment teaching mathematics. Principals and ILs also conveyed a sense of their own excitement in their teachers new learning. Teachers were “really working hard to make this work” (P5 rural). The sense of excitement and enjoyment was considered to be “contagious. They’ve learned so much from BNL, they are so excited about what they’ve learned” (IL2 metro). “I get a sense of excitement ... I’m enjoying it. They’re enjoying it and the kids are loving it, so it makes my job easier” (IL1 rural).

All principals told ‘stories’ about visits to classrooms when they experienced “moments of excitement and pride” (P5 rural) because of what their teachers and their students were doing in mathematics. After a classroom visit from the deputy principal of a nearby primary school, one principal was told “that she was really impressed with the way the teacher was delivering the mathematics lesson. She said, ‘Jeez this guy's a model for what I want to see happen here’. I went up to him and I said, ‘that was a fantastic lesson’” (P2 metro). Similarly, the principal of a rural school proudly spoke of the day when the deputy principal of the local high school visited a year 1/2 classroom.

He was just blown away with the language that's being talked about, the level of enthusiasm and the commitment from the kids. The perseverance because they had to struggle ...the collaboration that was going on between the children. He just loved it. It was actually hard to get him back out of the room. Then he asked, ‘they're a Year 3 or Year 4?’ I was like, ‘No, they're a 1/2’. He goes, ‘Oh, that's blown my mind!’. I get to see that all the time and see the discussion and things like that but to actually have somebody think that ... that was a proud peacock moment! .... I'm just really proud of the way the teachers have actually taken it on board, they can see the value in it. There are very few times in a person's teaching career where you come across programs that genuinely have an impact. This one does. (P5 rural)

#### *4.3.3. Knowledge of mathematics and pedagogy*

While principals and instructional leaders were convinced that “the learning has been amazing” (P5 rural), the nature of changes to teacher knowledge was more difficult for them to accurately describe during interviews. This difficulty is understandable given that changes to another person’s knowledge can really only be inferred from what they say and do in the classroom. This lack of precision also made it difficult to do a finer-grained analysis of teacher knowledge to determine explicit changes to the domains of MKT that were a

focus of the study. Prevalent aspects of teacher knowledge inferred by principals and instructional leaders included:

- Increased use of specialised mathematical language;
- Development of teacher specialised knowledge (SMK) especially around the ‘big ideas’ of mathematics;
- Development of teacher knowledge of students’ thinking (KCS);
- Development of teacher knowledge about sequencing of learning and making links between concrete and abstract representations (KCT).

The most commonly cited evidence for perceived changes in overall teacher MKT was “their language ... the language is definitely different” (P4, metro). Changes to teachers’ mathematical language was generally noticed “during staff meetings dedicated to BNL. It was really interesting to listen to the knowledge and for them to be able to back up what they said, based on what they’ve learned” (IL1 rural).

Teachers were reported as comfortably using specialised mathematical language in staff rooms to talk “about their lessons, they’re not just talking about we’re going to add this or anything like that. ...They use language like partitioning and trusting the count” (P5 rural). Changes in teacher specialised content knowledge (SMK) was repeatedly noted via the language “they use to describe those Big Ideas in mathematics” (P3/IL3). Teachers’ SMK and knowledge of students’ thinking (KCS) were interlinked, as noted by an instructional leader at a metropolitan school:

In stage 2 they’re really looking at fluency and he has been talking a lot about operational fluency ... the purpose is to have the understanding, the deep understanding, around additive strategies and build on those Big Ideas of trusting the count, place value, multiplicative thinking so that they can work fluently within them. (IL 2 metro)

Teachers’ pedagogical knowledge related to its sequencing for instruction and the choice of tasks or the representations used within those tasks were indicative of changes to their knowledge of content and teaching (KCT). A very noticeable “game changer for K-2 has been around the magic triangle .... Teachers are helping students make links between the symbols, the representation and the language” (IL2 metro). Instructional leaders noticed that not only were teachers implementing new pedagogies in the classroom, but they were talking about them to each other because they have a “common language” and this allowed “unpacking the pedagogy about why we’re doing it and why it is an effective pedagogy and everyone’s coming to a deeper understanding” (P3/IL3 metro) of teaching mathematics.

#### *4.3.4. Planning intentions*

Interview data from principals and instructional leaders were interpreted in two ways as part of the planning component of Clark and Peterson’s framework:

- Purposeful executive-level plans to achieve teacher buy-in, ensure sustainability and dissemination to other staff; and
- intentional strategies to assist teachers incorporate BNL ideas into their programs.

The first type of planning involved the executive-level strategies and goals intended to increase teacher and whole school commitment to BNL. These strategies involved their plans for teacher capacity building to ensure the approach and elements of BNL were disseminated to other teachers and sustained beyond their current exposure. Intentions to build teacher capacity around BNL were purposefully planned from the outset. Strategic decisions were made about which teachers should participate in BNL. It was considered important to select teachers who “were open to it” (P4 & IL4 metro) and “we had the buy-in straightaway” (IL1 rural). Principals were mindful of sending “a leader out of the primary area to make sure that this was embedded across the school and then two of the infants...who were probably more willing to change” (P1 rural). Selecting teachers who were considered “respected by the other staff” (IL2 metro), “innovators and who would be willing to share their skills and knowledge across the school to take it forward” (P2 metro) was an important consideration for the capacity building of other teachers not attending the BNL conferences.

Some principals selected staff for participation in BNL based on identified areas in need of improvement in the school. For instance, the “transition from infants to primary is something that we're really interested in. Making sure that we've got those high expectations in Year 2, moving into Year 3. So, we picked our Stage 2 supervisor” (P2 metro) to participate.

The second type of planning referred to by principals and instructional leaders was the intentional strategies implemented to assist teachers plan and program their teaching of mathematics. Foremost among these strategies was regular school-level staff meetings that “scheduled in BNL time” (P1 rural) with most schools implementing some form of “distributed instructional leadership” (P3/IL3 metro) where individual teachers would take the lead during a staff meeting or full day of professional development “to share some information about what they've been doing and show everyone” (IL4 metro). A few schools provided opportunities for teachers to “plan a lesson together and then we actually taught the lesson and videoed it and watched it together. It was like a mini lesson study... We call these JELO days – Job Embedded Learning Opportunities” (P3/IL3 metro).

School-level organised professional learning sessions were considered to be “making a difference” in most schools “because the teachers that haven't been BNL'd are asking their colleagues how they do things. They're effecting change ... providing leadership. It was purposeful ...” (P4 metro). An extension to the distributive leadership model was adopted at one school as a strategy to deepen individual teachers' understandings of the principles and approaches emphasised in BNL and to help disseminate its impact.

We collaborate with a local six classroom school up the road ... our teachers explain their practice, their pedagogy to teachers at that school. So not only is BNL being delivered in our school, it's also delivered at [school name]. (P2 metro)

As part of their planning for teacher change, one school decided to visually document what, how and why their practices had changed. The photographic evidence was used “to remind teachers of our journey” (P5 rural) (see Figures 4, 5, 6 and 7), but also served as a form of reflection on their practices that stimulated deep discussions about pedagogy.



Figure 4 and Figure 5. School 5 (Rural) posters displaying record of teachers' new and improved practices

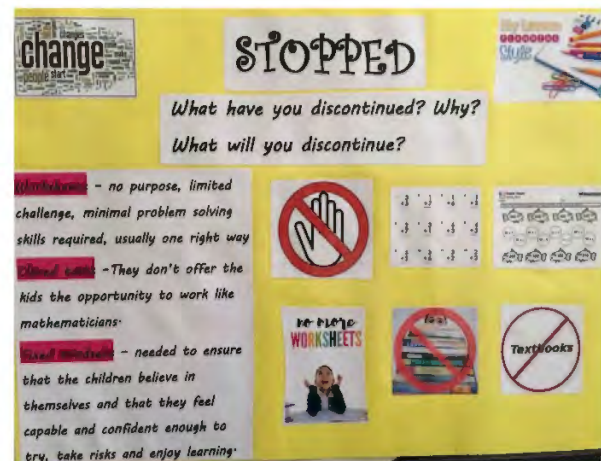


Figure 6 and Figure 7. School 5 (Rural) posters displaying record of practices teachers' kept and stopped implementing

While all schools made strategic decisions about which teachers to send to formal BNL sessions and communicated deliberate intentions for its spread across K-6 teachers, not all principals were so structured in their approach for achieving these goals. One instructional leader explained that “we're very anti programs here. The principal likes to give teachers the ability to choose, to manage their own pathway rather than being told their pathway” (IL4 metro). It was thought that BNL allowed a level of flexibility for individual teacher growth “because it's not about a program, it's about a philosophy and it's about a theory and it's about research”. School-level professional learning focused on “passionate teachers



explaining to others what they've done in their classrooms" and exposing everyone to BNL events hosted at their school with the intention of "just letting it trickle down into their thinking ... and it is!" (IL4 metro).

While the majority of schools adopted collaborative planning and programming approaches, by far the "the biggest change for us has been the way in which we are programming, planning for mathematics" (P3/IL3 metro).

One of the things that we've looked at, which has been a very big shift, is what collaborative practice looks like when you're programming ... We've called it *responsive planning* or *responsive programming*. The idea being that you cannot plan next week's lessons when you don't know what you're going to tune into today. Planning needs to be based on the formative assessment and the assessment that the teacher does during the course of that lesson that actually informs the next days' learning.... it's intended to be responsive to the needs of the students. (P3/IL3 metro)

All principals and instructional leaders emphasised that their BNL journey "has only just started and we're excited and we're seeing change of practice and changing children's thinking. I can't wait to see where we end up!" (P1 rural). Because of the perceived length of time needed to familiarise teachers with the underlying philosophy communicated through BNL and the associated pedagogies, principals and instructional leaders talked about the necessity of "starting small ... and to put it into our school plan for next year so that will hopefully spread further across the School" (IL 2 metro).

#### 4.3.5. Classroom actions

The classroom actions component of the guiding analysis framework refers to the enactment of instructional approaches, specific activities implemented in the classroom and to strategies teachers used to structure their classrooms for mathematics instruction. The major changes to teachers' classroom actions reported by principals and instructional leaders included:

- changes to classroom organisation and resources such as the use of ability-groupings or textbooks;
- increased use of student talk;
- use of challenging problems; and
- increased emphasis on all working mathematically processes.

The impact of BNL professional learning sessions was regularly reported by principals and instructional leaders to be rapid and profound. Teachers from one school "came back from the first PL day - I've never seen teachers so excited! They actually pulled apart the streamed maths groups that day. Then, they started team teaching" (IL1 rural). The principal of the same school confirmed that "I wander into classrooms during maths nearly every day ... and the change in what's happening in the primary is astounding ... working mathematically is really embedded in our school now" (P1 rural).

Immediate impact also occurred at a metropolitan school when a "no textbooks" policy was introduced because the "principal said, 'If there are no textbooks K-2, then no textbooks for

3-6 either'. It was all or nothing. That's meant that there's a lot more sharing of ideas" (IL4 metro).

The most frequently occurring type of lesson noticed by principals and instructional leaders that differed from previous lesson-types conducted by teachers were those involving number talks (P1 and IL1 rural, P2 and IL2 metro, P3/IL3 metro, IL4 metro, P5 rural, P6 and IL6 rural). The instructional leader (IL2 metro) explained how the teachers had started soon after their first BNL session implementing and video-recording number talks and how the focus had now shifted to a finer-grained level of critical reflection about the quality of their enactment:

We've done things like, Number Talks. Even with teachers who aren't on BNL and they've been videoing themselves doing the Number Talks and tweaking them. So for future directions .. we're working on what they actually look like and what's the quality of them like. Really starting to target those Big Ideas within those Number Talks. (IL2 metro)

Associated with the increased use of talk in mathematics lessons was the very obvious development of students' overall mathematical language, "it's a lot more advanced than what it has been in the past" (P5 rural). Principals associated the increased frequency and "really rich" (P2 metro) mathematical language with the greater emphasis on student reasoning and problem solving occurring in classrooms. Teachers demonstrated that they were "better at anticipating student thinking" (P3 metro) because of their BNL participation. It was noted that students were also "being asked to explain in their own words they're reasoning. Having seen that in action, it's pretty powerful!".

Principals and instructional leaders considered that all students were being challenged in mathematics a lot more than in previous years. Classrooms were described as "humming - really humming with learning". The increased use of challenging problems led to "a lot of productive struggle for those kids, because they actually have to reason ... not just a formula and not rote learning anything now. They need to be flexible in their thinking (IL 1, rural).

Changed classroom actions of teachers were attributed to the growth in confidence in both teachers and their students. The use of "the traffic light cups" whereby students can indicate their level of understanding by placing a particular coloured plastic cup (e.g., red cup for "I don't understand, I need help" and green cup for "I understand") on their desk while working on tasks "has given teachers and students the confidence to say, I don't understand it, I need some help, but not in a hand-up sort of way" (P5 rural).

Not all changes to teacher actions occurred easily or rapidly. Instructional leaders were careful to stress that changes to classroom practices were on-going and mostly "in little steps" (IL4 metro). The role of instructional leaders in helping teachers enact many of the new approaches and ideas in their classrooms was evident from episodes of teachers "coming to me and said, well, okay. We have all this stuff ... and all this information. Where do we start? How do we do it? How?" (1L rural).

#### *4.3.6. Student responses*

Student responses were closely linked to what the principals and instructional leaders witnessed in the classrooms and as a result of teacher actions. No schools reported doing systematic or formal evaluations to gauge student responses. However, some student responses were gleaned via a general 'sense' or 'feeling' from a range of anecdotal evidence. Such responses included:

- changes to students' conceptions of and attitudes towards mathematics; and
- improvements in NAPLAN (for schools involved in BNL for two years).

Overall, there was a sense that "children's whole attitude towards mathematics, their whole conception of mathematics and who does mathematics is changing" (P3 Metro) because of changes in approaches taken by teachers. Changes to students' attitudes towards mathematics and their willingness to persevere in the face of challenge were reflected in a principal's "feeling of positivity about it from the kids. There's not this concern that I can't do maths. They're willing to get in there and have a go" (P2 metro).

It will be recalled that most principals cited the "need to improve NAPLAN" for numeracy as an initial reason for involvement in BNL. One principal at a school in its second year of participation considered that "our NAPLAN results for Year 3 were better than previous years" partly because she felt that teachers were "probably getting better feedback from the kids. The kids are able to articulate a little bit better whether they've got an understanding of what's been taught. It gives the teachers a better idea of how to differentiate their lessons" (P5 rural) to accommodate students' needs.

#### *4.4. Teacher interviews and observations*

In this section, interview data for 15 classroom teachers and data from 16 lesson observations are reported according to the main components of the adapted Clark and Peterson (1986) framework presented in Section 3.3. Data categorised as part of the 'Knowledge of mathematics and pedagogy' component is reported using the finer-grained categories of mathematical knowledge for teaching described by Ball et al. (2008). Observational data, including data generated from classroom visits and photographs taken before and during lessons, are used to support comments about and descriptions of teachers' practices made during interviews. Hence, observation data is mostly referred to in the sub-section reporting teacher practices. To ensure teachers' responses could be matched to those of their principal and instructional leader, their comments are labelled with the same school number. For example, interview and classroom observation data generated from three teachers at the same school as P1 and IL1 are labelled T1A-Kinder, T1B-1/2 and T1C-5/6. Each teacher label is followed by the respective year level(s) they taught.

##### *4.4.1. Opportunities and Constraints*

All teachers interviewed described their involvement in BNL in extremely positive terms, agreeing that it was "a really interesting and enjoyable opportunity" (T1C-5/6) to learn new knowledge and practices to enhance their teaching of mathematics. Commonly, teachers referred to the BNL opportunity:

- as an approach to teaching; and
- as positively impacting their knowledge, beliefs, practices for, and enjoyment of, teaching mathematics.

Overwhelmingly, teachers expressed their thanks “to the department, because it’s a wonderful opportunity obviously for me and for all schools to be a part of” BNL (T3B-3/4/5/6). Teachers considered their participation in BNL to have resulted in an incredibly “steep learning curve” with a Year 1 teacher from a rural school believing that her pedagogical knowledge had “just gone from here to wow!” (T6A-1). She felt “sorry for people that haven’t done BNL”. Learning new practices, “like number talks. If you don’t know what it is then you’re not going to do it and you don’t see the benefits” to students.

Teachers referred to BNL as a philosophy or “approach to teaching” (T1A-Kinder), rather than a professional development “program. It’s this pedagogical practice that should be embedded in your teaching” (T2A-3/4). Teachers commonly referred to their exposure to new theories, new philosophies of learning mathematics and their associated practices which “we wouldn’t know to do these things if we didn’t have the opportunity to do BNL” (T5B-1/2).

Those who had the opportunity to participate in BNL were enthusiastic to share their experiences with colleagues not attending. Teacher-led PL sessions were conducted at nearly every school visited and were organised with the intention of introducing BNL to staff not formally involved. These sessions were reported as “empowering” (T3B-3/4/5/6) for presenters when “feedback from staff has always been” positive. A Kindergarten teacher at a rural school reported that “after one of our PL sessions” they said “thank you so much for offering us another way to do things” (T5A-Kinder).

Importantly, the support of principals was paramount in ensuring the opportunities provided through BNL experiences were valued by other staff during the school-level PL sessions. Principals were acknowledged as “giving us as much time as she can” (T5B-1/2) for PL and taking personal interests as indicated through their classroom visits during mathematics lessons and their willingness to engage in professional conversations surrounding BNL experiences.

Teachers referred to a small number of obstacles surrounding the implementation of approaches and ideas emphasised in BNL. However, they were always mindful of the fact that the benefits far outweighed any constraints. Those mentioned by teachers included:

- the amount of content and the pace at which it was presented;
- the relatively short period of time for individual teacher involvement in formal BNL sessions;
- feelings of isolation (mostly for teachers from rural/remote areas) and uncertainty about the quality of their enactment; and
- the need for school-level strategies to alleviate the effects of ‘resistors’ and ‘blockers’.

Acknowledging that BNL is “just amazing, the professional learning, I can’t criticise it, it’s just absolutely amazing. It’s quality. It’s inspiring, it’s motivating” (T3B-3/4/5/6), four teachers commented that at times they wanted to “slow it down a little bit” (T5A-Kinder) mostly

because they considered every aspect to be important and they wanted time to better understand the ideas and get a sense of the implications for their teaching practice.

I'm wondering is it just too much? I mean, I go home, I read of a night, I read on weekends, I'm really working hard to develop my understanding of it. Is everyone doing that? I just don't know. I'm somebody that when I'm introduced to something, I have to know everything about it and not everyone is like me [laughs]. (T3B-3/4/5/6)

Teachers often referred to the BNL experience as being part of a "wonderful journey that has only just begun" (T1C-5/6). The richness of what BNL offered meant teachers felt that their first year of involvement allowed them to "play around" with new ideas and "to dabble and get my head around it...Seeing the growth in the students was absolutely fantastic". But that the opportunity for a second year of BNL involvement meant "I could improve in my own knowledge and the way that I do it. I am much more confident in doing everything now" (T5A-Kinder). Every teacher interviewed expressed the desire for more time of direct exposure to BNL sessions — "at least another year!" (T2C-Kinder).

Two teachers from rural settings expressed feelings of isolation after returning from the Sydney-based conferences. Teachers felt "inspired" (T6B-3/4) after the BNL conferences and a little overwhelmed "because there is so much within the days...and it is a long way from Sydney. You do forget some of the ideas even though you take notes". These teachers expressed the desire to have someone "in the flesh" from BNL visit their rooms so they could know "are we actually doing this stuff properly. Are we on the right track?" (T5A-Kinder).

The notion of someone with "more knowledge and experience" of BNL "going into schools and seeing us quite regularly" was also suggested by teachers from metropolitan-based schools as a strategy for the sustainability of BNL. It was thought that "more coaches" from teachers involved in BNL from previous years could be recruited so that "each school feel as though they've got a personal coach who comes in on a termly basis, gets an update on what we're doing, gives us refinement of our practice. That would really spark us to keep on track" (T2A-3/4). Similarly, the recruitment of teachers who are "further down the BNL track" to act as a "mentor or coach" for neighbouring schools "who are still fairly early" on their journey was suggested by teachers from rural schools so they could "share" their experiences (T5A-Kinder).

Teachers from all schools spoke about strategies to deal with resistance to BNL from other teachers – or 'blockers'. It was thought that "you're going to get resistance for any type of new thing just because it's a new thing" (T2A-3/4) and schools needed to be prepared for such obstacles. It was recommended "not to force anyone" (T2C-Kinder), but to do the activities "as a staff" PL and discuss "how could you use this in your classroom? Because the minute you make it practical and make it make sense, that's how we've overcome any hurdles and resistance" (T5A-Kinder).

#### 4.4.2. Affect

This section refers to changes that teachers reported about their own beliefs, attitudes, values, emotion and confidence teaching mathematics. Information about changes to students are reported in Section 4.3.6. Affective changes reported by teachers:

- included increased interest, enjoyment and confidence for teaching mathematics; and
- resulted from different experiences for different teachers.

All teachers considered that their involvement in BNL had deeply impacted their enjoyment of, and confidence for, teaching mathematics. BNL “re-invigorated my love of teaching maths ... it's just so interesting now” (T1C-5/6). The increased enjoyment for teaching mathematics was linked to their love of learning “so much” about teaching mathematics and the growth in “my teaching confidence - everything's grown” that created a sense of excitement “to see what's next” (T6A-1).

A metropolitan based Kindergarten teacher considered that she had to re-build her “confidence through the year”. Initially she was “scared that I'm having to really give over a lot of control to the kids” (T4A-Kinder). Prior to BNL, she implemented a rigid routine of teaching mathematics: “You teach this, then everyone does it in their books and the lesson ends! But the BNL approach doesn't work like that”. Similarly, a Year 5/6 teacher reflected that she needed to “start small” and relied on “a lot of collaboration, a lot of team teaching...” because:

Initially my confidence wasn't good. I was a little bit scared ... there's so many great ideas and then we've literally had to process it and then go and do it, but not change everything at once because I couldn't quite handle that. Once we sort of talked it over, came up with a plan of - alright, this is what we'll do. Then tried it and I was like, oh, it actually worked. (T1C-5/6)

Other teachers felt “absolutely fantastic” that they could “make a difference” to the “enthusiasm” for mathematics by their colleagues following their presentations at school-level PL. It was a real “confidence boost, a real win for me. They are oozing this enthusiasm... we call it a BNL cult” (T5A-Kinder).

The majority of teachers felt the increase in enjoyment of and confidence for teaching mathematics was linked to their capacity to put the “new ideas into practice” (T3A-Kinder), “make a difference” to the beliefs and practices other teacher or because “we're seeing results and we love teaching this way” (T2A-3/4). However, a few teachers revelled in exposure to the theoretical knowledge because it not only encouraged them to deeply reflect on their own beliefs, but it helped build understanding of why certain practices were more effective in the longer-term than others.

I do like the theory. It makes me feel more confident that I'm actually implementing quality teaching practices. The theoretical knowledge motivates me to go and implement it and see it actually in practice. So, definitely that's very powerful. The understanding of progression. The theory and practice coming together. Yeah, it is really good. I'm just loving it! (T3B-3/4/5/6)

#### *4.4.3. Knowledge of mathematics and pedagogy*

This section reports the impact of BNL on teachers' knowledge of mathematics and pedagogy as perceived by the teachers themselves. The sub-domains of mathematical knowledge for teaching (MKT) described by Ball et al. (2008) are used as sub-themes under which teacher data is presented. However, as noted by Ball and her colleagues, these sub-domains of knowledge interact, which means that evidence in the form of a teacher quote, might often provide evidence of knowledge in multiple sub-domains. The salient aspects of teacher knowledge evident from interviews included:

- increases in teachers' knowledge of students' thinking strategies (KCS);
- increases in teachers' knowledge of specialised mathematical content knowledge (SMK);  
and
- changes to teachers' knowledge of content and teaching (KCT).

Changes to teachers' **knowledge of mathematics content and students (KCS)** was evident from their references to student thinking strategies, including how to build upon their thinking and address likely errors. Teachers' new knowledge of approaches and activities that were designed to elicit student thinking strategies and develop their understanding of mathematical language and relationships also were indicative of changes to their KCS. The most regularly cited activity to achieve many of these goals was "number talks and the rationale behind them". Every teacher interviewed referred to their implementation of number talks and of the increased use of "talk and maths language" ((T6B-3/4) as a result. Classroom walls in nearly every classroom attested to the fact that number talks were firmly embedded into the practices of teachers (see Figures 8 and 9). At least four teachers (e.g., T3B-3/4/5/6/; T2A-3/4; T3A-Kinder; T2B-2/3) could also convincingly articulate the benefits of number talks for students beyond the development of mathematical language. For example, T3B-3/4/5/6 compellingly stated that "the whole purpose of a number talk is for students to be able to develop an understanding of relationships in mathematics" (T3B-3/4/5/6).

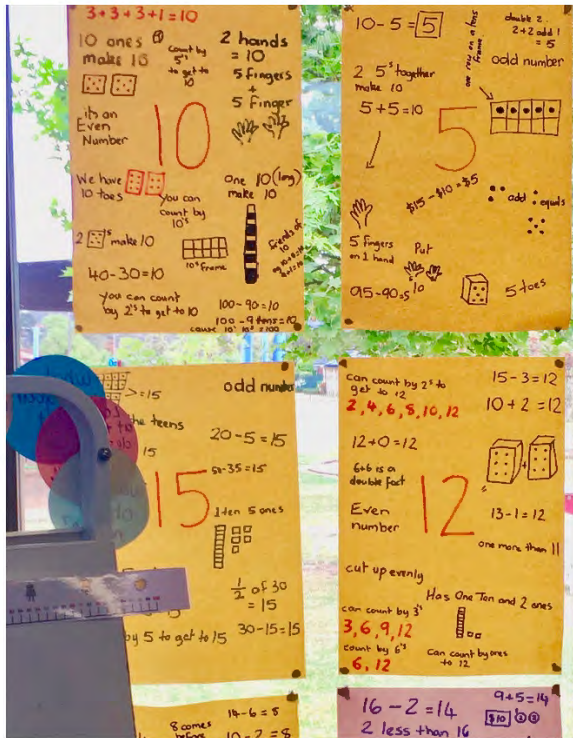


Figure 8. T1B-1/2 Wall displays/recordings of recent number talks

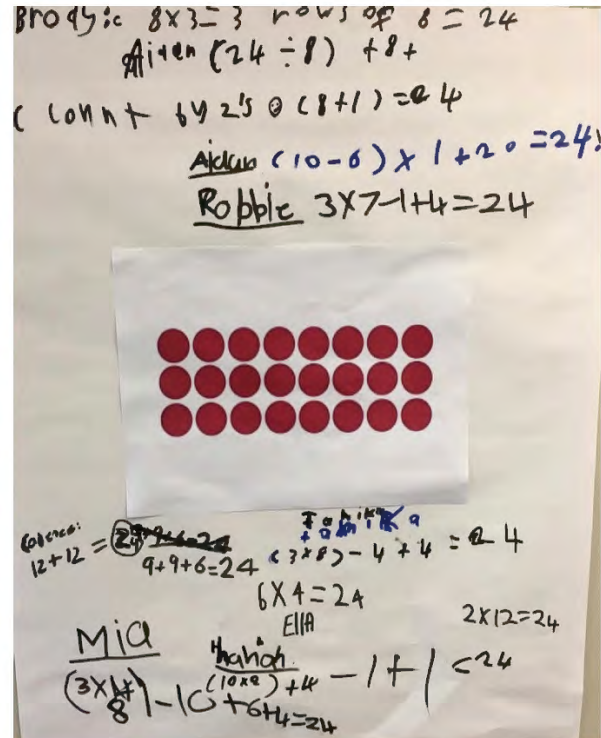


Figure 9. T2A-3/4 Wall display of a number talk conducted in a previous mathematics lesson

Prior knowledge of teachers, particularly that derived from their involvement in other quality professional learning opportunities, assisted teachers make sense of the central ideas inherent in BNL. Teachers were aware that they were “very much using my prior knowledge” (T3A-Kinder) and were “integrating or synthesising my prior knowledge with all the new knowledge that I’m receiving” (T3B-3/4/5/6). These teachers communicated a greater feeling of readiness to not only trial new activities but to embed them into their practice with little associated stress caused by the change. A teacher explained that:

I was already very observant of children’s strategies. Because of my knowledge of the Count Me In Too Framework in Number I know how important it is to get children to talk about their thinking so I can identify where they’re at. I know how to move them forward in their thinking. But I feel BNL has gone beyond that Framework. With BNL, there’s no real ability groups. You’ve got your whole class. The children are in mixed ability groups and they’re getting the opportunity to see and hear other ways of thinking, other ways of viewing a problem, other strategies that could be used. Which of course would be developing their understanding. (T3B-3/4/5/6)

Teachers’ **specialised content knowledge (SCK)** was evident when they spoke about their understanding of the big ideas (e.g., trusting the count, place value, multiplicative thinking) or referred to strategies and processes (e.g., partitioning) that are specific to the teaching of mathematics and beyond that which is commonly known by people in non-teaching professions (Ball et al., 2008). SCK was usually evident in tandem with knowledge of content and teaching mathematics (KCT) as teachers talked about “putting that specialised knowledge into practice” (T5A-kinder). As explained by another Kindergarten teacher from a metropolitan school, “learning about those Big Ideas – trusting the count and place value - gave us the terminology” and “a shared understanding of those foundational mathematical



understandings” that enabled professional “conversations to occur in PL and planning sessions” (T4A-Kinder).

Changes to teachers’ **knowledge of content and teaching (KCT)** were noticeable when they specifically referred to the sequencing of instruction and made decisions about appropriate representations for the purpose of instruction in mathematics. The “purposeful crafting of problems and the importance of those number conversations” (T4A-Kinder) to advance children’s thinking was something that all teachers were aware of, but many were concerned about whether “I’m doing it right...” (T4B-1). Teachers regularly reported experiencing an immediate increase in their SMK and KCS with their involvement in BNL. The capacity to enact that knowledge (KCT) was where the majority of teachers reported the greatest degree of challenge with some reporting initially “feeling a bit lost” (T5A-Kinder).

Teachers readily acknowledged that they were “still developing” their understandings “around those big ideas in mathematics and what that actually looks like in practice” (T3B-3/4/5/6). They agreed that a sound theoretical understanding of the big ideas was provided at the BNL conferences, but the greatest challenge was when “you come back, and you’ve got to put it in the classroom” (T5A-Kinder). Advice to implement activities and approaches in the first 48 hours “otherwise it just becomes theory and notes” was well received and generally followed as teachers all felt they “needed to actually see it in practice” (T6B-3/4) to build links between their new knowledge and their practice.

The importance of building firm links between teachers’ theoretical knowledge and all domains of their mathematical knowledge for teaching (MKT) was inherent in statements by T3B-3/4/5/6:

Anyone can give a child a task, but you need to know the purpose of the task. You need to know what you are looking for in that task. I wouldn’t say implementing the task was the challenge. It was the theory of pedagogy underpinning that task that you really need to be aware of and know what it looked like and experiment with how to actually apply it in order to further develop your understanding of what it actually does mean in practice. (T3B-3/4/5/6)

#### *4.4.4. Planning intentions*

While principals and instructional leaders were mostly concerned with bigger picture planning surrounding the sustainability and spread of BNL messages and ideas to the whole staff, teachers’ comments were understandably more focused on planning for teaching their students and included structural changes to the way instruction occurred and their strategies for student assessment of and for learning. Teachers’ planning intentions:

- heavily relied on formative assessment with planning for the next week (or even day) dependent on student responses from immediate previous lessons;
- involved structural changes to the way students were grouped for instruction;
- involved structural changes to the way they planned and programmed with increased use of collaborative planning strategies;

- involved a slower pace of progress than typical of programs planned prior to BNL with the intention that concepts be treated in more depth; and
- involved a greater variety of resources to inform planning than prior to BNL.

When asked about their approaches to planning for instruction and how they might have changed as a result of their involvement in BNL, teachers regularly spoke about the “powerful information you get from formative assessment” (T3B-3/4/5/6) to provide directionality in terms of “where the children are now and where I need to take them” (T4A-Kinder). Teachers at most schools visited commented that their schools were “heavily focused on formative assessment. We've realised that formative assessment underpins the whole learning process within each lesson” (T2A-3/4).

Strategies for collecting evidence from students as part of formative assessment varied from “SENA testing to find out what strategies they are using now” to the use of “those ideas from the Victorian Department to get a quick sense of their understanding of the big ideas” (T3B-3/4/5/6) to “just a book where I write notes down and keep lots of work samples”. Nearly every teacher mentioned the use of “lots of photos...of the whiteboard, of the students working” and their representations (T4A-Kinder; T3A-Kinder). Teachers enthusiastically shared their photographic evidence from their mobile phones during the interview. The collection of evidence was then used to:

plan for next lessons or I might use them for reports or for my data plan or anything like that - so if I'm tracking something about Part-Part-Whole, I can look through my photos and see which kids are demonstrating understanding of those concepts. (T4A-Kinder)

Teachers considered formative assessment to be a powerful guide to their teaching, “it is responsive teaching. It's straightaway”. (T2A-3/4) This teacher elaborated upon how he implemented formative assessment or ‘responsive teaching’ based on the lesson observed just prior to the interview (see Figures 10a-d):

Like today's lesson. I got them to identify their mental strategies about how they're mentally solving this problem. I then asked them to record their strategies, so then I can at any one point in time check for student understanding. I usually take photos of their work, their strategies on the white boards. We also use a maths journal ... I get them to draw or - draw any type of reasoning, any type of way they want to show me. Then they describe what they've drawn. I want to see if they can actually explain their reasoning through writing.

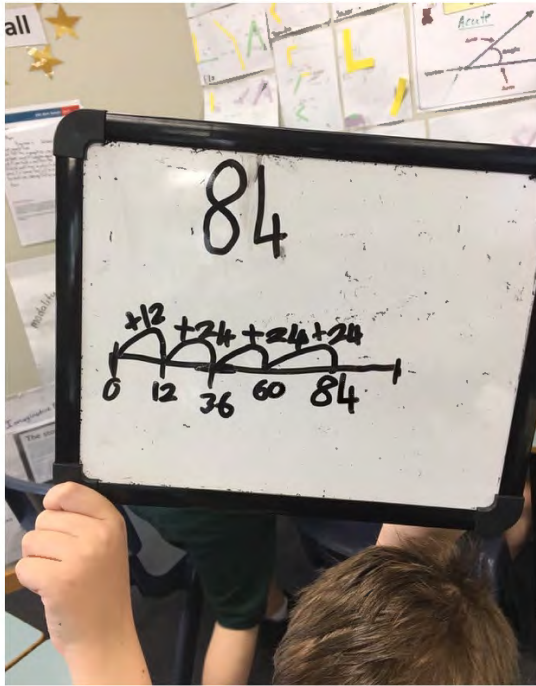


Figure 10a.

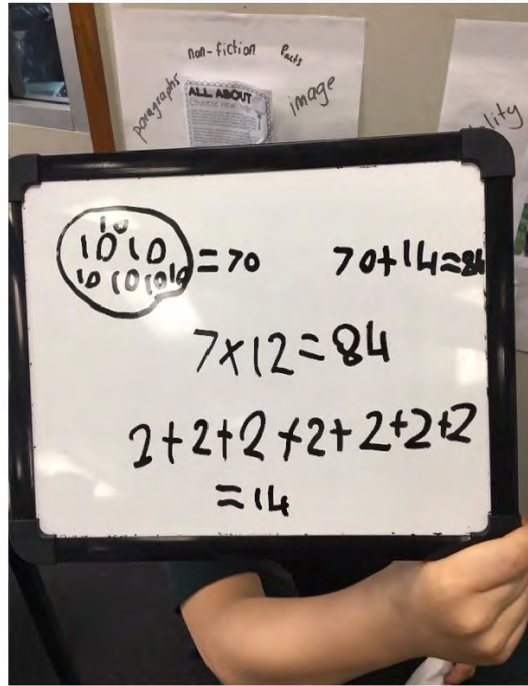


Figure 10b.

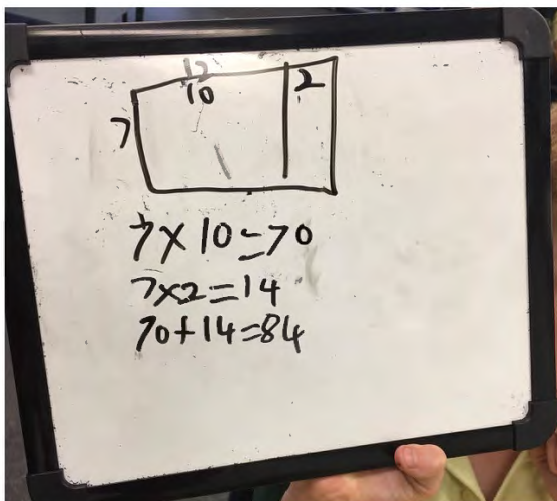


Figure 10c.

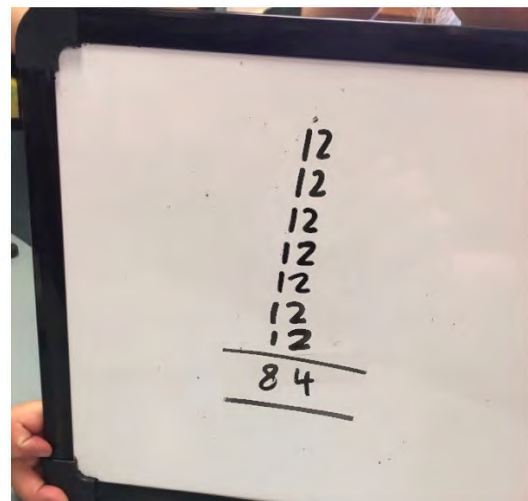
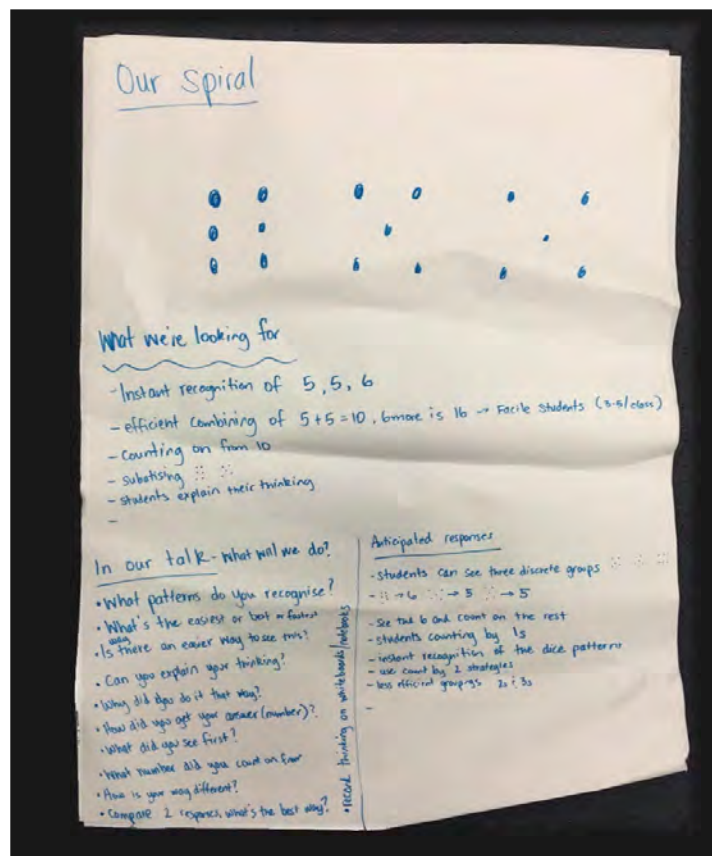


Figure 10d.

Figure 10. T2A-3/4 Student representations of  $7 \times 12$

Participation in BNL stimulated changes to how teachers structured their classes for mathematics instruction. Most teachers commented that “we’re teaching primary maths completely differently” (T1C-5/6). As confirmed in interviews with principals and instructional leaders, teachers at two different schools referred to the dismantling of streamed ability groups for mathematics instruction as a direct result of participation of BNL. At one rural school, they implemented mixed-ability classes with team-teaching of mathematics for Years 5 and 6. Reasons for the restructure included the desire to have a beginning teacher “share the knowledge, experience and skills that I’m learning from BNL with her” and “the whole idea of team teaching really appeals” (T1C-5/6). The year 5 and 6 teachers acknowledged that the change in structure was taking “time for the kids and teachers” to adjust but it seemed to be “working”.

The manner in which stage and year level planning and programming for mathematics instruction occurred was also reported as changed in schools. Changes were characterised by a great deal more collaboration amongst teachers (T5A-Kinder) and organised around big ideas. Teachers described the collaborative process took time to develop at some schools and evolved rather organically when “we started doing some collaborative processes and practices, like staff meetings, stage meetings. Now we've really concentrated on collaborative planning” (T2A-3/4). The majority of schools deliberately employed collaborative planning strategies through “our spiral of inquiry” (T3A-Kinder). It was explained that “at our last professional learning day... the team did some planning around best practice and what it looks like in practice” (T3A-Kinder). Notes taken during that planning day as part of the Spiral of Inquiry are reproduced in Figure 11.



**Figure 11.** T3A-Kinder Notes taken during school-level PL session as part of the Spiral of Inquiry surrounding BNL learning

Teachers described previous instructional planning processes as usually based on “a two-week cycle scope and sequence” (T4A-Kinder) but “this year I’ve been programming based on big ideas”. Having trialled a different approach to their programming, teachers regularly indicated their intentions to modify it further in the future. A Kindergarten teacher explained that this year “I programmed a unit of work around counting strategies...But I've taught the number strand and measurement and geometry separately. The plan next year is to integrate it all” (T4A-Kinder).

At the individual lesson level, teachers reported changes in the way they planned to ensure more collaborative work among students occurred. A Kindergarten teacher explained that “at the beginning of the year, it was a lot of focus on individual work”. But while observing

her lesson, it was noted that students were comfortable working in pairs with one student “having to notate what the other person had made, the person had to really explain it to them, or they had to be able to show it in a way that was clear” (T4A-Kinder). The teacher felt that the change in how she structured her lessons encouraged students to more regularly articulate their mathematical thinking.

There was a notable change in emphasis in teacher programming from “rushing through the content” to “slowing down and taking one task across many days” (T4A-Kinder) which came “directly from BNL. Especially the term three conference where we were looking at investigations and more open-ended maths tasks” (T3A-Kinder). Teachers changed their plans to “spend the whole rest of the week working on these same concepts that we've developed today” noting “That's something very different to what we've done over the past couple of years where it's been one lesson per day” (T3A-Kinder).

Questionnaire data indicated that teachers were using a broader selection of resources to inform their instructional planning. This was confirmed by teacher reports during the interview. Teachers regularly arrived at their interview clutching books and articles or their laptops with websites (e.g. NRICH) bookmarked to share information about the resources they use when planning lessons. The most regularly cited sources included Jo Boalers’ (2015) *Mathematical Mindsets*, Cathy Humphreys and Ruth Parker’s (2015) *Making Number Talks Matter* and Sherry Parrish’s Number Talk book series. These resources were considered inspirational for planning instruction. “...then I got introduced to this book. It really breaks it down into areas and shows progression...it's really good for stage and staff meetings, showing other teachers, having discussions of what they see and planning our lessons” (T2A-3/4).

#### 4.4.5. Classroom actions

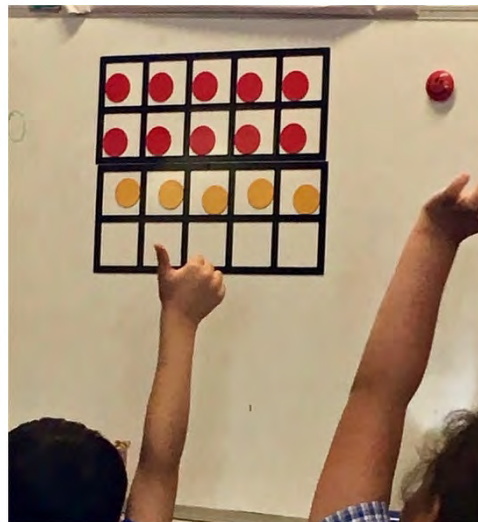
Despite some teachers’ initial concerns about how to enact the ideas and activities suggested in BNL sessions, all teachers reported making changes to their practices. Changes were not only wide-ranging but were generally significantly different to previous practices and implemented immediately or very soon after a BNL session. Importantly, teachers emphasised the need to “just do it... teachers need time to play around with these practices before they can understand and embed them” (T2A-3/4). The most notable changes to teachers’ practices included:

- More time for students to talk with each other and as a whole class,
- More opportunities for students to investigate, explore and struggle without teacher intervention or ‘telling’;
- Greater use of teacher questioning to elicit student thinking;
- More noticing, listening and responding to student strategies by teachers;
- Greater emphasis on students noticing the structure of number; and
- More opportunities for students to record and represent their thinking in a variety of forms.

Number talks and the associated use of talk moves were the most frequently observed lesson during classroom visits from Kindergarten to Year 6. Number talks were “new” to most teachers and one of the changes to practice that teachers felt most comfortable

implementing. The importance of “giving students time to talk and think and explain their thinking” (TT4B-1) was readily accepted by teachers who all made “improving the mathematical language of students” a goal that was considered valuable and “very visible in our classrooms” (T3A-Kinder).

During a number talk observed with Kindergarten, the teacher presented students with ten frames representing the number 15 (see Figure 12). The representation selected emphasised the structure of 10 in teen numbers, which the teacher later confirmed as her focus (T4A-Kinder). The representation was revealed with the teacher careful not to ‘tell’ students that there were 15 counters. Instead, through teacher questioning and students’ explanations of ‘what they saw’, talk about patterns and structure emerged. It was obvious to the teacher that quite a few students were still struggling to “see 10 as a unit” and her plans for follow-up lessons were already being adjusted in response to students’ thinking revealed via the number talk.



**Figure 12.** T4A-Kinder focus on seeing ten structure in teen numbers during a number talk

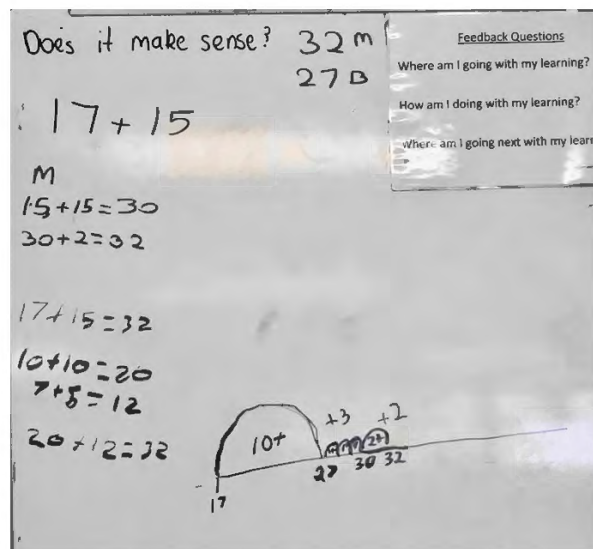
The opportunity to investigate and explore challenging tasks with little or no teacher ‘telling’ was a common approach for teachers to launch the lessons observed. This change in practice was deliberate and one suggested at BNL conferences.

Previously I would model a strategy or strategies for kids.... I’m now consciously aware of why I shouldn’t be doing that and giving the children opportunities to explore and conduct those investigations and be able to construct their own learning but also be aware that there are times where children do need that explicit modelling. (T3B-3/4/5/6)

During another Kindergarten lesson that intended to give students “plenty of time to investigate volume and capacity” (T3A-Kinder), students were faced with “the problem about which container was going to hold the most or would they hold the same” to launch the lesson. In the follow-up interview, the teacher confirmed that the launch phase of the lesson was deliberately planned to motivate students to explore without being told the answer or how to solve the problem. The teacher explained her rationale for the launch phase, saying that “there was just not a lot of thinking going on before in terms of how to

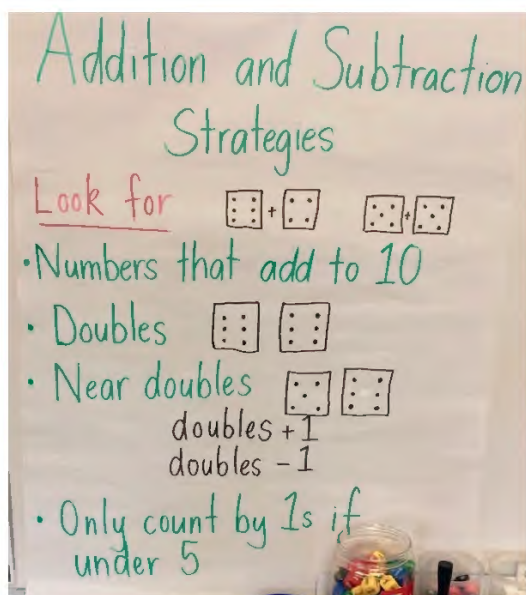
develop the mathematical thinking” of students (T3A-Kinder). It was felt that “BNL has focused on students’ talking and working mathematically. I purposefully had a lesson focus on working mathematically”.

Teacher questioning to elicit student thinking was an obvious action in every lesson observed. Incorporating “think time” (T2A-3/4) was also commonly observed. Moreover, teachers were aware that “facilitating all that accountable talk, ask thought-provoking questions and open-ended questions to get children just to really open up and just talk” about their strategies “was not enough” (T3B-3/4/5/6). Questioning has to be accompanied with “listening or knowing what to listen for and then once I had it, I was like yes, I’m on the right track, I’m hearing it” to enable teachers to appropriately respond to students’ thinking. In her number talk lesson, T3B-3/4/5/6 focussed on student mental strategies for  $17+15$ . Students not only shared their strategies with an ‘elbow buddy’ but different strategies were carefully selected by the teacher for display on the whiteboard (see Figure 13) to enable whole class discussion. To summarise the strategy discussion, the teacher asked students to think about and respond to two questions: “what’s the same about these strategies?” and “what’s different about them?”. During the follow-up interview, she confirmed “That’s something from BNL, definitely. Just getting them to identify what’s the same and what’s different I think is so important” (T3B-3/4/5/6).

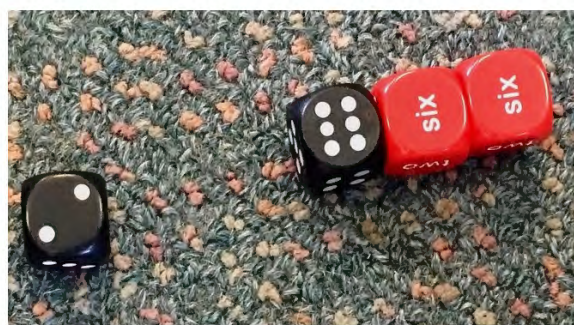


**Figure 13.** T3B-3/4/5/6 Students’ recordings of their mental strategies for solving  $17+15$  during a number/strategy talk

Strategy discussions were also observed in a Year 2 classroom. Students were required to roll four dice, group the dice according to the most efficient/convenient way of adding the numbers shown and find the total (see Figure 14a). A poster was constructed to summarise efficient student strategies devised during a number talk. During the follow-up interview, the Year 2 teacher explained her focus on Working Mathematically aspects such as reasoning and communicating saying “I feel like at the beginning of the year I didn't even think of Working Mathematically. I didn't know how to execute that in the classroom” (T4C-2).



**Figure 14a.** T4C-2 Addition and subtraction strategy poster



**Figure 14b.** T4C-2 Looking for numbers on dice that are convenient to add together

A number of the lessons observed emphasised student noticing of structure in mathematical situations. This emphasis was often accompanied by the use of student representations—concrete to symbolic. Returning to the Kindergarten number talk observation and lesson that focussed on the structure of ‘ten’ in the teen numbers introduced earlier, the teacher provided students with opportunities to explore the structure of ‘12’ using manipulatives and their own drawings (see Figures 15a and 15b) (T4A-Kinder). While the students explored various constructions of 12 using the unifix, the teacher moved around the room talking with pairs of students about their representations. On reflection of the lesson, the teacher questioned why most students did not use 10 but represented 12 with twos, particularly when the number talk revealed that students identified the 10 and 2 structure (see Figures 15a and 15b). She reasoned that:

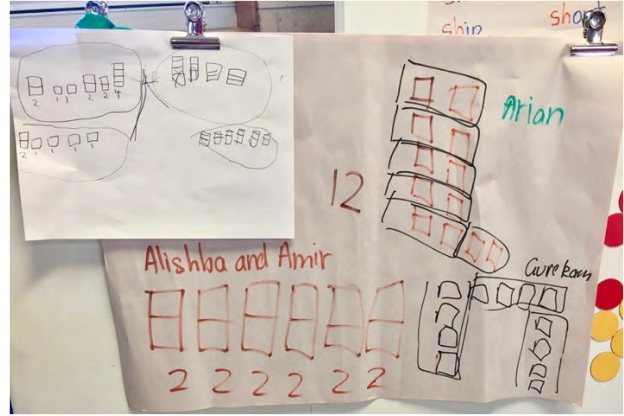
They knew that you could make 10 out of groups of twos, they automatically went back to what they were comfortable with. I find that they haven't been grouping in 10s, because they don't need to. I have some kids that are capable of using concrete materials up to 30. Getting them to group in 10s for say 30 would be interesting to see if they'd use it or if they're still grouping in smaller amounts. (T4C-Kinder)

As demonstrated by the above quote, teachers were constantly noticing, interpreting and reflecting on student responses, which informed their future classroom actions.





**Figure 15a.** T4C-Kinder combinations to 12 representation using unifix



**Figure 15b.** T4C-Kinder combinations to 12 recordings by students and teacher during whole class discussion

Student noticing the “structure of number and to structure large collections of items to support counting” (T6A-1) was also a focus of a lesson observed in a Year 1 classroom. To launch the lesson, students were presented with large numbers of discrete objects (hundreds of counters, popsticks, dice, unifix etc) and asked to “count them, but everyone must be able say how they structured” their items to prove to another person their count is correct. At this particular lesson, two Year 6 children were present in the room so they also participated in the activity. At one point in the lesson, the teacher paused all the students from their own counting and asked half the class to “go on a gallery walk...that’s definitely a BNL thing we’ve introduced”. During the gallery walk, students walking around were asked by the teacher if they “trusted the count” and “can you see the structure?” by the way the other students had arranged their collections. Most of the children structured their collections around 10 (see Figures 16a-16d). However, the Year 6 children structured their count using twos. A Year 1 student was overheard telling them “I don’t trust your count. You should have used tens. I can’t see much structure”. One Year 1 student (Figure 16b.) put elastic bands around groups of ten pencils and when she arrived at ten lots of ten, she removed her headband and tied it around the ten lots to make “one group of 100”.



**Figure 16a.** T6A-1 focus on structure and trusting the count



**Figure 16b.** T6A-1 focus on structure and trusting the count



**Figure 16c.** T6A-1 focus on structure and trusting the count

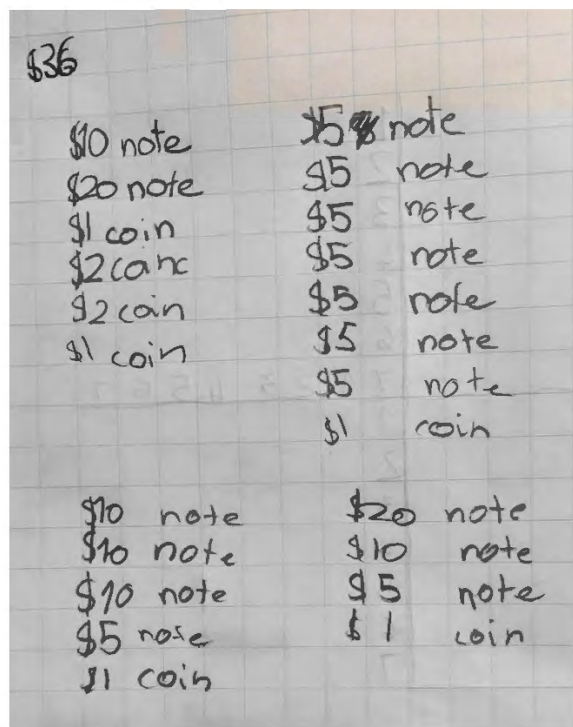


**Figure 16d.** T6A-1 focus on structure and trusting the count

In addition to the ‘thinking time’ teachers provided students during lessons, was increased responsibility for their own learning and time for reflection. At one school, teachers reported that there is “lots of talk around their responsibility for their learning” and “we’ve actually extended maths time to allow for reflection by students” (T1C-5/6). The teacher explained further:

The last 10 minutes is reflection and we talk to the kids about what they’ve learnt today. Sometimes they get an opportunity to write on a sticky note and they can just stick it on the window. Then, often we’ll then use that as a springboard, perhaps for what we’re going to do the next day. That feedback and reflection has been a really valuable part of our lesson because we were just finding that that was a bit of a downfall for us in the past.

These aspects of practice were confirmed during the lesson observation, with students asked to “find a buddy” they could work with to work on an open-ended problem requiring students to find combinations of notes and coins to make \$36 (see Figure 17 for student response to task). The nature of the tasks teachers now presented to students were considered to be “more open-ended-ness which means that many more students can have that buy-in. It's more inclusive”. When asked about her choice of activity for the observed lesson, T1C-5/6 replied that “the nature of the activities has changed and that's been driven by BNL ... the big ideas, thinking mathematically, working mathematically. That kind of drives our activity choice”.



**Figure 17.** T1C-5/6 work sample showing combinations of notes and coins that make \$36

#### 4.4.6. Student responses

Children’s cognitive responses can be inferred from many of the work samples and teacher comments presented in previous sections of this report. Therefore, this section focuses on reports from teachers that cannot be easily inferred from the work samples provided but rely more on teacher perceptions of students’ responses that were reported during interviews or witnessed during lesson observations. These responses included:

- Shifts towards growth mindsets;
- Increased use of mathematical language;
- Increased enjoyment of, and confidence to do, mathematics
- Enhanced capacity to explain their reasoning; and
- Greater persistence to work on challenging problems.

Changes to students’ mindsets about what it means to do mathematics and be a mathematician were referred to by all teachers interviewed. Teachers reported surveying

their students after returning from their first BNL session and were often alarmed when students “couldn’t tell us” what “mathematics or being a mathematician was”, they “definitely did not see themselves as mathematicians” (T1C-5/6). Teachers reported that their initial assessments of students’ mindsets indicated that “they were stuck in single ideas and had only one-track minds” (T5A-Kinder).

The journey to shift students’ mindsets from “fixed to a growth mindset” (T2A-3/4) was an aspect of BNL that seemed to permeate every lesson observed. In three lessons, the desire to have a “growth mindset” (T1C-5/6), to “think like a mathematician” (T5A-Kinder), have a “sweaty brain” (T5B-1/2) was specifically addressed through class discussion. However, evidence on classroom walls (see Figure 18) and students use of phrases such as “my brain is sweating” (T6A-1) when questioned by teachers during lessons, clearly indicated a great deal of effort had “gone into changing the culture of doing mathematics and what it means to be a mathematician” (T5A-Kinder) including working with parents to ensure that the messages at home are consistent with those at school:

We did a big session on sweaty brains at the start of the year. My little guys go home and talk to their parents about it's okay mum, your brain is just sweating. Then I did that session with the parents. The parents said, ‘now we know what it means to have a sweaty brain!’. (T5A-Kinder)

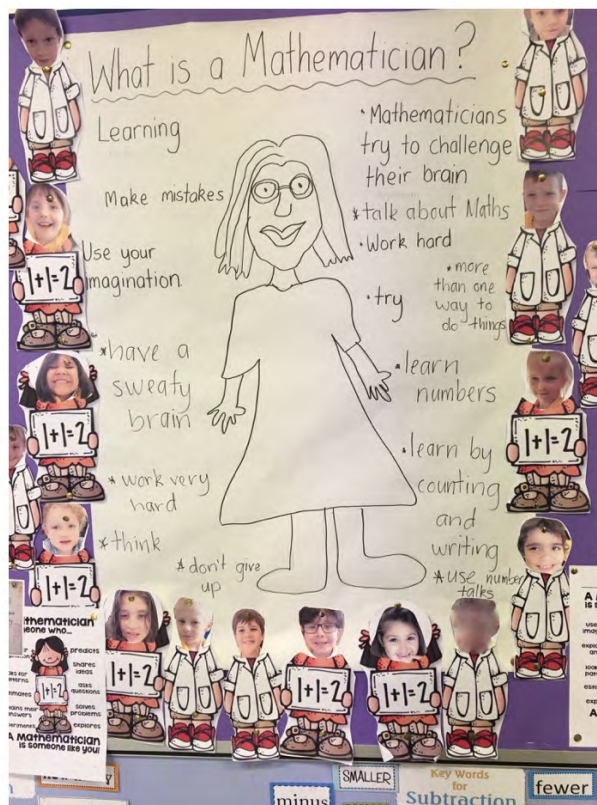


Figure 18. T5A-Kinder display: What is a mathematician?

Teachers confirmed comments by principals and instructional leaders regarding the increase in both the amount of mathematical language and the quality of the language being used by students. Every teacher spoke about the “massive increase” in mathematical language that

they regarded as a result of the “focus on language through all the number talks and explaining students are asked to do. They can really articulate their reasoning” (T6A-1).

Accompanying the increase in language and change in culture surrounding growth mindset, teachers perceived that the “students are so much more confident” to “have a go and say what they’re thinking” (T2A-3/4). A Year 1 teacher considered the increase in student confidence meant they would “challenge the thinking or answers of just about anyone. They’re not shy to do it to anyone at all” because “they trust their count, they believe in themselves and that they have the evidence to back it up. They enjoy maths, they like talking about it” (T6A-1).

The notable increase in student confidence in mathematics also had positive repercussions for their willingness to persistent on challenging tasks. When number talks were first introduced in classrooms, teachers recalled that:

they were a little bit nervous because they felt they had to get the idea straight away. We really have to build that culture of struggle and sweaty-brains from the beginning. That it's okay if learning can be a little bit hard sometimes. We talk about sweaty brains a lot. (T5A-Kinder)

Students’ willingness to persistence on challenging problems was also part of the “culture we had to work on” when “we got rid of streamed maths groups”. Teachers worked to ensure that “all students have a go” and “building resilience about it and having that determination to persevere because there's been lots of occasions at first where, you know, ‘oh it's too hard’, So building up that resilience of kids has been great but a work in progress” (T1C-5/6).

## 5. Summary of Results and Recommendations

The aim of this study was to analyse and evaluate BNL’s impact on teacher participants’ knowledge and teaching practices. This section synthesises the findings from the result sections to inform responses to each of the research questions. It then makes recommendations for the improvement of BNL.

What impact does BNL have on participating teachers’ pedagogical and mathematical knowledge?

Increases in the amount and quality of teacher specialised content knowledge of mathematics (SMK), their knowledge of content and students (KCS) and knowledge of content and teaching (KCT) were evident from and (to a lesser degree) participants responses to the scenario task. Generally, the introduction of the vast majority of ideas and concepts, and the theoretical underpinnings of those ideas and concepts, were new to nearly all participants. Teachers differed in their prior knowledge, which meant that their readiness to accommodate this knowledge also differed. Many participants felt that they needed a longer timeframe to fully take on board all the benefits of BNL. Nevertheless, all teachers who participated in the data collection demonstrated positive growth in their mathematical knowledge for teaching to some degree.

### Recommendation 1

The NSW Department of Education consider strategies to extend the length of time in which either individual teachers and/or their schools can participate in formal BNL sessions for at least two years, and ideally, three year.

#### What impact does BNL have on teachers' instructional practices in mathematics?

Changes to teachers' instructional practices in mathematics were evident from questionnaire responses, interviews with principals, instructional leaders, teachers themselves, and from the lesson observations. Most notable changes involved:

- More opportunities for students to investigate, explore and struggle without teacher intervention or 'telling';
- Greater use of teacher questioning to elicit student thinking;
- More noticing, listening and responding to student strategies by teachers;
- Greater emphasis on students noticing the structure of number;
- More opportunities for students to record and represent their thinking in a variety of forms.
- Greater emphasis on formative assessment with planning for the next week (or even day) dependent on student responses from immediate previous lessons;
- Structural changes to the way students were grouped for instruction;
- Structural changes to the way they planned and programmed with increased use of collaborative planning strategies;
- A slower pace of progress than typical of programs planned prior to BNL with the intention that concepts be treated in more depth; and
- A greater variety of resources to inform planning than prior to BNL.

Changes to instructional practice were immediate and quite often profound. Teachers noted that the implementation of their new knowledge was the most challenging aspect of BNL. Knowing what these practices looked like in the classroom and whether they were "on the right track" was an on-going concern for many teachers.

### Recommendation 2

The NSW Department of Education consider strategies to increase the time allocated to instructional leaders to allow more 'in-class' support and that the expertise of past BNL participants be utilised as mentors or coaches to support new schools as they implement BNL.

#### What impact does BNL have on teachers' confidence to teach mathematics?

Positive changes to all aspects of teachers' affective states were noted throughout the study. The increase in teacher confidence to teach mathematics was accompanied by increase in enjoyment, growth mindsets and renewed interest in learning about mathematics pedagogy and content. Confidence was further stimulated when teachers witnessed positive responses by students. The positive affective impact was often contagious, with principals experiencing a sense of pride in their teachers and students particularly when visitors from outside the school could share and witness the impact.

### Recommendation 3

The NSW Department of Education consider strategies for sharing of practices, possibly through a teacher showcase or open-door/classroom event specifically designed to share the positive impact of BNL on teachers and students.

### Conclusion

There is overall evidence that BNL has had, and continues to have, a positive impact on teachers' knowledge of mathematics and pedagogy, their instructional practice and their confidence levels for teaching mathematics. It is important to explore the reasons for its effectiveness in finer detail to better inform teacher professional learning initiatives of the NSW Department of Education in the future.

### Recommendation 4

The focus on future impact analyses of BNL shift from *whether* it works to HOW and WHY it works.

## 6. References

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**Research Integrity & Ethics Administration**  
Human Research Ethics Committee

Thursday, 10 May 2018

Prof Janette Bobis  
School of Education and Social Work Research Operations; Faculty of Arts and Social Sciences  
Email: janette.bobis@sydney.edu.au

Dear Janette

The University of Sydney Human Research Ethics Committee (HREC) has considered your application.

After consideration of your response to the comments raised your project has been approved.

Approval is granted for a period of four years from **10 May 2018 to 10 May 2022**

**Project title:** Building Numeracy Leadership Evaluation

**Project no.:** 2018/284

**First Annual Report due:** 10 May 2019

**Authorised Personnel:** Bobis Janette

**Documents Approved:**

Date Uploaded	Version number	Document Name
02/05/2018	Version 2	PCF V. 2 Final
02/05/2018	Version 2	Questionnaire V. 2 with changes
02/05/2018	Version 2	Letter to Principals v. 2
02/05/2018	Version 2	Interview Questions v.2
02/05/2018	Version 2	PIS Final v.2
02/05/2018	Version 1	PCK scenario/vignette task
26/03/2018	Version 1	PCK open ended assessment task

**Special Condition/s of Approval**

1. It is a condition of approval that Department of Education and Communities approval is obtained and a copy kept on file prior to the relevant part of the research being conducted.

**Condition/s of Approval**

- Research must be conducted according to the approved proposal.
- An annual progress report must be submitted to the Ethics Office on or before anniversary of approval and on completion of the project.
- You must report as soon as practicable anything that might warrant review of ethical approval of the project including:
  - > Serious or unexpected adverse events (which should be reported within 72 hours)
  - > Unforeseen events that might affect continued ethical acceptability of the project

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ABN 15 211 513 464  
CRICOS 00026A



- Any changes to the proposal must be approved prior to their implementation where an amendment is undertaken to eliminate immediate risk to participants.
- Personnel working on this project must be sufficiently qualified by education and experience for their role, or adequately supervised. Changes to personnel must be reported and approved.
- Personnel must disclose any actual or potential conflicts of interest, financial or other interest or affiliation, as relevant to this project.
- Data and primary materials must be retained and stored in accordance with relevant legislation and University guidelines.
- Ethics approval is dependent upon ongoing compliance with the University's Statement on Ethical Conduct in Human Research, the Australian Code of Research, applicable legal requirements, and with University and governance requirements.
- The Ethics Office may conduct audits on approved projects.
- The Chief Investigator has ultimate responsibility for the conduct of the research and is responsible for ensuring all others involved will conduct the research in accordance with the above.

This letter constitutes ethical approval only.

Please contact the Ethics Office should you require further information or clarification.

Sincerely,

Dr Jennifer Scott-Curwood  
Chair  
Humanities Review Committee (Low Risk)

The University of Sydney HRECs are constituted and operate in accordance with the Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007) and the NHMRC's Australian Code for the Ethical Conduct of Human Research (2007).



## Appendix B – SERAP



Professor Janette Bobis  
11 Warekila Road  
BEACON HILL NSW 2006

DOC18/471784  
**SERAP 2018258**

Dear Professor Bobis

I refer to your application to conduct a research project in NSW government schools entitled *Building Numeracy Leadership Evaluation*. I am pleased to inform you that your application has been approved.

You may contact principals of the nominated schools to seek their participation. **You should include a copy of this letter with the documents you send to principals.**

This approval will remain valid until 21-Aug-2019.

The following researcher has fulfilled the Working with Children screening requirements to interact with or observe children for the purposes of this research for the period indicated:

Researcher name	WWCC	WWCC expires
Janette Bobis	WWC0807080E	11-Sep-2020

I draw your attention to the following requirements for all researchers in NSW government schools:

- The privacy of participants is to be protected as per the NSW Privacy and Personal Information Protection Act 1998.
- School principals have the right to withdraw the school from the study at any time. The approval of the principal for the specific method of gathering information must also be sought.
- The privacy of the school and the students is to be protected.
- The participation of teachers and students must be voluntary and must be at the school's convenience.
- Any proposal to publish the outcomes of the study should be discussed with the research approvals officer before publication proceeds.
- All conditions attached to the approval must be complied with.

When your study is completed please email your report to: [serap@det.nsw.edu.au](mailto:serap@det.nsw.edu.au)  
You may also be asked to present on the findings of your research.

I wish you every success with your research.

Yours sincerely

A handwritten signature in blue ink, appearing to read 'Elsa Lat'.

Elsa Lat  
**R/Director, School Policy and Information Management**  
27 August 2018

**School Policy and Information Management**  
**NSW Department of Education**  
Level 1, 1 Oxford Street, Darlinghurst NSW 2010 – Locked Bag 53, Darlinghurst NSW 1300  
Telephone: 02 9244 5060 – Email: [serap@det.nsw.edu.au](mailto:serap@det.nsw.edu.au)

Confidential

### Building Numeracy Leadership Survey

Thank you for agreeing to complete this survey. Please read the Participant Information Statement commencing.

Please provide an anonymous identification code so that we can match your response in this survey to the responses provided in a similar survey at the end of the BNL program.

Your ID is the first 2 letters of your surname, and the last 3 digits of your phone number.

For instance, John Smith's ID would be "SM 123".

1. Where is your school located?

- Metropolitan
- Rural or remote

2. What is your current teacher classification level?

- Classroom teacher
- Assistant or deputy principal
- Principal
- Instructional leader
- Other

Please specify other teacher classification level

3. What is the enrolment number at your school (approximately)?

- Less than 50
- 51-100
- 101-200
- More than 201

4. What is your gender?

- Male
- Female
- Prefer not to say

5. How many years of teaching experience do you have (including this year)?

- First year
- 2-3
- 4-5
- 6-10
- 11-15
- Over 15

6. What is the current grade level you are teaching? (Select all that apply)

- K
- 1
- 2
- 3
- 4
- 5
- 6

7. What is the highest academic/teaching qualification you have completed?

- Diploma
- Bachelor degree
- Masters
- PhD or EdD
- 2 or 3 year teacher diploma
- Other

Please specify your other academic/teaching qualification

8. Have you attended a mathematics or numeracy professional development (PD) program or conference in the last 3 years?

- Yes
- No

Please provide details (e.g. name of PD, provider, presenter name, conference name, etc.)

9. Where do you get ideas for teaching mathematics? (Please select all that apply)

- A particular text book
- Conferences
- A variety of texts
- Mathematics teacher journal
- Internet
- Research articles
- Other staff

Class/student organisation structures are used to instruct the children you teach mathematics? (Please tick all that apply)

- Direct instruction with children working independently
- Mixed grouping within my class
- Mixed grouping across year and/or stage levels
- Ability groupings
- Friendship groupings
- Needs-based groupings

Any other class/student organisation structure(s)

For each of the following statements, please select the response that best indicates your level of agreement.

**When teaching mathematics...**

	Strongly disagree	Disagree	Unsure	Agree
1 I start lessons by explaining to students how they should do the task or problem	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2 I feel confident that I can motivate students who show little interest in mathematics	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3 I allow students to struggle before I intervene	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4 I like to use mathematics problems that can be solved in many different ways	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5 I regularly have my students work through real-life maths problems that are of interest to them	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6 I feel confident in my understanding of the mathematics content I am about to teach	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7 I often learn from my students during maths lessons because my students come up with ingenious ways of solving problems that I have never thought of	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8 It is not very productive for students to work together during maths lessons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9 There will always be some children who will never 'get' the maths concepts, no matter what I do	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10 I integrate maths assessment into most maths activities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11 In my classes, students learn maths best when they can work together to discover	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- When students are working on maths problems, I put more emphasis on getting the correct answer than on the process followed.
13. Creating a set of criteria for marking maths questions and problems is a worthwhile assessment strategy.
14. I often provide the same task for all students and then offer enabling and extending prompts.
15. I don't necessarily answer students' maths questions but rather let them puzzle things out for themselves.
16. A lot of things in maths must simply be accepted as true and remembered.
17. I feel confident that I can get my students believing that they can do well in mathematics.
18. I like my students to master basic mathematical operations before they tackle complex problems.
19. I teach students how to explain their mathematical ideas.
20. If students use calculators they don't master the basic maths skills they need to know.

## Appendix D – Questionnaire Dimensions

Questionnaire Item		Dimension
1	I start lessons by explaining to students how they should do the task or problem	Struggle
3	I allow students to struggle before I intervene	Struggle
15	I don't necessarily answer students' maths questions but rather let them puzzle things out for themselves	Struggle
2	I feel confident that I can motivate students who show little interest in mathematics	Confidence
6	I feel confident in my understanding of the mathematics content I am about to teach	Confidence
17	I feel confident that I can get my students believing that they can do well in mathematics	Confidence
4	I like to use mathematics problems that can be solved in many different ways.	Nature of Tasks
5	I regularly have my students work through real-life maths problems that are of interest to them.	Nature of Tasks
12	When students are working on maths problems, I put more emphasis on getting the correct answer than on the process followed. *	Nature of Tasks
14	I often provide the same task for all students and then offer enabling and extending prompts	Tasks
7	I often learn from my students during maths lessons because my students come up with ingenious ways of solving problems that I have never thought of.	Teacher's Role
19	I teach students how to explain their mathematical ideas.	Teacher's Role
8	It is not very productive for students to work together during maths lessons *	Instructional Approach
11	In my classes, students learn maths best when they can work together to discover mathematical ideas	Instructional Approach
10	I integrate maths assessment into most maths activities	Assessment
13	Creating a set of criteria for marking maths questions and problems is a worthwhile assessment strategy	Assessment
9	There will always be some children who will never 'get' the maths concepts no matter what I do *	Conceptions of mathematics
16	A lot of things in maths must simply be accepted as true and remembered *	Conceptions of mathematics
18	I like my students to master basic mathematical operations before they tackle complex problems	Conceptions of mathematics
20	If students use calculators, they don't master the basic maths skills they need to know*	Conceptions of mathematics

\* Reverse scoring item

## Appendix E – Scenario Task

### Please record your ID

First 2 letters of your surname + the last 3 digits of your phone number

Date: \_\_\_\_\_

#### Four Strikes and You Are Out: A classroom scenario

Imagine you are playing **Four Strikes** with a group of Year 1 and Year 2 students.

After a few turns of guessing the digits, you see this:

$$\_ \_ 7 + 2 4 = 6 \_ \_$$

0 1 ~~2~~ 3 ~~4~~ 5 ~~6~~ ~~7~~ 8 9

You pause the game and ask the students:

*What is your strategy for finding the final two digits? Explain your strategy to your partner and record it in your journal.*

1. Describe your learning intentions for pausing the game and giving students this task.
2. What student responses do you anticipate? (use words, symbols etc to help explain)
3. If a student was 'stuck', what hint or hints would you provide to scaffold their thinking?
4. How would you modify this task to make it more challenging for students?
5. What follow-up activities would you plan for the children who achieved your learning intentions?

## Appendix F – Summary of Scenario Time 1 and Time 2 Responses

Teacher level & Location	Time	1. Identify learning intentions	2. Anticipate & interpret student strategies	3. Differentiating the task	4. Suggest variations for different grades	5. How to progress student learning
AP/DP rural/ remote	1	Use our knowledge of place value to solve problems with missing values.	I guessed/if I add the tens column this would be too much or too little/60 + 20 is too high etc/I am just testing some of the numbers.	I would ask questions such as 'what do you already know?', 'what are the possible answer that we can have?', 'what are the options for the 0?'	They need to come up with a range of strategies to solve the same problem, increase the range of numbers such as they can use the numbers 0 to 9 twice, larger numbers, write a work problem to match	Ask students to demonstrate their strategies using hands-on materials?
	2	Learning Intentions: Check if students are noticing and using strategies. What reasoning has been made already that can support our next steps. Ask 'what if' questions	The 0 cannot be placed in the sentence as neither can be true. It is possible that the 1 can be placed to make 61. The 9 8 and 5 are too large to be at any place	What do you already know from the information? Are there any numbers that we can rule out and why? What do you know about place value that can support your reasoning?	Three-digit numbers, change the operation, provide them with less steps, ask students to create their own	More activities based on place value of larger numbers that reinforce concepts of number partitioning and renaming. Could move onto larger numbers, could have students record their understanding of two-digit numbers by drawing
Interpretation		<i>Focus shifted to students. Teacher mentions student noticing and use of strategies. Focus on questioning type - 'what if'</i>	<i>Move from focusing on students just guessing solutions to looking for students to use 'can be' 'can't be' as qualifiers of thinking based on prior knowledge. Students knowing what won't work is an important step in working out what will work</i>	<i>Teacher asking specific questions to link to prior knowledge and for students to use elimination strategy. This indicates growth in teacher's MCK</i>		<i>More detailed and specific advice for students shows teachers increased MCK. Suggestions also include a focus on working mathematically - communicating through recording.</i>

AP/DP rural/ remote	1	Provide students an opportunity to communicate with their peers and give an explanation of how they may solve the problem	Using their knowledge of numbers and estimation - $24 + ?$ to get to a 6? The first missing digit would most likely be a 3. Some students will get stuck and not know what to do	Estimation eg $87 + ?$ would be too large to get at 6? Number	More digits	Opportunities to communicate, justify, share strategies when solving questions
	2	To gain an understanding of students' depth of knowledge of addition strategies. Are they able to communicate their reasoning for what the final two digits are? Using Talk Moves to promote classroom talk - this also frees up the teacher to observe students' discussions and thinking with their partner.	The first missing digit can't be a 5, 8 or 9 because I know that the sum would be too high eg $50 + 20 = 70$ etc I know that it can't be the 0 because 07 is not a two-digit number 1 for the first missing number would be too small eg $10 + 20 = 30$	Eliminate the more obvious digits that would not possibly fit. Explain thinking to partners using Talk Moves	Larger digits Different operations	Opportunities to play Four Strikes and You're Out with a small group independently. Are they able to draw upon strategies etc without teacher scaffolding/support? Allow for students to devise the questions themselves and lead the group to play the game. Using observations while students are engaged in dialogic talk to identify areas of needs and strengths. Activities could be devised on building students understanding in areas identified from observations.
Interpretation		<i>Focus shift to working mathematically processes not just talking about solutions. Explains what the students will be reasoning about, not just stating 'reasoning'. Less "Telling". More discussion &amp; scaffolding using prompts. Introduction of quality pedagogical teaching strategies leads to increase in teacher KCS.</i>	<i>Mention of 'can' and 'can't be' strategy of elimination, proving 'truths' through understanding of 'falses'</i>	<i>Mention of talk moves, increase in PCK</i>	<i>larger numbers</i>	<i>Clear links made between teacher's learning intension and next steps in learning. Mention of importance of classroom discourse - 'dialogic' Clear indication from level of language used that teachers have been exposed to current research that is in turn having an impact on their practices.</i>

CT metro	1	We are learning to problem solve using addition and subtraction strategies.	Guessing, some students will immediately know that it will be smaller numbers.	Remind student of place value, and what 6 stands for	Up the numbers, use larger numbers and even allow multiple correct answers	Allow exposure to similar questions, and more challenging questions
	2	Allowing wait time for students to problem solve. This allows students to trial and error, estimate and understand number sentence.	8 because that's left (guessing) 5 (guessing), 4 because 40 and 20 make 60 (Knowledge of tens) 3 because the 7 and 4 make 11 so it has to be 30 + 11 + 24 deep knowledge of place value and able to partition numbers with knowing value – split, 1 because 7 and 4 make 11	Strategic questioning. What do you know? What numbers are possible? (What is not crossed out) Can it be zero? why not? Can you use your knowledge of subtraction- 60 - 24? estimate? Have you used estimation to solve this?	Take the number sentence up to 3/4/5 digit depending on student. Change it so the equal sign is in a different position. Different operation.	Missing addends in a different position, encourage the use of inverse operations. Create representations of their thinking, turn and talk to allow students to discuss their different methods to problem solve
Interpretation		<i>Greater understanding of being intentional in pausing the task, not just saying a learning intention 'verbatim' Focus is on allowing students time. Mention pedagogical strategy Talk Moves</i>	<i>Increase detail in what students may offer indicates teachers are more familiar with KCS and the tasks' links to Place Value and partitioning</i>	<i>Teacher talks about being strategic and being a 'questioner'</i>	<i>different operation</i>	<i>Higher use of mathematical content words eg. 'addends' Mentions other pedagogical strategies such as discussions of different methods and creating representations with students</i>

CT metro	1	See if the students have a strong understanding of 'Place Value'	tens, ones, I know that 7 and 3 is 10 and 1 more makes 11, that means that the last digit has to end in 1 and then the 10 from the 11 is added to the tens placing, then 10 plus 20 is 30 and the final answer has a 6 tens so the digit near 7 has to be 3?	'Guess and check?' to step through things that could work. Ask questions, tell me about 24 and 60 (something)? and more but I ran out of time!	single digits and maybe use number strings	number strings
	2	I would see this as a moment to almost do a number talk... to see if students are using their knowledge of place value to solve this. What additive strategies they are using to solve, flexibility of the how they see numbers. To share their thinking and allow other students to repeat the thinking of their peers	I know that twenty plus forty makes sixty so the first digit isn't a 4 = 47 that's too much. so the first digit must be 3 = 37. and I know the last digit is going to be 1 because I know 3 and 7 makes 10 and one more make 11. The answer will be 61. I could also have done it another way, using my knowledge of 7 and 4 and that it makes 11 so the answer is 61 then I need to work out what the first digit of the 2digit number is.	use their knowledge about 60 and 'sixtyness' looks like and what they can see with twenty to start with. I also use a number string to simplify the problem.	not give the numbers 0-9 as markers - just have the tallies of 4 represented as markers. use a problem like $35 + 25 = 12 + \underline{\quad}$	finding out other ways to 61, using 2, 3 addends. relating it with subtraction.
Interpretation		<i>Link to KCS &amp; KCT Number talks, Talk moves (repeating) Evidence of increase in teacher MCK by use of mathematical terms "additive strategies"</i>	<i>This teacher already has some good suggestions of what to look for but second scenario still shows greater understanding of MCK and a variety of prior knowledge students may draw on to solve the task</i>	<i>Number String teaching strategy mentioned (note: also mentioned by teacher in first scenario)</i>	<i>Understanding of 'less is more', knowing when to hold back with students and give them less so the task is more open for interpretation</i>	<i>inverse operation</i>



CT metro	1	To ensure students are on task and are completing understanding the process. What is their thinking around the expectations of the task?	Blank responses, $07+24=61$ , guess and check	guess and check, use the inverse operation	Have one number missing and the response missing as well	Further activities that involve problem solving and higher order thinking questions
	2	To give students time to turn and talk to a partner and think critically about the question. Develop a 'sweaty brain' and 'think like a mathematician'. What can they guess and check from the remaining numbers? What strategies are students using?	$37+24=61$ ; $17+24=6$ ; guess and check responses	what do we know about place value? How can we use our knowledge of place value/borrow and pay back to guess and check?	Removing more numbers	using numerous strategies e.g. multiplication, division, subtraction with further missing numbers
Interpretation		<i>Focus is on students thinking, teacher shows increase in KCS and understanding of purpose of pausing lesson is to engage students in deeper thinking. Mentions thinking like a mathematician but doesn't really explain what they would be. Uses term 'sweaty brain' in reference to students experiencing productive struggle</i>		<i>Includes questions here instead of just listing things to tell or expose students to</i>		

CT rural/ remote	1	You've given the students the basis for finding the answer and now it is their turn to problem solve and work it out using the remaining numbers. So my learning intention would be process of elimination.	Students just putting any number in to complete the task. Students using addition strategies to work out the answer. i.e. $7+4=11$ , $30+20=50+11=61$	Start with the last unit number $7+4$ then the tens. What numbers will work together to give you an answer in the 60's.	Change the end number goal or the action of addition to subtraction.	I would make the questions increasingly difficult to push the children. Or extend on the learning intention to incorporate another.
CT rural/ remote	2	I would pause it at this point to observe what type of thinking/strategies the students would use to answer the question. Then I would record the multiple strategies to visibly represent students thinking. Then discuss if anyone has changed their thinking about their strategy, was it the most effective way or do they believe they could use a peers' strategy to be more efficient.	$(7+4=11)$ , $(30+20=50)$ , $(50+11=61)$ randomly adding the remaining numbers into the blank until they get the answer. Out of the numbers left what is the most likely to get them to the 60s, can't be too high or low. Elimination i.e. $(69-24=45... no)$ $(68-24=44... no)$ $(65-24=41... no)$ $(63-24=39... no)$ $(61-24=37...yes)$ .	Try eliminating the numbers that could not possibly be used. What numbers that you already have could you add together to help guide you.	Eliminate another number. Change the addition symbol.	I would look at changing the symbol, partitioning and part-part whole activities using 3 digit numbers.
Interpretation		<i>Focus of pausing is to focus the teacher on what to look for just as much as time for students to share. Use of visual representations of student thinking and mention of how to guide discussion around changes in thinking and why student's strategy is more efficient shows increase in teacher KCT.</i>	<i>increase in number of possible solutions students may have may indicate increase in teacher's MCK</i>	<i>(still telling students)</i>	<i>change operation</i>	

CT rural/ remote	1	Mathematical reasoning, knowledge of the tens frame, knowledge of place value and carrying or trading and compensation strategies.	We need to have 6 tens so we need to add four tens to the two tens' 'But then we have another ten after you add the 4 ones and the 7 ones' 'So we only need 5 tens, so 3 tens and 2 tens' 'Ok so the question would be $37 + 24 = 61$ '	What do we know about the numbers in the problem?' 'What do we have so far?' 'How could we get there?' 'How many tens will we end up with?' 'How many ones do we have?' 'How can we balance this equation so that we have the 11 ones fit with the 6 tens we have over here'	incorporate decimal place value, incorporate fractions, incorporate multiple operations on both sides of the equation	Plan their own problem, Work backwards to discover an array of solutions
CT rural/ remote	2	Observational and recorded assessment of student strategies relative to the Big Ideas in number: Trusting the Count and Place Value. Strategy sharing for students to target point of need teaching and foster discussions on efficiency of strategies.	Trusting the Count- '24, 34, 44, 54, $64 = 4$ tens = 40' 'I don't understand because 4 is already gone' Trusting the Count- 'I know that $7 + 4 = 11$ because 7, 8, 9, 10, 11 so I would guess 1' Place Value- 'I'm not sure because $60 - 20 = 40$ ... but it can't be 4' Place value- I know that $7 + 3 = 10 + 1 = 11$ so I would guess 1. That also makes another 10 and I know that $60 - 20 = 40 - 10 = 30$ so that's 3 tens so I would guess 3.	*What do you already know? *Which numbers can we eliminate? *Can you use Trial and error? *What would a mathematician do to solve this problem?	*Include 3 add ends *Include fractions *Include balanced equations *Include other operations *Include multiple operations	*How could we include multiplicative thinking to solve this problem? *Can you design your own 4 strikes you're out? *How could we use this game to balance equations? *Could you teach someone else your strategy? *Can you think of more than one strategy?
Interpretation		<i>Moving from just listing bits of knowledge to expressing as a collective whole what the purpose is. Focuses on Big Ideas of Trusting the count and Place Value Mentions 'strategy sharing' this is evidence of developed knowledge, namely, KCT &amp; KCS.</i>	<i>specifically names the strategies and content linked to possible student solutions - evidence of teacher's KCS</i>	<i>consistent with good questions from first to second scenario</i>		<i>phrasing as questions</i>

CT rural/ remote	1	To hear their thought processes, to ask open questions, look at tens and ones, think about landmark numbers	If we add we have to pay back, 24 is close to 25, the 7 and 4 equals 11	Real objects, pop sticks and base ten blocks, make the numbers, record to show their understanding	offer paper and <u>textas</u> , show thinking, create more opportunities for further challenge	Using larger numbers to add, model addition of two-digit numbers in a variety of ways, ask students to share their thinking, use of what if questions
	2	Let's see if anyone can work out which numbers won't work. What do you already know about the answer, look at the answer - what value is the digit in the tens place, Can you look at the two digits in the ones place- can you work out the total of 7 and 4 ... Listen to student conversations...	It can't be 9. It can't be zero. 7 and 4 will be 11 so 1, choose 1! 47 will be too much so maybe 37, choose 3, choose 3!!	What do we already know? What won't work? Could it be? How many tens do we need? How many ones do we have- what should we do with 11 ones?	I would need to revise, evaluate understanding. Begin to extend to three digits operations, using what is already known- start without trading and then move to more tricky numbers. Include subtraction equations. Also extend to more than one addend on each side of the equation. Encourage students to design their own game boards and play with a partner or small group.	Using numbers that we have already worked with in the game- pose a mathematical problem and ask the students to go back to their work areas, draw pictures, show their thinking, use some symbols to show your understanding. Gallery walk. Share. Offer games and inquiry materials to consolidate skills- place value games...
Interpretation		<i>Clear purpose with prior thought about pausing at this point. Questions show understanding of what the teacher is looking for use of words "what we already know" links to prior knowledge. Specifically mentions teacher's role to listen.</i>	<i>Can and can't be language for process of elimination</i>	<i>changed wording to questioning</i>	<i>more descriptive plan for how to modify task with mention of how to create an entry point for students and then ensuring there is extension</i>	<i>Mention of gallery walk shows increase in PCK and also linking to importance of representations, visually through pictures, symbols etc</i>

IL metro	1	Thinking time, allowing the students to reason and problem solve and communicate their thoughts.	It can't be 0 8, 9 for the first missing digit.	Are there any numbers we can eliminate? that wouldn't fit?	Three digits or change it to a subtraction.	Allow the students to participate in this activity in small groups...mixed abilities creating their own problems.
	2	To identify how students are going to utilise the Information they have to solve the problem. Students are given an opportunity to reason and explain their thinking to a peer. Teacher can eavesdrop on these discussions and gather information on student understanding.	They would hopefully eliminate 0, 9 and 8 quickly. This would leave them with 1, 3 and 5. Using the information of adding 7 and 4 should allow them to place the 1 accurately.	We could strategically place the remaining numbers in the blank spaces and problem solve from there.	Change the operation, extend to adding two 3-digit numbers, use decimals.	Allow time for those students to engage with the activity independently in small groups to enable time for targeted teaching with a small group who showed little evidence of understanding. Beyond this, provide opportunities for the successful students to be challenged in other problem solving extending their knowledge of place value, addition and number sense.
Interpretation		<i>Talks about the role of the teacher in listening, 'eavesdropping' on students' conversations.</i>	<i>Understands the need for students to use information they have/ know already. This indicates growth in MCK and how mathematical concepts connect.</i>		<i>change operation</i>	<i>Still talks about grouping of students and provision of time but extends knowledge of 'what to do next' to include targeted teaching, this is evidence of PL on PCK for this teacher having an impact.</i>

IL rural/ remote	1	We are looking for students to be looking to use addition/subtraction strategies to solve two-digit problems, using place value with missing addends so we want to be specific with students and not have them just guess.	I want to put <u>four</u> but it is crossed out? Some would just wildly guess.	To use what we know - the 24 and look at the place of the 6 and what that means.	2 <u>digit</u> to 3 digit, having a zero in a place	I don't know (yet)
	2	I want to ensure students are thinking mathematically and can reason why a digit may work, rather than just guessing. It also gives me a chance to see what strategies students employ (allows to eavesdrop and compare to the artefact recorded in journals) to see where I might take the teaching/experiences next.	I could take away the twenty. I could add the ones together to help me (7+4) I know that last digit will be one.	What do you know? What are you finding tricky? What could we use to help us? What wouldn't make sense?	Giving them less strikes! Possibly having three-digit numbers.	My learning intention was based around reasoning but I also want to ensure what they are recording matches their reasoning so would look to develop activities that allow students to investigate a problem and record their thinking. Would be looking towards all the working mathematically proficiencies.
Interpretation		<i>More specific focus on reasoning and working mathematically, not just content areas. Mentions use of journals and listening for the role of the teacher to gain insight into what strategies students are using. Sees lesson as part of a bigger whole sequence.</i>		<i>Questioning structure to this section. Change to the way the teacher will talk to the student, moving from telling and statements to questions that would guide students to that understanding.</i>		<i>Linking reasoning to recording - this is essential to be able to see what students are thinking. Working mathematically centre and focus of teaching.</i>

IL metro	1	we are learning to use multiply strategies to find the answer to a question	adding 2 amounts, subtracting one amount from answer	go through the numbers that are left and substitute to see what suits	take the addition out	to create their own problems
	2	As Mathematician we are learning to add 2 digit numbers using known facts to support us. Allowing students to use strategies that they currently know but not necessarily using out of content, doubles, known facts of addition, multiplication	I know: there will be 2 digit numbers to add to the total, 20 plus a number under 40 will add up to 60, so i can eliminate numbers above 5, i know 7 and 4 add up to 11	What do your already know, what can you eliminate, have you trialled different numbers that are given	create this number problem with resources, show me the place values of these numbers - hundreds, tens, ones, can you create your own problems to share with class, write up and draw the procedure you used to solve the problem	create the problem visually with writing and with resources to explain your process and thinking
Interpretation		<i>Growth in understanding purpose of lessons from use of strategies to more specifically how those strategies help. Gives reasons to use a variety of strategies when students know how it's helping them. Seeing this as an opportunity to try new strategies in an unfamiliar context.</i>	<i>Focus on 'knowing' using known information. Teacher will be looking for students to use what they know not just the immediate strategy at hand.</i>	<i>Moving from stating what they want the students to do, to phrasing these as questions to ask.</i>	<i>use of questioning to assist students</i>	<i>Focus on need to have students represent their knowledge in writing and visually when explaining.</i>

P rural/ remote	1	To have the students develop some alternate strategies and look at the possibilities, talking with a partner to help understand other ways to work out questions.	They may just try all the numbers to see what works, or use number knowledge and patterns to work out the answer, they might write the question down and look at a variety of answers until they find the one that works.	What could work in this situation, what could we use to help find the answer. Think about how addition works.	3 digit numbers	More examples of this type of questioning.
	2	To allow the students time to discuss with other students the strategies needed to solve the problem, noticing any students who have not got any strategies to draw upon and use this information to inform the where to next	What number works, It can't be a 4 because that goes over 10,	Think about each part of the question, what do we know, how did we get to that, what parts help us work out the rest of the question.	Increase to 3-digit number, change the operation	Extend with higher numbers.
Interpretation		<i>more discussion time by students encouraged. Teacher noticing of student strategies to inform instruction</i>	<i>moved from trial and error type strategies to trial what it 'can be' and 'can't be'.</i>	<i>Similar line of questioning in both cases. Greater focus on breaking down the problem into chunks at Time 2.</i>	<i>Similar suggestions both times.</i>	<i>similar responses.</i>