Literacy and Numeracy Interventions in the Early Years of Schooling: A Literature Review

REPORT

to the

Ministerial Advisory Group on Literacy and Numeracy

Australian Council for Educational Research
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Among the team Marion Meiers had the lead responsibility for reviewing literacy interventions, Kate Reid numeracy interventions and Phil McKenzie costs studies.

The views expressed are ours as is responsibility for any errors and omissions.

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ACER
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Abbreviations and Acronyms

ACARA	Australian Curriculum, Assessment and Reporting Authority
ACER	Australian Council for Educational Research
ACU	Australian Catholic University
AEI	Australian Education Index
AM	Accelerated Math
BASICS	Building Accuracy and Speed in Core Skills
BEI	British Education Index
CASS	Cognitive Aptitude Assessment System
CEO	Catholic Education Office
CM	Corrective Math
CMIT	Count Me In Too
CMITI	Count Me in Too Indigenous
CPV	Conceptual Place Value
DEEWR	Department of Education Employment and Workplace Relations
EAD	English as an Additional Dialect
EAL	English as an Additional Language
EMU	Extending Mathematical Understanding Intervention
ENRP	Early Numeracy Research Project
ERC	Education Resource Complete
ERIC	Education Resource Information Center
ESL	English as a Second Language
FASTT	Fluency and Automaticity through Systematic Teaching with Technology
GiR–LNS	Getting it Right - Literacy and Numeracy Strategy
GRIN	Getting Ready in Numeracy
IEW	Indigenous Education Workers
LFIN	Learning Framework in Number
LIEN	Learning in Early Numeracy
LLANS	Longitudinal Literacy and Numeracy Study
LLB	Literacy Learning Blueprint
MAGLN	Ministerial Advisory Group on Literacy and Numeracy
MERGA	Mathematics Education Research Group of Australia
NAPLAN	National Assessment Program - Literacy and Numeracy
NIP	Numeracy Intervention Project
NIRP	Numeracy Intervention Research Project
NPLN	National Partnership on Literacy and Numeracy
NSW DEC	New South Wales Department of Education and Communities
PALL	Principals as Literacy Leaders
PATMaths	Progressive Achievement Test in Mathematics
RR	Reading Recovery
RtI	Response to Intervention
SEAL	Stages of Early Arithmetical Learning
SENA	Schedule of Early Number Assessment
SES	Socio-economic status
SINE	Success in Numeracy Education

SME	Success in Mathematics Education
TEMA	Test of Early Mathematical Ability
TEN	Targeted Early Numeracy
TOWN	Taking Off With Numeracy
WARP	Wheldall Assessment and Reading Passages
WWC	What Works Clearinghouse

Terminology

In most cases in this review we have used the term Aboriginal and Torres Strait Islander to refer to the two broad cultural groups of people who are the original inhabitants of mainland Australia, Tasmania and some islands adjacent to Australia. We acknowledge the variation in nations, language and culture within these two broad groups. In some cases, different programs and research reports described in this review have used the terms 'Indigenous' or 'Aboriginal' to describe the cultural groups represented by Aboriginal and Torres Strait Islander people. Where this is the case, we have in most instances preserved the wording used in the original reporting.

EXECUTIVE SUMMARY

1. Purpose and Approach to the Review

This review has analysed the research evidence for the efficacy and effectiveness of a range of literacy and numeracy interventions in the early years of schooling, that is Kindergarten to Year 3. The term 'literacy and numeracy interventions' broadly referred to programs, strategies or initiatives currently implemented (or which could be implemented) by schools, education sectors and systems in order to improve student outcomes in literacy and numeracy. To supplement the analysis of evidence on specific interventions, the review has also examined the evidence for general principles in the design and delivery of effective literacy and numeracy interventions in the early years of schooling.

Most of the interventions reviewed originated in Australia and the majority have been implemented, at least to some extent, in NSW schools. A small number of internationally developed interventions were included in the review either because the intervention was widely implemented in Australia (e.g. *Reading Recovery*), or because the example extended the limited base of research on Australian interventions (e.g. *Numeracy Recovery*).

Each of the interventions reviewed was classified according to the tiered structure of a *Response to Intervention* (RtI) framework. All of the interventions reviewed were categorised as either Tier 1 (quality literacy or numeracy instruction for all students with regular progress monitoring) or Tier 2 (small group or individual instruction for students identified as being at risk of not achieving expected literacy or numeracy levels). None of the literacy or numeracy interventions considered in the review were designed specifically as Tier 3 interventions (intensive work over an extended period with students at high risk). A small number of the interventions adopted an individualised approach to instruction; however, these interventions were designed as Tier 2 interventions for students identified as having low performance in the classroom environment.

In practice, relatively few of the interventions reviewed had a focus on specific groups such as learners of English as a Second Language (ESL) or Aboriginal and Torres Strait Islander students.

A set of criteria was developed for the literature review that guided the evaluation of the quality and outcomes of included research. These criteria drew on significant commonalities between the protocols of the *What Works Clearinghouse* (WWC) for beginning reading and elementary mathematics interventions, Ritchie, Chudler and Della Sala's (2012) protocol for assessing research evidence, and the Standards of Evidence used to determine the inclusion of literacy and numeracy strategies and research on the *Teach, Learn and Share* national database. The criteria provided a basis for judging

whether specific evidence should be subjected to detailed analysis and for assessing whether the evidence reviewed provided high-quality information on efficacy.

The review considered a wide range of academic literature (including peer-reviewed journal articles, conference reports, meta-analyses and research syntheses), program evaluations, and policy documents, as well as evidence provided by NSW education sectors on currently implemented interventions. Where the amount of research evidence related to a specific intervention was small, the review considered most or all available evidence. With other interventions, the research base was extensive and in these cases the review considered a selection of the most relevant evidence.

Efficacy was considered in relation to the impact of interventions on both short and long-term improvement in students' literacy and numeracy learning. *Effectiveness* was considered in terms of the relationship between the measurable inputs (total resource investment in implementing the intervention) and outputs (long and short term). Almost all of the research identified for the review focused on the efficacy dimension. There were only a few studies that explicitly addressed resourcing questions, especially in cost-effectiveness terms.

2. Conclusions about Specific Interventions

In general, independent, valid and reliable evidence for the efficacy and effectiveness of specific literacy and numeracy interventions currently implemented (or which could be implemented) in the early years is relatively scarce, particularly for interventions focused on numeracy.

Many of the interventions have received strong support from education authorities, schools and teachers, and such endorsements are clearly an important consideration. It should also be noted that a lack of evidence that meets specified criteria does not necessarily mean that an intervention is ineffective.

Based on the criteria used for the review, among the ***literacy interventions*** reviewed there is no research evidence or very limited evidence available for the efficacy of: *Accelerated Literacy*; *Best Start*; *First Steps*; *Language, Learning and Literacy; Literacy on Track, Literacy Lessons*; *Focus on Reading*, *Off to a Good Start: Learning to Read K–2 (OTAGS); Principals as Literacy Leaders (PALL)*; *Reading Matters; or Reading to Learn*.

Some evidence is available for the positive impact of: *Successful Language Learners; MiniLit; and QuickSmart Literacy.*

Only in a small number of cases is there a reasonably strong base of research evidence which assesses the efficacy of literacy interventions*; Reading Recovery*; and *MultiLit.*

Most of the literacy interventions with at least some research evidence of efficacy are Tier 2 interventions. The Tier 2 interventions focus on small group or individual instruction for students at risk of not achieving expected literacy or numeracy levels.

In general, it is not possible to draw conclusions about the *effectiveness* of the interventions reviewed because little detailed information is available on resource use and costs, and there are almost no systematic cost-effectiveness studies available. The limited cost-effectiveness studies that are available on literacy interventions in the early years of schooling underline the importance of the time frame used in evaluating effectiveness. The longer the time frame that can be used when evaluating early interventions, the greater the scope to consider potential cost savings in other aspects of schooling (e.g. less placement in special education and less grade repetition); such savings need to be taken into account for a thorough assessment.

Based on the criteria used for the review, among the ***numeracy interventions*** reviewed there is no research evidence or very limited evidence available for the efficacy of: *Getting Ready in Numeracy (GRIN)*; *First Steps*; *Learning in Early Numeracy* (*LIEN)*; *Mathematics in Indigenous Contexts; Numeracy Intervention Research Project (NIRP); Numeracy Matters*; *Mathematics Intervention*; *Train a Maths Tutor*; *Count Me in Too Indigenous* (*CMITI)*; *Success in Numeracy Education* (*SINE)*; *Targeted Early Numeracy* (*TEN)*; *Mathematics Recovery*; *Numeracy Intervention Project* (*NIP)*; *Taking Off With Numeracy* (*TOWN); Building Blocks*; *Everyday Maths*; or *Numeracy Recovery*.

Some reliable evidence is available for the positive impact of: *Count Me In Too (CMIT)*; *Extending Mathematical Understanding (EMU)*; *Number Rockets*; and *QuickSmart Numeracy*.

Most of the numeracy interventions with at least some research evidence of efficacy are Tier 2 interventions (with the exception of the Tier 1 intervention *CMIT)*.

It is not possible to draw conclusions about the *effectiveness* of the numeracy interventions because for most, there were no systematic cost-effectiveness studies available.

Although the review has concluded that there is a lack of strong evidence on the efficacy and effectiveness of a number of interventions, there is evidence that many of these interventions incorporate evidence-based general principles of effective intervention derived from research in early literacy and numeracy. A number of the interventions embed principles derived from the wider research literature, although the effectiveness of specific components of these interventions is often assumed, rather than subject to independent monitoring and evaluation.

3. Conclusions about General Principles Underpinning Effective Interventions in Literacy and Numeracy in the Early Years of Schooling

The review drew out a number of principles that are particularly relevant to designing and implementing effective literacy interventions and numeracy interventions respectively. For literacy interventions these principles include:

- Planning a sufficient duration for the intervention, including the amount of instructional time devoted to the intervention
- Inclusion of an array of activities involving reading and rereading of continuous texts, together with some word study
- Embedding phonological skills for reading within a broad approach
- The inclusion of a systematic focus on writing
- Use of interesting and engaging texts
- Planned assessments and ongoing monitoring of student achievement
- Extensive and ongoing professional learning for teachers.

For numeracy interventions these principles include:

- Effective instructional approaches in the teaching of mathematics
- Early intervention and number sense
- Professional learning for teaching mathematics
- Assessment approaches
- A conceptual framework for children's mathematical development.

In addition the review identified a number of principles that appear common to the design and implementation of effective interventions in both fields:

- Embedding interventions in a whole school approach to enhance learning
- Early diagnosis and intervention for literacy and numeracy difficulties
- Effective diagnostic assessment
- Individualised approach to intervention
- Incorporation of evidence-based principles of effective teaching in literacy and numeracy interventions
- Clarifying the focus of the intervention on key aspects of literacy and numeracy development

4. Recommendations for Strengthening Policy and Research on Interventions

Although a lack of research evidence does not necessarily mean a particular intervention is ineffective, education authorities and schools require solid evidence to inform their decision-making. It is important that education authorities take the lead and initiate steps to: improve the evidence base about literacy and numeracy interventions; tighten the criteria by which interventions are assessed as worthy of support (this includes at school as well as system level), and ensure that decision makers, particularly at school level, have the information they need.

Recommendation 1: ***Criteria for supporting an intervention***

Literacy and numeracy interventions should only be supported for implementation in schools when the interventions:

a. address the current syllabus requirements and learning objectives of the curriculum;
b. are based on independent and credible findings on their efficacy and effectiveness; and
c. include a full costing of the resources required by schools for implementation

Recommendation 2: ***Documenting the current use and impact of interventions***

a. Education authorities should document the literacy and numeracy interventions are currently being used in the early years of NSW schools in terms of: (i) the number of schools using the interventions concerned; (ii) the number, type and year level(s) of the students involved; and (iii) evidence on the efficacy and effectiveness, including costs of the interventions.
b. The mapping of interventions being used should be updated every 3 years.

Recommendation 3: ***School literacy and numeracy improvement plans***

a. Education authorities should require all schools to have a literacy and numeracy improvement plan. Such plans need to be developed and monitored on an ongoing basis and form part of schools' accountability requirements.
b. Education authorities need to ensure that they have the capacity and expertise to guide and support schools as they develop and implement their literacy and numeracy improvement plans.
c. Each school literacy and numeracy improvement plan should be externally reviewed every 3 years.

Recommendation 4: ***Evaluation plan for new or expanded interventions***

Education authorities should ensure that the introduction of any new literacy or numeracy intervention in the early years of schooling, or the expansion of an existing intervention, is accompanied by a research and evaluation plan to provide an independent assessment of the efficacy and effectiveness of the new or expanded intervention after 3 years. The research and evaluation process should commence before the intervention is introduced or expanded and include a dissemination strategy.

Recommendation 5: ***Consistent and comprehensive costing data***

Education authorities should ensure that resources and costs involved in implementing an intervention in schools are documented and reported in a comprehensive and consistent manner. The resource mapping and costing should:

a. identify the costs incurred at system and school levels;
b. itemise all the capital and recurrent personnel and other costs involved;
c. provide the present-value cost of the resources required by schools for implementation over the expected duration of the intervention; and
d. relate the costs to evidence on impact within a cost-effectiveness framework.

Recommendation 6: ***Strengthening the knowledge base***

Education authorities should strengthen the knowledge base about the efficiency and effectiveness of literacy and numeracy interventions by:

a. supporting research on how well interventions work for different groups of students, including Aboriginal and Torres Strait Islander students, students learning English as a second language, and students from low socioeconomic background communities; the factors that shape whether interventions are successfully implemented at school and classroom levels; and the resources involved;
b. supporting longitudinal and time series studies that follow students from school entry through their schooling so that a richer picture of their development over time, and the key factors involved, can be established;
c. linking students' performance data on NAPLAN assessments in Years 3, 5, 7 and 9 with other system and school data so as to obtain greater diagnostic and analytical value from information that is already collected;
d. producing regular updates every 3 years of the research on literacy and numeracy interventions, and the principles underpinning effective literacy and numeracy teaching in the early years, and disseminating the updates widely to teachers and schools; and
e. strengthening the capacity of school leaders and teachers in using evidence to improve practice in literacy and numeracy.

1. INTRODUCTION AND METHODOLOGY

The NSW Department of Education and Communities (DEC) commissioned the Australian Council for Educational Research (ACER) in August 2012 to conduct a literature review of the evidence regarding the efficacy and effectiveness of the range of literacy and numeracy interventions in use in the early years of schooling (Years K–3). The review was commissioned on behalf of the Ministerial Advisory Group on Literacy and Numeracy (MAGLN).

A significant aspect of the MAGLN's work involves the examination of evidence about literacy and numeracy teaching practices and interventions that are effective for children with varied learning needs.

The NSW Government's 10-year *NSW 2021 Plan*, sets out a number of targets aimed at improving education and learning outcomes for all students. Two of the targets are aimed at increasing the proportion of students in Years 3, 5, 7 and 9 above the national minimum national standard for reading and numeracy, and at increasing the proportion of students in the top two performance bands. To assist in achieving this, the NSW Government is implementing the *Literacy and Numeracy Action Plan (Action Plan)*. The role of the MAGLN is to provide expert advice on early literacy and numeracy learning and to report on the performance of the Action Plan.

Initially, the MAGLN (see MAGLN, 2012) was responsible for developing an *Initial Framework* (Framework) to contribute to the development of the *Action Plan*. This Framework was subject to a structured consultation process. Evidence was sought from the three educations sectors, stakeholders and providers of literacy and numeracy intervention programs as to the range of literacy and numeracy interventions programs in use in schools, including information related to the durability of each interventions outcomes and its cost-effectiveness. The outcomes of this consultation (see Report on the outcomes of consultation: Literacy and Numeracy Action Plan – Initial Framework, MAGLN, 2012) provided MAGLN with the impetus for the commissioning of this literature review.

1.1 Purpose and Scope of the Literature Review

The overarching purpose of the review was to contribute to the evidence base on the efficacy and effectiveness of the range of interventions in literacy and numeracy teaching and learning, focusing on the early years of schooling by documenting the most current research and knowledge from Australia and internationally about the short and long-term impacts, of a range of literacy and numeracy interventions on student learning outcomes. Where possible the literature review was to refer to any cost-effectiveness analysis that had been undertaken with the view to identifying evidence-based models of effective practice in literacy and numeracy interventions. In turn the review was to provide an overview of the general principles of effective intervention in literacy and numeracy learning.

The target group was predominantly in Years K–3, taking the varied learning needs of children in these years into consideration. The terminology 'literacy and numeracy interventions' was used to cover programs, strategies or initiatives that could be implemented by schools, education sectors and systems in order to improve student outcomes in literacy and numeracy. The terms of reference included paying particular attention to the needs of low performing students, and groups, including learners of English as a Second Language (ESL) and Aboriginal and Torres Strait Islander students. Significant challenges exist in addressing issues of low achievement among particular groups of learners, in particular Aboriginal and Torres Strait Islander students (NSW Auditor-General, 2012). In practice, relatively few of the interventions examined in the current review had a focus on specific groups such as ESL learners or Aboriginal and Torres Strait Islander students.

The review identified, documented and critiqued current research evidence from Australia and internationally, about the short and long-term impacts of a range of interventions on student learning literacy and numeracy outcomes, and about the resource use and cost effectiveness of these interventions.

In addition to assessing the research evidence for the efficacy of specific literacy and numeracy interventions, the review has identified general principles in the delivery of high quality literacy and numeracy interventions in the early years of schooling. General principles are those elements of the design and delivery of literacy and numeracy intervention programs for which there is evidence that these facets impact upon student achievement.

1.2 Methodology

The general approach adopted for the conduct of the literature review was to gather, describe and evaluate appropriate and available evidence on the efficacy and effectiveness of literacy and numeracy interventions in the early years of schooling.

1.2.1 Initial searches of national and international indexes and databases

Three levels of search were used in the collecting of data appropriate to the research evidence required to conduct the literature review in each of the fields. These searches were conducted to identify research evidence focusing on the specific literacy and numeracy interventions described in sections 2.1 and 3.1, and to also identify a broader range of literature describing educational interventions and general principles in effective intervention. Although the description given here of the stages of the search is of necessity a sequential one, after the initial Cunningham Library search, the approach included further iterative searches which were undertaken contiguously.

Searches of the following education indexes and databases were undertaken by the Cunningham library at ACER: Australian Education Index (AEI); Education Resources Information Center (ERIC); Education Research Complete (ERC); British Education Index (BEI); PsycInfo; and Scopus.

To maximise the retrieval of relevant records from the databases, preference was given to using subject thesaurus terms rather than free-text terms. As an illustration of the terms and the structure of this initial level of the search, the search used in this case in the search of ERIC is given below.

- 'reading intervention' or 'educational intervention' or 'early intervention education' or 'response to intervention education' or ('literacy' or 'emergent literacy' or 'reading' or 'numeracy' or 'mathematical ability' or 'mathematics' or 'number') AND 'intervention'

  and
- 'Kindergarten' or 'early childhood education' or 'first grade or second grade or third grade' (etc)

  and
- 'program effectiveness' or 'achievement gains' or 'academic improvement' or 'academic achievement' or 'educational outcomes' or 'cost effectiveness'.

The initial database searches also included a focus on the broad range of target groups, including low-performing students, ESL learners, and Aboriginal and Torres Strait Islander students.

To ensure currency the database searches were initially limited to publications from the year 2000 onwards.

Initial searches of educational databases yielded more than 200 articles related to literacy interventions and over 70 related to numeracy interventions.

1.2.2 Further literature searches

The database and index search also involved subsequent iterations. In recognition that much relevant research and associated literature is not located readily through formal searches of education databases, subsequent searches also focused on identifying relevant 'grey literature' for inclusion in the analysis. The Cunningham library and researchers supplemented the initial search by targeted retrieval of the following:

- Education database searches, using specific literacy and numeracy program titles as search terms, especially using the terms 'evaluation' and 'effectiveness'.
- Reports of evaluations of literacy and numeracy intervention programs.
- Studies prior to 2000 which were widely cited in the initial searches.
- Published research on literacy and numeracy intervention products.
- Meta-analyses, reviews or syntheses of intervention research that articulated general principles in the design of literacy and numeracy interventions.

1.2.3 Review of MAGLN materials

The MAGLN provided ACER with a range of evidence which included the following materials:

- Major international reports
- Commonwealth and State and Territory government reports

- Program and intervention descriptions
- Research overviews
- Evaluation studies of interventions.

Two types of evidence were provided by the MAGLN. The first of these were reports, policy documents, evaluations and research articles providing information on literacy and numeracy interventions, approaches to literacy and numeracy teaching and the development of literacy and mathematical thinking in the early years of school.

The second type was evidence about the range of interventions currently being implemented or which could be implemented in NSW schools. This range of evidence had been collected from the three education sectors in NSW, from stakeholders and from providers of a range of literacy and numeracy intervention products.

These sources of additional evidence were diverse and largely descriptive. The material generally did not provide compelling evidence regarding the efficacy and effectiveness of a specific intervention. The utility of this evidence as to specific interventions was assessed and, where relevant has been integrated into the broader literature review. The sector evidence on program efficacy and effectiveness was similarly reviewed, and, where relevant, was integrated in the program analyses. The identification of interventions and evidence is discussed further in Section 1.5.

1.3 Key Concepts

To conduct the review in ways that would lead to the achievement of the purposes outlined in Section 1.2, a number of definitional issues were considered. The following text reports the results of this consideration, and indicates the meanings attributed to these terms during this report. They are further expanded in the relevant chapters.

1.3.1 Defining literacy and numeracy

In this section, definitions of literacy and numeracy are highlighted to provide a foundation for the current review. In the context of the Australian Curriculum currently being developed by the Australian Curriculum and Assessment Authority (ACARA) for implementation in Australian schools from 2013, it was determined that the ACARA definitions would be the most relevant and appropriate definitions on which to base the review. In doing this, it was noted that NSW Board of Studies syllabuses for English and Mathematics K–10, incorporating Australian curriculum content are due for full implementation in 2015 (New South Wales Board of Studies, 2012). It was also noted that the Government and Catholic sectors in NSW have varied policy statements and guidelines for the teaching and learning of literacy and numeracy.

The definitions of literacy and numeracy, as presented in the ACARA *Australian Curriculum: General Capabilities* have been adopted for this review. This enables the literacy and numeracy interventions programs to be linked to learning in all curriculum areas.

A broad concept of literacy is reflected in the definition of the general literacy capability used by ACARA. This definition describes the nature of the development of literacy, and the aspects of literacy that are required for successful learning in all learning areas.

> *In the Australian Curriculum, students become literate as they develop the knowledge, skills and dispositions to interpret and use language confidently for learning and communicating in and out of school and for participating effectively in society. Literacy involves students in listening to, reading, viewing, speaking, writing and creating oral, print, visual and digital texts, and using and modifying language for different purposes in a range of contexts.....Success in any learning area depends on being able to use the significant, identifiable and distinctive literacy that is important for learning and representative of the content of that learning area....Literacy encompasses the knowledge and skills students need to access, understand, analyse and evaluate information, make meaning, express thoughts and emotions, present ideas and opinions, interact with others and participate in activities at school and in their lives beyond school.*[1]

This definition reflects the complexity of literacy in the school curriculum, and the ways in which, from school entry, students develop literacy skills through all learning areas. It highlights the interconnectedness in literacy learning of the receptive language modes of listening, viewing, reading, and the expressive modes of speaking, writing and creating.

A further complexity relates to the centrality of literacy in a schooling system where the language of instruction is predominantly English. The large proportion of students in Australian schools who are learners of English as an additional language has clear implications for literacy learning and development. The educational and cultural contexts in which students learn to be literate must be considered in planning for effective teaching and learning.

Defining numeracy is complex because of the range of skills underpinning effective numeracy and because the term numeracy is often used interchangeably with several related terms (e.g. mathematical skills, quantitative literacy, and mathematical literacy). A limited characterisation is common in popular definitions, with numeracy often equated to a basic facility with mathematical concepts and calculation. In contrast, definitions of numeracy favoured in education emphasise the wide range of numeracy skills that children must acquire to problem solve across different contexts (Milton, 2000). In the context of a broader definition of numeracy, Steen (2001) emphasises that effective numeracy is interdisciplinary, involves a capacity to apply mathematical thinking across curriculum areas and to meet the need for quantitative thinking in everyday life.

[1] http://www.australiancurriculum.edu.au/GeneralCapabilities/General%20capabilities.pdf

The ACARA definition of numeracy embodies the broader definition of numeracy favoured in current thinking and describes the acquisition of numeracy as a process of developing:

> *…the knowledge and skills to use mathematics confidently across all learning areas at school and in their lives more broadly. Numeracy involves students in recognising and understanding the role of mathematics in the world and having the dispositions and capacities to use mathematical knowledge and skills purposefully.*[2]

In the context of the focus of this review on the early years, it is necessary to consider what mathematical understanding children of this age must successfully grasp in order to progress through school. In this way, the definition captures what is most often the focus of intervention for children in the early years. To succeed at mathematics in the early years, children must integrate their early informal understanding of mathematics (often referred to as number sense) with formal mathematics. Developing number sense, or a failure to develop number sense, is thus seen as critical to children's ability to successfully progress in mathematics. Gersten and Chard (1999, pp. 19–20) propose that number sense:

> *…refers to a child's fluidity and flexibility with numbers, the sense of what numbers mean and an ability to perform mental mathematics and to look at the world and make comparisons.*

The early years numeracy interventions reviewed generally focus on developing aspects of students' number sense. It should be recognised though that definitions of number sense vary somewhat and it is important to understand the conceptualisations that underpin different interventions. A wide range of skills have been suggested as central to a child's number sense. These skills include counting and the use of counting to solve simple problems, number identification and reasoning about the relationships between numbers and the results of simple transformations. The importance of these early skills to later mathematical development is often asserted in the literature, and as such further consideration of the concept of number sense is warranted in assessing evidence for the efficacy of numeracy intervention programs.

1.3.2 Efficacy and effectiveness

Efficacy was considered directly in relation to the impact of interventions on both short and long-term improvement in students' literacy and numeracy learning and achievement. Key considerations in this review have been the availability of evidence of improvements in student achievement, and of the durability of the improvement. The focus on the impact of the interventions on student achievement meant that evidence of possible impact on other outcomes, such as changes in student engagement, attendance, and well-being were not considered.

Most evaluations of educational interventions focus on the efficacy or impact of the intervention concerned. While that is clearly important, such studies provide only part of the picture that decision makers need when deciding how to best use limited

[2] http://www.australiancurriculum.edu.au/GeneralCapabilities/Numeracy/Introduction/Introduction

time and budgets. *Effectiveness* concerns the relationship between measurable inputs (total resource investment in the intervention) and outputs (long and short term). Denton et al. (2010) refer to studies of effectiveness that are conducted to demonstrate that the intervention can produce similarly strong effects when implemented in field settings where resources, teacher qualification, and the quality and intensity of implementation will vary.

Cost-effectiveness analysis is an evaluation tool that can assist educators to make choices between competing alternatives or courses of action with budgets, time or other resources in mind (Levin & McEwan, 2001). Cost-effectiveness analysis provides a means of bringing together data on an intervention's use of resources and costs with measures of the intervention's impact.[3]

There is considerable evidence from longitudinal studies of the long-run economic and social benefits from improving students' foundation skills in literacy and numeracy. Students who struggle with literacy and numeracy have lower educational aspirations, and are more likely to leave school early (McMillan & Marks, 2003). Early school leavers are more likely to be become unemployed, experience more frequent and longer bouts of unemployment, have lower earnings, and over the life-course accumulate less wealth (Marks, Headey, & Wooden, 2005; McCaul, Donaldson, Coladarci, & Davis, 1992; Rumberger & Lamb, 2003). In addition, there are increased societal costs in the provision of unemployment and other welfare benefits, costs associated with generally poorer health outcomes, the criminal justice system and reduced taxation revenue (Access Economics, 2005; Business Council of Australia, 2003; Rumberger, 1987). Longitudinal research from the United States and the United Kingdom that followed participants in early intervention programs through until their late 30s indicates very substantial returns to society on the initial investment (Schweinhart et al., 2005; Heckman & Masterov, 2007; Every Child a Chance Trust, 2009).

What is not so clear from the research is the relative cost-effectiveness of different types of early intervention. Simon (2011) drew on Levin and McEwan (2001) to set out the elements and steps in conducting a rigorous cost-effectiveness study (Table 1.1). Such studies involve four main elements: planning; analysing effectiveness; analysing resources and costs; and describing the results. Few of the evaluation studies reviewed in this report follow all of the steps outlined in Table 1.1.

To help inform the discussion of effectiveness, the resources required by schools for implementation for the various literacy and numeracy interventions are included in the discussions in Chapters 2 and 3 respectively. The resources information in Chapters 2 and 3 focuses on the resources required by schools to *implement* the intervention concerned rather than the resources needed to *develop* it in the first place. In most instances, little information is available about developmental costs, although for a number of interventions they are likely to have been substantial and incurred over a considerable period. A further consideration for the focus on implementation is that, in terms of choosing among the available alternatives, the development costs are not

[3] *Cost-benefit analysis* is a particular form of cost-effectiveness analysis used when it is possible to express outcomes in monetary terms. This approach enables a comparison among projects with very different goals as both costs and benefits are expressed on the same scale (Hummel-Rossi & Ashdown, 2002).

directly relevant except to the extent that they may be reflected in licensing fees or other terms of use. Of course, if an education authority or other organisation was considering developing a new form of intervention or substantially modifying an existing intervention, the development costs would be a critical part of assessing that project's likely cost-effectiveness.

Table 1.1: Steps in conducting cost-effectiveness analyses

Element	Step	Description
Planning	Identify the educational problem	What is the question to be addressed? What are the probable causes of the problem? Who will use the results of the research?
	Identify alternative interventions that are supposed to affect the same educational outcome	The alternatives should respond to the identified problem. Some alternatives will be less politically acceptable, even if they are educationally superior.
Analysing effectiveness	Identify a method of obtaining appropriate effect sizes for each of the alternatives	Costs must be linked to effect sizes to create an understanding of how best to use resources to improve student outcomes given budget constraints.
	Identify effect sizes to be used as effectiveness measures	Analysts may use one effectiveness measure from each program, presumably using results from high quality studies. They may also wish to combine results from a number of high-quality studies using statistical techniques (meta-analysis or multilevel modelling) to provide a composite effect size.
Analysing resources and costs	Use program documents, publications, interviews and observations to identify all of the resources used to implement each intervention	The ingredients include all of the resources that are used within five categories: personnel, facilities, equipment/materials, client inputs, and other inputs such as transportation or fees. The list of ingredients should be as thorough as possible to help decision makers consider the possibility of replicability.
	Assign costs to each of the interventions	When all of the ingredients are accounted for, their cost values are determined. There are a variety of ways to estimate these costs. In the case where ingredients are purchased in competitive marketplaces, the costs are readily obtainable through the prices paid. Other approaches are often used to estimate the value of facilities and equipment. In general, the technique for measuring costs is to ascertain their annual value. Because facilities and equipment have a life that is greater than one year, the annual value is derived through determining annual depreciation and interest costs. These ingredients' costs are summed up to obtain total annual costs, and they are usually divided by the numbers of students to get an average cost per student that can be associated with the effectiveness of each intervention.
Describing the results	Combine cost and effectiveness measures	The ratio of cost per unit of effectiveness can then be compared across interventions by combining the effectiveness results with costs. The cost-effectiveness ratio is defined as effects divided by costs; a higher ratio signals a more cost effective program. Alternatives with the largest effectiveness relative to cost are usually given highest priority in decision-making, although other factors such as ease of implementation or political factors also need to be considered. Where assumptions have had to be employed in estimating cost and/r effectiveness, the effects of varying the assumptions can be tested through sensitivity analysis.

Source: derived from Simon (2011) and Levin and McEwan (2001).

1.3.3 Response to Intervention Models

Each of the New South Wales education sectors outlined a Response to Intervention (RtI) model as the framework for providing increasingly intensive support to students in their submissions to the MAGLN. This classification was incorporated in the analysis of the interventions included in the literature review.

Response to Intervention models are multi-tiered instructional frameworks used extensively in the United States to identify, remediate and monitor progress for children experiencing learning difficulties (Hughes & Dexter, 2011). Models of RtI and the manner in which they are implemented vary widely, and there is significant debate on the utility of different implementation models (Fuchs, Mock, Morgan, & Young, 2003).

A unifying feature of RtI models is the process of establishing a child's response to a scientific and research based Tier 1 curriculum (Christ, Burns, & Ysseldyke, 2005). This requirement of RtI models means that a child's lack of response in the context of Tier 1 instruction reflects a true need for higher intensity intervention, rather than the inappropriateness of the Tier 1 curriculum (Hughes & Dexter, 2011).

A three-tiered RtI model comprises:

Tier 1: Personalisation of learning in the classroom consistent with instruction aligned to syllabus outcomes.

Tier 2: Small group or individual intervention for students at some risk of not achieving expected levels in literacy or numeracy

Tier 3: Intensive work with students at high risk. Such interventions are longer term, individualised and sustained.

The first tier, which is universal, should provide quality instruction for all students differentiated to meet their needs, with regular, periodic screening and assessment to identify struggling learners who need additional support. The second tier targets students who are not making adequate progress. They are provided with increasingly tailored instruction matched to their needs on the basis of levels of performance and rates of progress.

In the third tier, students receive interventions which are intensive and usually individualised, typically involving referral to specialist services which may involve other professionals (e.g. speech therapists, or special education) for ongoing sustained work with children who are at high risk and have not responded to initial Tier 2 interventions. None of the literacy or numeracy interventions considered in the current review were designed specifically as Tier 3 interventions. A small number of the literacy and numeracy interventions considered in this review adopted an individualised approach to instruction (e.g. Reading Recovery, Mathematics Recovery); however, these interventions were designed as Tier 2 interventions for students identified as having low performance in the classroom environment.

In implementing a Tier 3 intervention for students who do not respond to a Tier 2 intervention, a number of different approaches may be taken depending on the needs of individual children and available resources. Schools may choose to implement a Tier 3 intervention by increasing the intensity or duration of existing Tier 2 interventions, or by moving the instructional format from small group to individual. Nonetheless, existing research tends to focus on the efficacy of short-term Tier 2 interventions for students deemed at risk in the classroom, rather than assessing their efficacy over the longer term for students who do not progress as expected in a Tier 2 intervention. Identifying an effect of Tier 3 interventions more generally is problematic due to the individualised nature of these interventions.

1.4 Identification of Interventions and Evidence

1.4.1 Scope of interventions in the review

The review concentrated on literacy and numeracy interventions identified as currently implemented (or which could be implemented) in NSW. Several programs identified in the MAGLN materials were not included in the review because they were not interventions but were rather funding programs (such as Language, Literacy and Numeracy Program; Literacy, Numeracy and Special Needs Program). The focus of the review is primarily literacy and numeracy intervention programs suitable for children in K–3. Some interventions outside of this range are included in the review; where this occurs the discussion includes a justification for its inclusion in terms of implications for the K–3 years.

Research evidence that focused on interventions for children with intellectual disabilities was not considered central to the review. Research focusing on the effectiveness of interventions designed exclusively for children beyond Year 3 or for children prior to school was not reviewed in detail, with the exception of selected studies supporting early intervention in numeracy. Selected studies from the United States focused on Kindergarten were included because these children are of a similar age to Australian children in their first year of school. Interventions designed to improve student achievement in literacy or numeracy that did not fall within the scope of the RtI framework (see for instance Van Voorhis, 2011 on the efficacy of an interactive homework process) were also not considered.

1.4.2 Assessing the strength and credibility of evidence

The literature review was guided by a set of criteria to evaluate the quality of the findings of each individual research report and study, and the sector material where relevant. The process required assessment of the credibility of diverse sources of evidence (e.g. academic research, conference papers, evaluation reports, policy documentation). To achieve such an assessment required a systematic process of analysing and critiquing the strength of the evidence for specific interventions and developing a judgement about what contribution individual reports made to the evidence base for specific interventions. Underlying the review process were some considerations related to the type of evidence assessed, as well as broader implications regarding factors related to student achievement and learning contexts. These considerations are outlined below.

1. Research on literacy and numeracy interventions uses a wide range of study designs that vary in their usefulness for establishing the efficacy of an intervention. Randomised controlled trials are often regarded as the pinnacle of a hierarchy of rigorous research designs, particularly in medical research (Concato, Shah, & Horwitz, 2000). These designs are expensive and are rare in educational research often because they are not appropriate or feasible in an educational context. Nonetheless, the limitations of this type of design for establishing causality in the context of educational interventions have been noted (Scriven, 2008) and studies comparing the effects of randomised controlled trials and other types of design suggest they are similar (Concato et al., 2000). To impose a further limit on the breadth of literature, the review did not consider research using case studies and interventions with very small samples (fewer than 10 students) because of limitations in generalisibility. To facilitate the review process, the review focused on identifying and including in the review a number of research syntheses and meta-analyses that have sought evidence for general principles in effective literacy and numeracy interventions.

2. The What Works Clearinghouse (WWC) review protocols for beginning reading interventions[4] and for elementary school mathematics interventions[5] as well as the protocols outlined by Ritchie, Chudler and Della Sala (2012) and the *Teach, Learn and Share* Standards of Evidence[6], informed the approach that was adopted. There were significant commonalities across the protocols which made it possible to derive a single set of criteria which was used. WWC reviews apply more stringent standards for inclusion than those adopted for this literature review. However, where a WWC review exists for a specific intervention (e.g. Everyday Mathematics), the results of this review are reported, rather than undertaking an independent review of the often substantial body of literature on which the WWC review is based.

3. Defining outcomes in terms of student achievement does simplify the complex relationship between 'inputs' and 'outputs'. Selected inputs that may be predictors of student achievement include the type of intervention, individual student characteristics such as self-efficacy and motivation; school characteristics such as the skill of the intervention teacher, and the quality of classroom teaching; and home characteristics such as additional support from parents. Similarly, improved student achievement is just one possible outcome of an intervention, but other impacts such as increased student confidence, engagement with literacy and mathematics and motivation to learn may occur in addition to, or even in the absence of, evidence of improved student achievement. This disjunction is noted because evidence for efficacy of an intervention on student achievement does not imply that a scaled up implementation of the intervention will produce similar outcomes. Difficulties achieving comparable success on a scaling up of successful small-scale

[4] The WWC review protocol for beginning reading interventions is available from http://ies.ed.gov/ncee/wwc/documentsum.aspx?sid=27#

[5] The WWC review protocol for elementary school mathematics interventions is available from http://ies.ed.gov/ncee/wwc/documentsum.aspx?sid=21

[6] The *Teach, Learn and Share* Standards of Evidence are available from http://www.teachlearnshare.gov.au/Static/StandardsOfEvidenceForPublicationFinal.pdf

initiatives occur frequently. The reasons for this are complex, but Elmore (1996) suggests, they relate to the degree to which educational innovations require large changes in the 'core' of teachers' educational practice.

4. The process of implementing and considering the possible impact of interventions should be undertaken in the context of two general propositions regarding learning. The first of these is that learning is influenced by the learning culture in which it occurs. If interventions are developed and implemented within schools and classrooms with strong learning cultures, where there exists an active recognition that learning is an individualised process requiring active support for staff and learners, then the approach to implementing a particular intervention may be different to the way the same intervention is implemented and received (by staff and learners) in another school. Differing school learning cultures may be a factor in the differences in the nature of the implemented interventions in literacy and numeracy which were identified in this literature review, despite attempts to have a uniform implementation. The second general proposition regarding learning, which should form part of the context when examining interventions, is that they should be implemented in such a way and by teachers who have deep understanding of how learning occurs within the field concerned. The expertise of teachers is difficult to measure, but its variability is an inevitable factor in effectiveness.

The criteria that were adopted from the review protocols were used to identify relevant research, and to provide guidelines for a critique of that research. These criteria were:

1. The specific interventions had been designed to improve children's literacy or numeracy learning and achievement.
2. The interventions were appropriate for children in Kindergarten through to Year 3.
3. The research report had been published in a peer-reviewed journal or judged by the reviewers as capable of being published in a peer-reviewed journal.
4. The research reports were based on an accessible and clearly articulated theory, supported by evidence from previous research.
5. The research provided evidence of the cost effectiveness of the intervention.
6. The research design was appropriate to the questions under consideration.
7. The sample in the study was appropriate in terms of size and representativeness (i.e. lack of bias) to warrant the conclusions drawn.
8. The research included reliable and valid measures of student achievement and other relevant constructs.
9. The research used systematically collected and analysed data to inform its conclusions.
10. The research applied data-analytic techniques appropriate to the research questions posed and clearly affording the conclusions drawn.
11. Evidence was provided of allowing for, and investigating, the possibility that factors other than the intervention might have produced the observed results.

12. The research included sufficient detail to enable replication of the intervention (e.g. it described skills targeted, the mode of delivery, and the duration of the intervention).

There was wide variation in the extent to which research included in the review met all of these criteria. In general, published peer-reviewed research meets higher standards against these criteria than other types of evidence (e.g. program evaluations, policy documentation), although wide variation in standards of evidence exists even within peer-reviewed research. These evidence sources have different purposes and varying scope for meeting these criteria. Generally, academic research meets a greater number of criteria because publication by peer-review is generally contingent on demonstrating the rigour of the research. Government reports and policies, and evidence syntheses bring together the results of research to establish directions in education policy. Program evaluations are intended to answer varied questions about the design and implementation of literacy and numeracy interventions. Often the approach of such program evaluations are limited due to the timing of the evaluation, resources allocated and methodologies adopted.

In some cases, the available research evidence for the efficacy of an intervention in the current review is drawn exclusively from research with less rigorous criteria. The discussion of each literacy and numeracy intervention assesses the strength of the available evidence, and identifies limitations in the research which moderate conclusions about intervention efficacy.

1.5 Structure of the Report of the Review

Evidence for the efficacy and effectiveness of literacy interventions and a discussion of general principles in the provision of literacy intervention are presented in Chapter 2, while Chapter 3 follows a similar structure for numeracy interventions. At the beginning of Chapters 2 and 3, tables summarise the classification of the interventions reviewed and their main features. These tables list the interventions alphabetically within Tiers and according to whether they are Australian or international in origin.

Within Chapters 2 and 3, each intervention is discussed in terms of the following four headings:

- *Program Description*
  This section outlines the origins and evolution of the intervention, and comments on the usual length of the intervention and any variations usually prescribed for implementation. The general purposes and goals are described, including any target groups of students. The description refers, where appropriate, to the professional learning associated with the intervention, the delivery methods generally employed, including the instructional and student assessment approaches, and the extent of implementation across different locations.

- *Research Evidence*
  This section discusses the studies that were identified for inclusion, their design, methods of analysis, and key findings. Where they are available, published syntheses of research evidence on the intervention are included (e.g. WWC reviews).

- *Resources Required by Schools for Implementation*
  To provide a basis for comparing the relative resource requirements of the interventions, a table format based on the 'ingredients' approach of Levin and McEwan (2001) is used to classify whether, and to what extent, a particular intervention requires modification of a room, special equipment, specific teaching materials, teacher time in terms of professional learning and classroom delivery, payment of a licence fee and so on.

- *Evaluation of Evidence*
  This section provides an overall assessment of the availability and quality of research on the efficacy and effectiveness of the intervention concerned.

Following the detailed review of the interventions, Chapters 2 and 3 conclude with a discussion of general principles in the delivery of high quality literacy and numeracy interventions in the early years of schooling respectively.

Chapter 4 presents the overall conclusions and develops some recommendations for strengthening policy and research on interventions in the early years of schooling.

2. LITERACY INTERVENTIONS IN THE EARLY YEARS OF SCHOOLING

This chapter outlines the key features of a range of literacy interventions currently implemented, or which could be implemented, in NSW schools, and assesses the available research evidence for the efficacy and effectiveness of the interventions. The focus is on the strength and rigour of the evidence for specific literacy interventions. Most of these interventions have been developed in Australia, although the review includes selected international interventions for which there was evidence of the efficacy of the intervention. The chapter concludes with a discussion of the evidence for general principles of effective literacy intervention in the early years of schooling.

2.1 Research Evidence for Selected Literacy Interventions

Table 2.1 lists the 16 programs reviewed according to whether the literacy intervention was Australian or international in origin and whether the intervention is best classified as Tier 1 or Tier 2 in the *RtI* framework.

Table 2.1: Overview of the literacy interventions reviewed

Australian Literacy Interventions	
Tier 1	**Origin**
Accelerated Literacy	ACT, Northern Territory
Best Start Literacy	New South Wales
First Steps Literacy	Western Australia
Focus on Reading 3–6	New South Wales
Language, Learning and Literacy (L3)	New South Wales
Literacy on Track	New South Wales
Off to a Good Start: Learning to Read K–2 (OTAGS)	New South Wales
Principals as Literacy Leaders (PALL)	Australia
Reading to Learn	New South Wales
Reading Matters	New South Wales, Victoria
Successful Language Learners	New South Wales
Tier 2	**Origin**
MINILIT	New South Wales
MULTILIT Reading Tutor Program	New South Wales
QuickSmart Literacy	New South Wales
International Literacy Interventions	
Tier 2	**Origin**
Literacy Lessons	New Zealand/US
Reading Recovery	New Zealand

Table 2.2 presents more detail on the literacy interventions reviewed. The target groups of students, and the year levels for which the interventions are designed, are provided. The literacy focus of each intervention is summarised, and the kinds and forms of student assessment used in the program are listed.

The descriptions and elements in Table 2.2 were drawn from publicly available research and reports. Most of the interventions listed in the table are designed for students in the early years of schooling, from K–3. Some interventions targeting older students, for example, *Focus on Reading 3–6* and *QuickSmart Literacy*, have been included because they include a focus on Year 3, or because the literacy teaching strategies and approaches they include have been used in the early years in some contexts. An explicit rationale for the inclusion of any literacy interventions beyond Years K–3 is included in the respective sections on the individual interventions later in the chapter.

Four aspects of each intervention are discussed in the section following Table 2.2: the key features of the program; a summary of available research evidence; the resources required by schools for implementation to implement the intervention in schools; and an overall evaluation of the evidence.

Overview of the Literacy Interventions

The literacy interventions discussed in this chapter encompass a range of approaches to supporting students' literacy development, and meeting the varied learning needs of all students.

These interventions have been developed in response to the recognition of the different literacy learning trajectories and wide distribution of achievement among students at all levels of schooling, including the early years. At school entry, students demonstrate a diversity of skills and knowledge, and have varied learning needs. Teachers' observations and monitoring of individual growth patterns in literacy in the early years enable them to diagnose difficulties and plan specific additional practice and experiences in specific aspects of literacy that are necessary for individual students to make progress.

The centrality of literacy to learning in all curriculum areas has been another strong influence in the development of literacy interventions. Without effective skills in reading, writing, listening and speaking, students experience difficulty in creating and responding to increasingly complex texts, and meeting the expanding literacy demands in the curriculum. It has long been recognised that early intervention is needed to address potential difficulties, and that this will require different levels of support and continued monitoring of literacy development.

The interventions featured in this literature review have been designed for the central purpose of providing appropriate literacy teaching and learning experiences for all students, and for students needing additional support. Successful interventions depend to a large extent on the knowledge and capacities of classroom teachers and of school leaders. In recognition of this, a recurring element in these interventions is the integration of programs of professional learning for teachers and school leaders with the intervention strategies and resources. For example, knowledge of how to teach comprehension strategies to students at different year levels is a common component of the interventions. Another element evident in a number of the interventions is professional learning to increase school leaders' knowledge of school-wide approaches to teaching literacy.

Literacy learning, from the early years of schooling, involves a number of critical aspects. These include alphabetic knowledge, letter sound relationships, phonics and phonemic awareness, concepts about print, fluency and accuracy in text reading, comprehension of texts for a wide range of purposes, writing for different purposes and audiences, oral language skills and, increasingly, the ability to create and respond to multi-modal texts. Some of these aspects are mastered early, while others continue to develop throughout the years of schooling. The interventions included in this review focus mostly on aspects related to aspects of reading, such as comprehension (for example, *Focus on Reading 3–6*), or on the integration of aspects of reading and writing (for example, *Accelerated Literacy*). The relative lack of interventions that encompass other aspects of literacy is an issue.

Assessment to monitor and track progress is a significant aspect of all the interventions reviewed. Initially, a student's learning needs will be diagnosed by teachers using observation and other forms of assessment, which might include continua on which development can be mapped, or tests selected from a range of standardised tests. In some cases, within this review it has been difficult to locate evidence of what diagnostic instruments are utilised initially to identify students for participation in interventions. Information about assessments used within interventions to monitor progress is recorded in Table 2.2.

As can be seen in Table 2.2, a range of assessments are used to monitor students' progress. Some of these have been designed specifically for the intervention, for example, the Observation Survey in *Reading Recovery* (Clay, 2002), the Individual Reading Level test in *Accelerated Literacy*, and the *Best Start Literacy Assessment* used at school entry in government schools. Observation schedules, mapping of progress on continua to produce individual learning profiles, results of tests of specific aspects of literacy - such as vocabulary - are important in tracking students' development as they participate in an intervention, and for developing individual learning plans. Pre- and post-tests at the commencement and conclusion of a student's engagement in an intervention are generally used to determine what growth has taken place, and to plan the next steps in learning. There are resources available within some of the interventions with the capacity to closely monitor students' progress in key aspects of literacy learning, such as literacy continua for the early years of schooling, or continua that map the typical development of literacy skills over time.

The analysis of assessment data is a key component of the evidence used in evaluations of the impact of a number of the interventions on participating students' literacy achievement. Frequent use is made of NAPLAN results, for example, but there are limitations in the specificity of these findings in relation to the particular focus of an intervention. NAPLAN data provide a broad indication of achievement within literacy and numeracy, but are not designed to provide a precise measure of the efficacy of specific interventions.

An aspect of assessment which was not evident in the interventions reviewed is the collection of longitudinal data. While students who have participated in a Tier 1 or Tier 2 intervention may have shown significant improvement while involved in the intervention, the collection of data relating to these students' patterns of development through their schooling would provide stronger evidence of the long-term impact of an intervention. The increasing use of a unique student identification number to be

used in digital records kept by schools and education systems, and strategies such as the development of digital portfolios of student work samples maintained over time, are likely to provide sources of longitudinal data that can be analysed in evaluations of long term impact. The availability of longitudinal data would be particularly useful for analyses of the cost-effectiveness of intervention programs.

Many of the interventions currently implemented in NSW schools show awareness of the importance of school-level interactions, such as regular communication with the class teacher about a student's progress when that student may be involved in a small group or individual Tier 2 intervention. The significant role of literacy leadership in schools is recognised specifically in the *Principals as Literacy Leaders* intervention, but is also evident to some extent in other interventions. Another aspect of school-level interactions can be seen in those interventions where all teachers at particular phases of schooling participate in professional learning programs, and work in professional learning teams within the schools to share and extend their professional knowledge and skills. For example, this is a feature of *Focus on Reading 3–6*, and *Language, Learning and Literacy*.

Literacy interventions have been implemented in NSW schools over many years, and the current provision of interventions has evolved over time. Research into literacy learning continually reveals new insights into improved teaching practices, and interventions are designed to incorporate research-based knowledge from Australian and international sources.

Some interventions have been in use for many years, such as *Reading Recovery*. This intervention was first introduced in Australia in Victoria in 1984 and commenced as a pilot program in NSW in 1991. *Literacy Lessons* has evolved from *Reading Recovery*, as knowledge has become available about how strategies from this intervention could be made available to a broader range of students, and the potential benefits of doing this. Other interventions, such as the *Principals as Literacy Leaders* initiative developed by the Australian Primary Principals' Association are more recent, and still in a formative stage as their potential value is being recognised.

Interventions are planned, designed and developed in many contexts, drawing on expertise in many areas. The knowledge and experience of university researchers and curriculum officers in all education sectors has contributed to the development of a number of interventions currently implemented in NSW. This work has been influential in the review and refinement of programs over time, in the provision of high quality professional learning programs to build teacher capacity in literacy teaching, and in the conduct of rigorous evaluations of the impact of interventions on improving students' literacy achievement. Funding that supports the development and implementation of interventions has come from a variety of sources, including large-scale initiatives such as the National Partnership on Literacy and Numeracy.

International and Australian research has provided insights into the principles and practices that underpin effective interventions and it is clear that the interventions currently implemented in NSW schools are based on these principles. The final section in this chapter outlines some principles of effective literacy intervention drawn from the wider literature.

Particular groups of students have particular needs, and many interventions are designed to accommodate the needs of groups such as Aboriginal and Torres Strait Island students and students from language backgrounds other than English.

In the context of this review of literacy interventions in NSW schools, the needs of learners of English as a second language (ESL) merit careful consideration. ESL learners include newly-arrived, non-English speaking background students, and all students who are learning English as an additional language, including Aboriginal and Torres Strait Islander students. The needs of these students are different from each other and also vary at their different stages of learning English, which means that the nature of the teaching approaches required is varied. All ESL learners require continuing support until they have developed levels of competence in English that enable them to fully access all aspects of the mainstream curriculum.

ESL support is provided for students in NSW, with the nature of such support varying according to the needs of students and the availability of funding. Such support enables schools to provide appropriate instruction, but they are not appropriately described as interventions. As a result, specific ESL programs (e.g. *NSWDEC ESL Targeted Support Program* and *NSWDEC ESL New Arrivals Program*) have not been included in the analysis of intervention programs.

Table 2.2: Classification of the major features of the literacy interventions reviewed

Australian Literacy Interventions					
Tier 1					
Literacy Intervention	**Origin**	**Target group**	**Year level**	**Intervention Focus**	**Kinds and forms of assessment**
Accelerated Literacy	ACT, Northern Territory	Low achieving students Aboriginal students	K–12	This intervention integrates a series of activities focused on age-appropriate selected texts. It is based on the premise that students need to learn the discourse of literacy lessons in school, and provides supportive teaching around these texts. Students engage in reading, close examination and manipulation of text, spelling, and writing. The program addresses reading, writing speaking, listening.	Individual Reading Level test. Individual Working Level test. Test of Reading Comprehension (ToRCH).
Best Start Literacy	New South Wales	All students	K–2	A range of resources, strategies and interventions support the teaching of critical aspects of literacy. Literacy assessment at school entry is used to identify the learning needs of all students. Student progress is monitored progress on the K–6 literacy continuum.	Best Start Literacy Assessment (school entry). *Literacy Continuum K–6*

Australian Literacy Interventions					
Tier 1					
Literacy Intervention	**Origin**	**Target group**	**Year level**	**Intervention Focus**	**Kinds and forms of assessment**
First Steps Literacy	Western Australia	All students	K–6	The focus of this intervention is on whole-school approaches to reading, writing viewing, speaking and listening. Maps of development for each mode enable teachers to monitor students' development at key phases. Resources link indicators of development in each mode to major teaching emphases and teaching and learning experiences.	The maps of development enable student learning in each mode to be mapped against key indicators at each level in strands: use of texts, contextual; understanding, conventions and processes and strategies. .
Focus on Reading 3–6	New South Wales	All students	3–6	A school-level intervention for teachers of Years 3–6, establishing the importance of a focus on reading at these year levels. All teachers in the school participate in ten professional learning workshops over three semesters, to build skills in teaching comprehension, vocabulary and text reading fluency. They undertake between-workshop tasks to translate new learning into classroom action.	Student learning is monitored against learning sequences for comprehension, learning, vocabulary knowledge and text reading fluency.

Australian Literacy Interventions					
Tier 1					
Literacy Intervention	**Origin**	**Target group**	**Year level**	**Intervention Focus**	**Kinds and forms of assessment**
Language, Learning and Literacy (L3)	New South Wales	Low achieving students, particularly from low SES communities.	K–2	Year level teams undertake extended professional learning (12 half days) across three terms designed to increase their knowledge of early reading and of effective instructional practices. They implement the small group intervention, focused on targeted instruction in reading and writing during regular literacy blocks, with the on-going support of a regional trainer.	Assessments of text reading, writing vocabulary and hearing and recording sounds in words conducted at five-week intervals.
Literacy on Track	New South Wales	All students	K–6	Professional learning program of six workshops and related school-based activities over a 12-month period for teachers, K–6, and school leaders to build school capacity in teaching reading, writing, talking and listening. Key areas include assessment of and for literacy learning; planning for literacy teaching; and balanced, integrated, explicit and systematic approaches to teaching literacy. Literacy leadership support is provided to participating K–6 school leaders.	Formative assessment strategies

Australian Literacy Interventions					
Tier 1					
Literacy Intervention	**Origin**	**Target group**	**Year level**	**Intervention Focus**	**Kinds and forms of assessment**
Off to a Good Start: Learning to Read K–2	New South Wales	Low SES schools with high proportions of students at risk of early reading difficulties	K–2	Participating teachers undertake professional learning to enhance their knowledge of foundation aspects of early reading development and targeted instructional strategies. They implement the intervention in classrooms with the support of mentors.	Criterion referenced assessments in skills targeted by the intervention (e.g. phonemic awareness, concepts about print), Independent Reading Level assessment.
Principals as Literacy Leaders (PALL)	Australia	Primary school principals	K–12	Principals undertake an action research project over two years, with mentoring support and five modules of professional development. Mentoring and coaching support principals' interaction with project tasks within their own school communities. Five professional development modules were developed.	Observational tools in the Literacy Practices Guide) used to support an evidence-based approach to literacy learning in schools.
QuickSmart Literacy	New South Wales	Middle years students, who have experienced literacy learning difficulties in the earlier years of school	5–7	Focuses on improving students' comprehension skills. Professional learning for teachers to develop understanding of comprehension, with a focus on automaticity in word recognition and fluency in reading connected texts. Teachers work with two students in a three-lesson cycle focused on an individual text.	ACER Progressive Achievement Test Cognitive Aptitude Assessment (CASS) System at beginning and end of program. Six tests on essential words and sentence understanding at different levels.

Australian Literacy Interventions					
Tier 1					
Literacy Intervention	**Origin**	**Target group**	**Year level**	**Intervention Focus**	**Kinds and forms of assessment**
Reading to Learn	New South Wales Victoria	All students Aboriginal students	Middle years	Eight day training workshops, with supported classroom practice and evaluation between workshops. Results in teachers preparing whole class for reading and comprehending curriculum texts, for guided and independent writing activities. Intensive support provided for students to manipulate language patterns in selected sentences, and to practise spelling, letter-sound correspondences and fluent writing.	Three levels of reading comprehension: literal, inferred and interpretative. Use of running records for miscue analysis. *Reading to Learn* writing assessment.
Reading Matters	New South Wales	All students	3–6	Online professional learning for individual teachers and leadership teams to increase understanding of reading development is part of a whole-school approach to improve the teaching of reading.	Not known

Australian Literacy Interventions					
Tier 1					
Literacy Intervention	**Origin**	**Target group**	**Year level**	**Intervention Focus**	**Kinds and forms of assessment**
Successful Language Learners pilot projects in low SES schools	New South Wales	Students learning English as a second language	K–12	Targeted support for students, professional learning for teachers, school leadership development, and provision of schools as centres for community activity.	Specially designed Assessment Bank tasks using previous *Basic Skills Test* items administered each term. Student profiles. ESL Scales used to assess the English language competence of all ESL students on four occasions during the two-year pilot.
Australian Literacy Interventions					
Tier 2					
Literacy Intervention	**Origin**	**Target group**	**Year level**	**Intervention Focus**	**Kinds and forms of assessment**
MINILIT	New South Wales	Bottom 25% of struggling Year 1 readers. Also appropriate for at risk Kindergarten students and struggling Year 2 students.	1	Teaching the basics of letter/sound knowledge and decoding skills for CVC words Extending word attack knowledge by teaching commonly used digraphs and longer words	Burt Word Reading Test South Australian Spelling Test Sutherland Phonological Awareness Test – Revised (SPAT-R) Peabody Picture Vocabulary Test – 1V The Wheldall Assessment of Reading Lists (WARL) The Martin and Pratt Nonword Reading Test

Australian Literacy Interventions					
Tier 2					
Literacy Intervention	**Origin**	**Target group**	**Year level**	**Intervention Focus**	**Kinds and forms of assessment**
MULTILIT Reading Tutor Program	New South Wales	Low achieving students Aboriginal students	2–10	Professional development program for teachers which leads to instruction for low-progress readers involving intensive, systematic and explicit instruction in three main areas: synthetic phonics (or word attack skills); sight words recognition; and reinforced reading (supported book reading).	Word attack placement test. Sight words placement test.
International Literacy interventions					
Tier 2					
Literacy Intervention	**Origin**	**Target group**	**Year level**	**Intervention Focus**	**Kinds and forms of assessment**
Literacy Lessons	New Zealand, USA	Lowest achieving students experiencing literacy difficulties	1–4	Daily one-to-one instruction for students in Years 1–4 identified as experiencing significant difficulties in literacy learning.	Observation Survey of Early Literacy (Clay, 2002, 2nd edition).
Reading Recovery	New Zealand	Lowest achieving students in Year 1	1	Diagnosis of individual students' reading needs, one-to-one instruction by trained Reading Recovery teachers in daily 30-minute lessons over a period of 12-20 weeks. Emphasis on the orchestration of skills within reading rather than development of separate skills.	Observation Survey of Early Literacy (Clay, 2002, 2nd edition).

Tier 1 Literacy Interventions

Accelerated Literacy

Program Description
The *Accelerated Literacy* teaching methodology is designed as a whole-class literacy intervention, implemented through a series of integrated activities focused on an age-appropriate reading text (Cowey, 2005). It has a particular focus on Aboriginal and Torres Strait Island students. The teaching sequence comprises five key elements: appropriate text selection, literate orientation including perspectives from authors' ideas to the use of specific language, transformations through deconstruction and reconstruction of the text, spelling through chunking, and writing together and independently (Gray, 2007). The program addresses all aspects of literacy: reading, writing, speaking and listening.

The teaching program is based on four main concepts: the notion of discourse as a primary goal for teaching; the importance of teaching in the zone of proximal development (Vygotsky, 1978); the staging of the teaching sequence around the two previous concepts; and the integration of scaffolding as the framework for teaching/learning processes (Cowey, 2005). The teaching methodology was developed as *Scaffolding Literacy* (Gray, 2007). As the *National Accelerated Literacy Program* the approach has been used in the Northern Territory to give Indigenous students access to literate discourse through intense engagement with age-appropriate texts (Gray, 2007). Initially the approach was known as 'scaffolding literacy' (Robinson et al., 2009) and the model was first used in Australia for Indigenous students in Alice Springs (Gray, 1998).

The focus on teaching discourse is intended to build students' understandings of the academic and literate discourses needed for educational success. Gray emphasises the need for teaching 'ways of thinking for operating successfully within literate discourses', and for teaching of knowledge about the vocabulary and grammatical resources of particular discourses (Gray, 2007). This explicit teaching of grammar in context draws from Halliday's work on systemic functional linguistics (Halliday, 1994).

The texts used as teaching material 'are always literate and close to age-appropriate for the students involved' (Cowey, 2005). The teaching sequence of the *National Accelerated Literacy Program* involves working with the same text over time. The teaching strategies are designed to teach students how to enjoy and interpret texts, particularly narrative texts, as well as how a literate person thinks and acts (Cowey, 2005).

Accelerated Literacy[7] has been implemented in several Australian states and territories, including New South Wales and South Australia. Professional learning for teachers implementing *Accelerated Learning* includes introductory training and support from consultants. Regular assessment is a feature of the program and there are two levels of the assessment of oral reading:

> *First students are assessed on reading texts they have not seen before to determine what they can read without support. This assessment determines their Individual Reading Level. Secondly they are assessed on a text that has been the focus of an*

[7] The program is currently referred to as *Accelerated Literacy* in some contexts, and the *National Accelerated Literacy Program* in other contexts.

> *Accelerated Literacy teaching sequence in the classroom: what they can read with the support of classroom teaching. This assessment determines their Independent Working Level (*Cowey, 2005, p. 8).

Writing assessment in *Accelerated Literacy* also uses two main resources: 'free writing' assesses a student's writing level on unsupported writing, and 'workshop writing' assesses a student's ability to apply writing techniques that have been taught as part of a teaching and learning cycle. Writing samples are collected over time and levelled using rubrics (Robinson et al., 2009).

Research Evidence

Several evaluation studies of *Accelerated Literacy* have been conducted in four Australian contexts between 2002 and 2012.

The first of these evaluations (Cresswell, Underwood, Withers, & Adams, 2002) used three main methods of investigation: school visits, telephone interviews and interviews at the University of Canberra. Schools involved were mostly from Western Australia, with an additional small number of schools from South Australia, Queensland and the Northern Territory. No student achievement data were collected for the evaluation, but data collected by schools and the program developers were examined and some evidence of change was reported (Cresswell et al., 2002).

An evaluation of the *National Accelerated Literacy Program* in the Northern Territory undertaken by the School for Social and Policy Research, Charles Darwin University, covered the period from the program's inception in 2004 to early 2008 (Robinson et al., 2009). Student outcomes in all participating schools were investigated systematically using two assessment measures: a purpose-designed observational test of reading accuracy and the *Test of Reading Comprehension (ToRCH)* (Mossenson et al., 2003). The major findings of the analyses of these data showed no general increase in student achievement.

An evaluation of the implementation of *Accelerated Literacy* was undertaken in 28 NSW National Partnership on Literacy and Numeracy schools where *Accelerated Literacy* was implemented as a whole-class intervention. This evaluation focused on reading, and drew on NAPLAN and assessment data gathered from tests designed for evaluation of the national partnerships that were based on previously designed NSW Basic Skills Tests. It was concluded that the analyses of these data from *Accelerated Literacy* schools showed minor benefits in reading score gains from Year 3 to Year 5 for both Aboriginal and non-Aboriginal students (Dione-Rodgers, 2012a). However, the evaluation report drew attention to the limitations of the data from the external performance measures due to variations in implementation patterns across schools and the problems of attribution because a number of schools had implemented other changes at the same time. However, there was stronger support for the effects of the intervention in teachers', parents' and students' impressions than in the test-based measures (Dione-Rodgers, 2012a).

Data on outcomes measured on TORCH (Mossenson et al, 2003) and NAPLAN for students in the *South Australian Accelerated Literacy Program* (SAALP) were analysed. TORCH data were used to generate growth measures from 2009 to 2010 and these were then compared with the differences in the TORCH national norms for the relevant Year levels (Literacy Secretariat, 2011). The national norms do not provide an ideal reference group for comparison because of the possibility of differences in other characteristics (such as age, type

of school and social background) from the SAALP group and because the norms were measured at a different time. For these reasons care should be exercised in interpreting the results. Except for Year 4, the SAALP students showed higher average growth scores on TORCH over 12 months than would have been inferred from differences in the relevant Year level norms. Mean growth scores for Year 3 to Year 4 for the SAALP students, over 2009 to 2010, were lower than those inferred for a national sample based on the differences in the published norms for Years 3 and 4. This suggests the possibility that *Accelerated Literacy* might be more effective beyond Year 4 than in the early years of school. Further investigation of this finding might provide insights into the relative effectiveness of *Accelerated Literacy* at different levels of schooling.

Resources Required by Schools for Implementation

Accelerated Literacy training package modules, class sets of recommended texts, transformation boards and strips, class sets of interactive whiteboards and activity resources are required for the implementation of this intervention. The practical classroom resources, including the whiteboards enable the display of enlarged copies of texts visible to all students, for use in text analysis. The production of the transformation strips allows text from books to be closely examined and manipulated. Funding is also required to support teachers' involvement in training sessions and programs of professional development, usually necessitating teacher replacement costs.

In summary, the resource requirements of implementing *Accelerated Literacy* are as follows:

Classroom modification	Not needed
Special equipment	Interactive whiteboards
Materials	Training package modules Class sets of recommended texts Transformation boards and strips Activity resources
Specialist teachers	Not needed
General classroom teachers	Attendance at introductory training sessions and other professional learning programs Teacher replacement during training
Other personnel inputs	Consultant support
Licence fee	Not applicable
Other inputs	Not specified

Evaluation of Evidence

Three of the four *Accelerated Literacy* evaluation studies cited provided limited evidence of gains for participating students, and one did not collect student achievement data for analysis. No cost-effectiveness studies were identified.

Both the Dione-Rogers (2012a) evaluation report and the South Australian study noted that there was little consistency in students' experience of *Accelerated Literacy* due to variations in patterns of implementation. The growth reported in the South Australian study *varied considerably from school to school, depending on implementation factors such as school leadership commitment, teacher turnover, and student transience* (Literacy Secretariat, 2011). The issues associated with the implementation variability, such as student transience and absence, indicate the difficulty of undertaking research in some contexts. Dione-Rogers (2012a) also notes the problems of attribution in a situation where there were several other interventions being made in schools at the time of the evaluation.

The methods of analysis of results, together with implementation variability, limits the reliability and validity of results observed in these data sets, and should be considered when drawing conclusions from the results. Dione-Rogers suggests that *further data gathering in subsequent years, including attention to measures of program implementation related to NAPLAN scores at the student level, would provide stronger evidence for effectiveness* (Dione-Rogers, 2012a).

Best Start

Program Description
Best Start Literacy is an initiative which provides a range of resources and professional learning activities designed to improve learning opportunities for all students. It is directly linked to the *NSW English K–6 English Syllabus*, and informs teaching practices and strategies that support students' progress towards the expected literacy achievement levels in the *NSW English K–6 English Syllabus*. Key components of the initiative are the use of the *Literacy Continuum K–6* and the *Best Start Literacy Assessment*, a diagnostic instrument that provides teachers with detailed information about the learning needs of all students early in their first year at school.

All children in government schools are assessed at school entry with the *Best Start Literacy Assessment* (NSW Department of Education and Training, 2009). This is conducted a one-on-one interview assessment based on a picture story book read aloud to students, and photographs of print in the environment. The assessment is designed to capture what students know and can do in areas critical to their early literacy development. Teachers use a literacy analysis guide to judge each student's overall performance on the critical aspects assessed, and are then able to place each student on the *Literacy Continuum*. This information can be used by teachers to identify particular strengths and weaknesses for the whole class, groups of students or individual students, for planning teaching, and for providing feedback to parents.

A wide range of research evidence, from Australian and international studies, was taken into account in the development of *Best Start Literacy*. Recent Australian work that influenced the scope and development of the *Best Start* initiative included *In Teachers' Hands: Effective Teaching Practices in the Early Years of Schooling* (2005), and the *National Inquiry into the Teaching of Literacy* (2005). The *Best Start Literacy Assessment* is based on the research in early literacy assessment that was used to develop the assessment model for the *Longitudinal Literacy and Numeracy Study (LLANS)*, ACER's research study into growth in literacy and numeracy in the first three years of school (Meiers et al., 2006). International studies included the US National Reading Panel report (National Reading Panel, 2000), and the report *Preventing Reading Difficulties in Young Children* (Snow, Burns & Griffin, 1998).

Eight critical aspects of literacy provide the focus of the *Literacy Continuum*: reading texts, comprehension, vocabulary knowledge, aspects of speaking, aspects of writing, phonics, phonemic awareness, and concepts about print. These are directly linked to directly linked to the NSW *English K–6 Syllabus*, and are also closely aligned to the aspects of reading found in the *Report of the Committee on the Prevention of Reading Difficulties in Young Children* to be common to effective literacy interventions: reading continuous text, decoding, word study, writing, and the selection of appropriate and engaging texts for students to read (Snow et al., 1998). The congruence between these two sets of key aspects provides a strong basis

for the perspective on supporting students' literacy acquisition and development in the *Best Start* initiative.

Further support for the breadth of the range of critical aspects embedded in *Best Start* can be found in the work of Paris on the development of reading skills (Paris, 2005). He identifies constrained skills such as letter knowledge, phonics, and concepts about print which *need to be mastered because they are necessary but not sufficient for other reading skills*, and unconstrained skills including vocabulary and comprehension. Paris warns that *excessive testing of constrained skills may lead to an overemphasis on these skills to the exclusion of unconstrained skills such as vocabulary and comprehension* (Paris, 2005).

Research Evidence

An evaluation of the *Best Start* Kindergarten assessment process was carried out by the University of Newcastle in 2008 (Whiteman, Foreman & Dally, 2008). The main aim of the project was to assess the inter-rater reliability of the procedures *Best Start* used in 2008. The results showed that the level of exact agreement, when a student was assessed by two different teachers, was moderate. These levels of agreement suggested that the *Best Start* assessment process is adequate for providing teachers with an overview of how their class is functioning in the areas of literacy and numeracy, to assist with planning for class programs (Whiteman, Foreman & Dally, 2008). To date, no other evaluations of *Best Start* have been reported.

Resources Required by Schools for Implementation

The *Best Start Literacy Assessment* and the *Literacy Continuum K–6* are key resources in the initiative. Additional resources include companion literacy teaching guides on phonics and phonemic awareness, linked to the early literacy continuum.

These *Best Start Literacy* resources were designed specifically for this initiative. Significant one-off costs were involved in the development of these materials, but they stand developed and available to users. Recurrent costs are related to the *Literacy Continuum K–6* and the *Best Start Kindergarten Assessment* which are made available to all government schools by the system. The literacy assessment task resources comprise a picture story book, *The Long Walk*, and six coloured photographs displaying print in the environment. The literacy tasks and analysis books, and all resources are supplied to schools by the system. Schools are encouraged to keep the resources from year to year, but replacement materials have been made available to schools as required, involving further recurrent costs for the system.

The one-on-one interview assessment can necessitate the employment of replacement teachers in order to free class teachers to undertake the assessments with all students in their Year K class. A range of professional learning activities have been conducted within the *Best Start* initiative over recent years, and these involve costs for paying replacement teachers to enable classroom teachers to participate in any out-of-school activities.

In summary, the resource requirements of implementing *Best Start Literacy* are:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Assessment materials Class sets of teaching materials and activities
Specialist teachers	Not needed
General classroom teachers	Time for one-on-one assessments Possible need for replacement teachers during one-on-one assessments Attendance at professional learning activities Teacher replacement during professional learning
Other personnel inputs	Consultant support
Licence fee	Not applicable
Other inputs	Not specified

Evaluation of Evidence
The *Best Start* program has not yet been independently evaluated. The study (Whiteman, Foreman & Dally, 2008) of inter-rater reliability and teacher perceptions of *Best Start* implementation and manageability was undertaken at an early stage in the implementation. The MAGLN 2012 report on the outcomes of consultation noted that an independent, external evaluation should be commissioned.

First Steps

Program Description
First Steps, developed by the Western Australian Department of Education, provides teachers with professional learning and resources to assess and record students' development and includes appropriate strategies to improve literacy learning. It offers a whole-school approach to literacy learning and provides a methodology for planning the next steps for each child's learning. Key components of the program are developmental continua in the form of frameworks, or maps of development, and resource books in the areas of oral language, reading, writing and spelling. *First Steps* was originally published in 1995, and the revised second edition was published in 2004.

The program encompasses literacy learning in all curriculum areas, and provides a wide range of strategies for developing reading, writing, spelling and oral language. The developmental continua provide a diagnostic framework that maps out the stages of language and literacy development, and are a means of informing and guiding instruction.

Research Evidence
The *First Steps* literacy resources and professional learning program were initially developed by the Western Australian Department of Education. A completely revised second edition, published in 2004, was developed by the STEPS Professional Development at Edith Cowan University for the Western Australian Department of Education and Training. The revised materials were trialled in schools, and teachers and students provided critical feedback.

An account of the initial development and implementation of *First Steps* was published in 1995 (Deschamp, 1995). This report refers to the theory of language underlying *First Steps*. The acquisition of language was seen as an integrated process, involving the interrelated skills of reading, writing, speaking and listening. The literacy program was organised around the four themes of reading, writing and oral language. The developmental continua were

used to organise each theme, and provided an ordered series of statements describing the development of literacy skills. Deschamps (1995) cites *First Steps* working documents that describe how the continua allow teachers to locate where students are at in their literacy development, and then to use strategies appropriate for that phase of development in the classroom. A whole-school program of teacher professional development was seen as the most effective means of changing teaching methods in ways that would become embedded into the school culture.

A number of reports were commissioned from ACER, during the development phase, including a validation study of the reading continua (Australian Council for Educational Research, 1993). One of these reports showed that on average, children in schools that had been using the *First Steps* methods for some time had results that *were superior to schools which on the traditional expectations related to socio-economic status would have been expected to have superior outcomes* (Deschamp, 1995, p. 31).

Research of major databases, including the Australian Education Index, yielded few recent research studies providing evidence of the effectiveness of *First Steps*. A US study (Conca, Schechter, & Castle, 2004) study reported on a project involving a partnership between an urban elementary school and a local college to support the school's implementation of *First Steps* as the school literacy framework. A teacher conversation model was used in which teachers could collaborate to make assessment-based instructional decisions, directly reflecting the *First Steps* focus on the maps of development and teaching strategies related to the phases of development. Twenty eight teachers were involved in the teacher conversations, working in groups at adjacent year levels. The audio-taped conversations about student work sample were coded using codes including description of work, interpretation of work, and instructional implications. More than half of the time in recorded conversation was spent discussing assessment related issues, but only 10 percent of the time was spent designing assessment-based instruction. The study concluded that in the context of this school, *the adoption of the First Steps framework was an example of a curricular reform effort that proceeded too quickly without sufficient time devoted to training and implementation* (Conca et al., 2004). The relevance of this study as research evidence for the effectiveness of the intervention lies in the way it points to the importance of linking professional learning with interventions.

Resources Required by Schools for Implementation

The maps of development for each of the language modes, and the resource books for each mode are central to *First Steps*. The professional learning programs, conducted by trained *First Steps* presenters, constitute the other key resource. These resources support the use of the maps of development, to enable teachers to identify students' growth in all aspects of literacy over the major stages of development. The resource books provide a comprehensive range of teaching strategies, targeting students' needs in relation to literacy learning in all modes at all stages of development.

In summary, the resource requirements of implementing *First Steps* are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Assessment materials and resource books Class sets of teaching materials and activities
Specialist teachers	May be needed depending on school contexts
General classroom teachers	Professional learning sessions; the quantity and mode are not specified Replacement teachers for teacher workshop participation School-based planning and monitoring
Other personnel inputs	Trained program presenters
Licence fee	Not applicable
Other inputs	Considerable use is made of Departmental materials and expertise

Evaluation of Evidence
The literature searches undertaken for the review did not locate external assessments of the impact of *First Steps* on students' literacy achievement. No cost-effectiveness studies were identified.

Internal evaluations undertaken by education systems may have been conducted and retained for internal use, but they are not publicly available. No reference to evaluative data for *First Steps* was found in any of the What Works Clearing House reviews of programs and products addressing the needs of beginning reading. This does not diminish the value of the resources, but, in the context of this review, it is a distinct limitation.

Focus on Reading 3–6

Program Description
Focus on Reading 3–6 was developed in NSW in the context of the National Partnership on Literacy and Numeracy (NPLN). This initiative acknowledges the importance of learning to read as the foundation for all learning, and the demands of the increasingly complex texts students are expected to read as they progress through school. The intervention is designed in three phases, and the first phase, involving schools, teachers and students in all three education sectors in NSW, commenced in 2010. The content is based on the integrated teaching and learning of three major aspects of reading: comprehension, vocabulary knowledge, and fluent text reading. Paris (2005) describes these three skills as 'unconstrained', that is, they continue to develop throughout life. Of the three, comprehension, and vocabulary knowledge are the less constrained. The concept of unconstrained skills highlights the need to teach these skills in the middle years, and in the later secondary years. *Focus on Reading 3–6* is implemented at the school level, with all teachers of Years 3–6 engaging in the phased professional learning and working as professional learning community to apply their new learning in the classroom.

The three linked phases of the professional learning model build on and complement each other (Rowles, 2010). Phase 1 is focused on teaching for comprehension, Phase 2 on vocabulary knowledge and fluent text reading, and Phase 3 on embedding new teaching practices in school and classroom structures. Sessions in the workshops for each phase include three strands: the teaching context and requirements for reading in Years 3–6, research-based strategies for learning, and the linking of teaching and learning in assessing and planning for student progress.

Between-session tasks intended to support teachers in translating the professional learning into classroom practices and school structures are included in the model.

Focus on Reading 3–6 complements the literacy support for teachers in K–2 within *Best Start*, and links with the department's published literacy teaching practice guides and the *Literacy Continuum*.

This intervention has a strong research base that emphasises the significance of comprehension, vocabulary knowledge and fluent text reading as key aspects of literacy teaching and learning in the middle years. The professional learning model implemented in the initiative originated in the Australian Government Quality Teaching Program (AGQTP) over 2000-2009. This model incorporated elements of the AGQTP research based principles for effective professional learning that provides opportunities for teachers to engage with relevant research evidence.

The focus on these reading skills, for an intervention of this size and scope, is well-supported by research. For example, Cassidy, Garrett and Barrera (2006) identified comprehension as a 'hot topic' in literacy instruction, indicating the close relationship between comprehension, vocabulary knowledge and reading fluency. In the program, comprehension is defined as responding to, interpreting, analysing and evaluating texts, drawing on contemporary research that indicates how effective learners use a variety of comprehension strategies, and know how to deliberately apply specific strategies to aid comprehension (Pressley, 2002).

Research Evidence

The Urbis evaluation of *Focus on Reading 3–6* conducted for the NSW DEC (Wallace 2012) analysed the effectiveness of the intervention for students in three sets of data: NAPLAN and NPLN assessment data, online survey data and qualitative data collected through interviews during site visits to schools. The survey and interview data indicated that school staff believed that *Focus on Reading 3–6* had been effective in improving student reading levels. Particular improvements noted by more than 80 per cent of online survey respondents focussed on improvements in students' use of effective strategies to assist in reading and understanding text; the volume, variety and complexity of texts read; and students' ability to read for meaning (Wallace 2012).

Changes in student literacy outcomes were investigated through analysis of aggregate data from NAPLAN and NPLN assessments. The Urbis evaluation report noted that in both data sets (NAPLAN and NPLN) gains in mean reading scores were observed for all cohorts using *Focus on Reading 3–6.* A further finding indicated that in both NAPLAN cohorts (students in Year 3 in 2008 and Year 5 in 2010, and students in Year 3 in 2009 and Year 5 in 2011) the gain score for students at schools participating in *Focus on Reading 3–6* was slightly higher than that for all schools in the state. However, the main reading score at *Focus on Reading 3–6* schools over the National Partnership on Literacy and Numeracy period was still notably lower than the State average. The gain scores for Aboriginal students were higher than for non-Aboriginal students in both cohorts, but the sample size was small. The data from the three NPLN cohorts show gains from the *Focus on Reading 3–6* schools in line with the gains from all NPLN schools with a slightly higher gain for the youngest students.

Qualitative evidence reported in the evaluation indicated positive outcomes for teachers. Evidence of the impact of teachers' knowledge, attitudes and skills was obtained from the online surveys, with the main impact being on changing pedagogy and increased

understanding of how to teach reading. For example, 94 percent of teachers reported that their understanding of comprehension strategies and comprehension strategies and the links to comprehension, vocabulary knowledge and text reading had improved to a major or moderate extent, and 92 percent reported a deepened understanding of effective teaching of reading to a major or moderate extent.

Resources Required by Schools for Implementation
The total time commitment for the professional learning program is 16 days. Participating teachers require 10 days to attend face-to-face workshops conducted in the form of 10 modules over 3-4 semesters, and a further 6 days for team meetings, team teaching, and school visits. The availability of certified trainers is central to the initiative. These trainers conduct the workshops, and provide in-school support. Considerable use is made of recommended reading guides, local and state-wide networks, and departmental literacy teaching guides.

In summary, the resource requirements of implementing *Focus on Reading 3–6* are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Assessment materials Class sets of teaching materials and activities
Specialist teachers	Not needed
General classroom teachers	Workshop participation of 10 days per teacher over 3-4 semesters Team meetings and school visits comprising 6 days per teacher Replacement teachers for teacher workshop participation and school visits
Other personnel inputs	A certified trainer/program facilitator (either school based or external)
Licence fee	Not applicable
Other inputs	Considerable use is made of recommended reading guides, local and state wide networks, and Departmental literacy teaching guides

Evaluation of Evidence
The methodology for the independent, external evaluation (Wallace, 2012a) was comprehensive, and included the following components:

- A review of program documentation relating to the intervention
- Visits and interviews in eight schools that had used *Focus on Reading 3–6*
- An online survey of staff in all NSW schools that had selected *Focus on Reading 3–6* as the whole-school intervention component of the NPLN
- Stakeholder interviews
- Analysis of NAPLAN and NPLN assessment data.

The report noted limitations in the data sets available for this evaluation, including the testing of students every second year in NAPLAN. This meant that growth in NAPLAN scores could only be assessed for students who were in Year 3 in 2008, and Year 5 in 2010 for the 2010 and 2011 Year 5 cohorts. Assessing growth from Year 3 2008 to Year 5 2010 included data for a year before the intervention commenced. It was not possible to compare results of NAPLAN and NPLN as the tests are on different scales. There were also limitations with attribution and consistency in comparisons across different groupings of schools. NPLN schools implementing *Focus on Reading 3–6* could also have been providing additional

literacy support for target students through individual interventions or other programs (Wallace, 2012a).

No cost-effectiveness studies of *Focus on Reading* were identified.

Language, Learning and Literacy

Program Description
Language, Learning and Literacy (L3) is a NSW DEC initiative (commenced in 2010) which focused on early intervention in text reading and writing for children in Kindergarten, particularly those in low socioeconomic communities. *L3* expanded to Years 1 and 2 in 2012. *L3* is a component of the Best Start initiative, which complements the K–6 syllabus and the daily literacy program for children entering school from a variety of language backgrounds (NSW Department of Education and Communities, 2011b). It is expected that schools will assess their need to participate in the intervention through an analysis of the proportion of Kindergarten children who have significant difficulties in early literacy at the beginning and end of the year. As an early intervention program, *L3* aims to reduce the proportion of students who require access to more targeted literacy intervention (e.g. *Reading Recovery*) at a later stage (NSW Department of Education and Communities, 2011a).

The *L3* intervention focuses on providing professional learning for participating year level teams (12 half days across three terms), with support from a *L3* regional trainer to implement the intervention (through four half day visits involving observation and discussion) (NSW Department of Education and Communities, 2011b). *L3* regional trainers are themselves supported by a trainer mentor who delivers the professional learning, provides coaching to regional trainers during school visits, and gives related support for the implementation of *L3* (NSW Department of Education and Communities, 2011a). Over the course of implementation, 94 *L3* regional trainers have received specialised professional learning to enable them to undertake the role. Each region receives resourcing from the NSW DEC of 20 casual relief days for up to 15 participating regional trainers.

The program of professional learning for teachers and regional trainers, in conjunction with the regional trainer support for teachers implementing *L3* is designed to improve participants' understanding of the development of early literacy and to assist them to translate this knowledge into improved classroom practice. In implementing the intervention, teachers provide explicit and systematic teaching in reading and writing to small groups of students (3–4) during regularly scheduled literacy blocks, as well as other individual and group activities in the classroom that complement the explicit teaching (NSW Department of Education and Communities, 2011b).

Research Evidence
As a relatively new initiative, no formal research evidence or program evaluation is available to assess the efficacy of *L3* in improving student achievement. However, data collection at five week intervals is embedded in the program design, which will enable an assessment of growth over time in the core skills of text reading, writing vocabulary and hearing and recording sounds in words (NSW Department of Education and Communities, 2011a).

Resources Required by Schools for Implementation
Resources required by schools for implementation of *L3* relate primarily to funding teacher time to participate in professional learning, to participate in discussions associated with regional trainer school visits, and for any time required to conduct assessments. Some additional literacy resources may be required to support implementation of *L3.* Additional personnel time may be required (from principals or other literacy support personnel) to support teachers in implementing *L3* in schools.

The resource requirements of implementing *Language, Learning and Literacy* intervention are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Literacy resources as required
Specialist teachers	Not needed
General classroom teachers	Participation in 12 half days of professional learning and associated time release, time release related to L3 trainer visits, and to conduct assessments
Other personnel inputs	Principals may join a professional network of L3 schools; principals and early years literacy coordinators provide support to teachers implementing L3
Licence fee	Not applicable
Other inputs	Not needed

Evaluation of Evidence
Language, Learning and Literacy is a relatively recently developed intervention, and there was no research evidence (or cost effectiveness studies) available at the time of the current review to enable an assessment of the efficacy of the intervention in improving student achievement in literacy.

Literacy on Track: K–6

Program Description
Literacy on Track: K–6 is a professional learning program of six workshops over a 12-month period, targeting all teachers, K–6, and school leaders. It is included in the selected interventions because it covers the early years, and because of its focus on literacy leadership in schools. *Literacy on Track: K–6* is intended to build school capacity in teaching literacy. Teachers, with the support of school leaders, are expected to engage in school-based activities between scheduled workshop sessions. It is delivered by trained regional consultants, and focuses on the teaching of reading, writing, talking and listening. Focus areas include: assessment of, and for, literacy learning; planning for literacy teaching; and balanced, integrated, explicit and systematic approaches to teaching literacy. A key feature of *Literacy on Track: K–6* is the literacy leadership support provided to participating K–6 school leaders.

Research Evidence
The *Literacy on Track* intervention was developed from research on a range of components to support literacy learning. There is reference to assessment of, and for learning. Balanced, integrated, explicit and systematic approaches to teaching were emphasised. The integration of reading, writing, talking and listening is central, and connects to the emphasis on these aspects in the NSW *Literacy Continuum K–6*.

Resources Required by Schools for Implementation
The major resource required to implement this professional learning program is time for teachers and school leaders to attend the six workshops, and to engage in school-based activities between workshops. The trained regional consultants are an essential resource. According to individual school needs and interests, additional teaching resources may need to be purchased.

In summary, the resource requirements of implementing *Literacy on Track: K-6* are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Teaching resources may need to be purchased, depending on school needs and interests
Specialist teachers	Not needed
General classroom teachers	Participation in 6 workshops School-based activities Replacement teachers for teacher workshop participation
Other personnel inputs	School leader time for participation in 6 workshops School leader time for school-based activities Trained regional consultants
Licence fee	Not applicable
Other inputs	Not specified

Evaluation of Evidence
Surveys of participating principals, K-4 school leaders and K-4 teachers were conducted in 2006, in order to determine the impact of *Literacy on Track* on professional learning needs, on changes in teacher learning and practice, and on student learning. No evidence was found from these surveys of the collection or analysis of student literacy achievement data over time for evaluation purposes. No cost-effectiveness studies were identified. The lack of such evidence is a limitation in relation to the efficacy and effectiveness of this intervention.

Off to a Good Start in Learning to Read K–2

Program Description
Off to a Good Start: Learning to Read K–2 (OTAGS) was a pilot project undertaken from 2008–2010 by the Association of Independent Schools NSW (AISNSW) as part of the DEEWR National Partnership Literacy and Numeracy Pilots for Low Socioeconomic (SES) School Communities. Schools targeted to participate in the pilot included those with high proportions of students potentially at risk of reading difficulties through reasons such as low SES, Indigenous status, geographic location, disability or Language Backgrounds other than English (LBOTE) (Association of Independent Schools NSW, 2010). In total, 18 teachers from 9 schools were scheduled to participate in the project at its commencement.

OTAGS focused on providing professional learning to teachers with a view to increasing their knowledge of research evidence on the development of early reading, and of teaching and learning approaches which are effective in enhancing children's proficiency in early reading. Three days of professional learning at the beginning of the project focused on providing teachers with an introduction to the project rationale, a greater understanding of foundation components of learning to read (i.e. concepts about print, phonological and phonemic awareness, letter/sound correspondence decoding; recognition of high frequency sight words; reading fluency and comprehension), and of targeted assessment, planning and teaching

strategies. In implementing *OTAGS*, teachers identified the individual needs of their students in foundational areas of early reading, provided targeted teaching in key areas, monitored progress of individual students, and adjusted teaching approaches based on the identified needs of individual students (Association of Independent Schools NSW, 2010).

School visits by the AISNSW project leader occurred regularly over the implementation of *OTAGS.* These visits provided opportunities for the consultant to observe classroom practice, liaise with principals, and provide support to teachers who were implementing the intervention. These visits included opportunities to discuss assessment data and student progress, as well as modelling by the AIS Project Leader, and providing feedback to teachers and principals on teacher skills in delivering lessons.

Reading Progress Tests administered by the AIS Project Leader provided assessment data which formed the basis for discussion with teachers during initial school visits. Teachers who participated in the pilot project also administered a range of criterion-referenced assessments to their students dependent on the student's year level. These included assessments of skills such as phonemic awareness, concepts about print, decoding skills, high frequency sight word recognition, reading fluency and comprehension. At each year level K–2 an Independent Reading Level assessment was conducted with students in Term 1 or 2 of the school year and again 12 months later.

A final day of professional learning occurred at the beginning of the final year of the project and provided an opportunity for participating teachers to discuss the results of the intervention, share teaching strategies, and discuss sustainability.

Research Evidence

Research evidence for the efficacy of *OTAGS* is reported in the AISNSW final report to DEEWR on the project outcomes (Association of Independent Schools NSW, 2010); the project is also featured in the meta-evaluation of all DEEWR National Partnership Literacy and Numeracy Pilots for Low SES School Communities (Colmar Brunton Social Research, 2011).

The AISNSW final report on *OTAGS* presents complete initial and final assessment data for 52, 58 and 48 students in their first, second and third year of school respectively. These data are presented descriptively (by the percentage achieving a criterion), and are aggregated across schools and classrooms. In general, these data suggest improvements across the range of the reading skills specifically targeted by the intervention. Independent reading level assessments (using PM benchmark assessment in most cases; one school used NSW DET Step by Step reading levels which were approximated to PM reading levels), suggested significant growth over a 12 month period, however, as far as can be determined in this report no indication of expected reading level at each year of schooling is provided to allow a more complete interpretation of the efficacy of the intervention (Association of Independent Schools NSW, 2010).

Teacher judgements of student skills (recorded in five categories from very low to very high ability) before the program commenced suggest that the students assessed had a range of abilities, but that overall, their performance tended to be represented disproportionately in the low, and very low, categories. At the end of the project, final teacher judgements indicated that the pattern of performance across year levels reflected higher proportions of students in the high, and very high, categories. The degree to which these data can be used as evidence

of the efficacy of *OTAGS* must be qualified by a lack of detail on whether there were complete teacher judgements for all students at participating schools, the potential unreliability of teacher judgements, and a lack of comparison to expected growth in reading.

The meta-evaluation of the DEEWR National Partnership Literacy and Numeracy Pilots for Low SES School Communities provides a very qualified categorisation of the level of impact on students' results as a function of funding and size of the pilot. On this basis, the evaluators suggest that *OTAGS* reflects a strong positive change in student results, for a relatively low level of funding at the site level (Colmar Brunton Social Research, 2011). These conclusions are heavily qualified by the lack of (and variability in) information related to resource inputs, and difficulties interpreting student outcome data.

Resources Required by Schools for Implementation

The commitment for schools, in regard to resourcing, relates primarily to the costs of professional learning, for teacher time release to attend off-site professional learning for four days, and additional in-school time to meet with mentors. Included in the pilot program was significant mentoring support, which, in the context of the pilot, was not a cost to the school. The degree to which this resourcing might be sustainable in the long term is not clear.

The resource requirements of implementing the *OTAGS* intervention are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Teaching materials as required
Specialist teachers	Not needed
General classroom teachers	Attendance at four days of professional learning and associated accommodation and time release costs for each participating teacher
Other personnel inputs	External consultants
Licence fee	Not applicable
Other inputs	Not needed

Evaluation of Evidence

The available evidence provides limited evidence of the efficacy of *OTAGS* in improving student achievement in reading. For the small numbers of students assessed, the data suggest some growth in core reading skills targeted by the intervention and progress in independent reading levels. Nonetheless, these conclusions are qualified substantially by limitations in the nature of the data. These limitations also impact upon the rigour of the analysis of student outcomes in relation to resourcing.

Principals as Literacy Leaders

Program Description

The Principals as Literacy Leaders (PALL) project was initiated by the Australian Primary Principals Association. It was funded under the Australian Government's Literacy and Numeracy Pilots in Low SES Communities initiative, and designed as an action research project to be implemented over two years (2009-2010). PALL provided mentoring support for principals and a program of professional development. Literacy achievement advisers, professional peers with expertise in leadership, knowledge and understanding of literacy learning, and with experience of working in disadvantaged communities, were appointed in each state/territory. The mentoring and coaching role was carried out through interaction in

project tasks with principals in their own school communities. Five professional development modules were developed.

Research Evidence
This initiative synthesised research-based knowledge about school leadership, literacy teaching and learning, effective professional learning and school improvement, and change management. Research findings from PALL were presented in the report by Dempster et al. (2012).

As a consequence of their involvement in PALL, school leaders placed an increased emphasis on:

- literacy as a pre-eminent improvement priority for the school and for the teachers;
- professional development activity related to literacy;
- professional dialogue with teachers about literacy and the analysis and use of achievement data on reading, and in the design and delivery of literacy interventions;
- the alignment of resources to facilitate literacy teaching and learning (Dempster et al., 2012).

A second major finding related to the practical application of literacy content knowledge, and of leaders' knowledge of research evidence on the effective teaching of reading:

- improved confidence in the principals themselves that led to their active involvement in professional learning and to their influence in changes to school-wide systems and processes for the learning and teaching of reading; and
- application of frameworks (the Leadership for Learning Blueprint and the Big Six) and the use of observational tools (the Literacy Practices Guide) to support an evidence-based approach to literacy learning in the schools (Dempster et al., 2012).

Resources Required by Schools for Implementation
The major resources provided were the provision of leadership mentoring through the literacy and numeracy advisors, and the set of five professional development modules to stimulate learning for the 60 participating principals.

In summary, the resource requirements of implementing PALL are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Five professional development modules
Specialist teachers	Not applicable
General classroom teachers	Not applicable
Other personnel inputs	School leader time for participation in workshops School leader time for school-based activities Literacy and numeracy advisors
Licence fee	Not applicable
Other inputs	Not specified

The report of research findings noted that the outcomes achieved by the project were based on an investment of $2.13 million (Dempster et al., 2012), and working with and through principals was seen as cost-effective way of directly enhancing teachers' professional competence.

Evaluation of Evidence
The evidence on which this evaluation is based comes from information taken from school-based intervention evaluation reports, prepared by principals towards the end of 2010 (Dempster et al., 2012). The process used to manage the discussion of this evidence involved a detailed examination on one school's evaluation report, which was then extended by the inclusion of examples from the other 55 evaluation reports. Principals were asked to structure their data gathering and analysis around two key purposes. The first purpose was to focus on changes to literacy teaching and learning experience and in student achievement in literacy; and the second purpose involved an examination of the impact of aspects of the leadership for Literacy Learning Blueprint (LLB) on the effectiveness of the literacy interventions (Dempster et al., 2012).

A total of 56 school-based evaluations of the interventions implemented in their schools were received from principals, out a possible 60 evaluations. Analysis of this data provided a strong indication of the pilot project's application and impact in participating schools (Dempster et al., 2012). Overall, the data comprised qualitative and quantitative evidence. A wide range of information sources was gained from various school personnel, including middle-school teachers and students, literacy coaches, heads of curriculum. Schools also provided a range of student achievement data, including school NAPLAN results, and Progressive Achievement Tests in Reading (PAT-R) results.

Although these data lack the rigour of studies where students are randomly assigned to control or intervention groups, it covers many aspects of the intervention. A major finding was evidence that principals' increased understanding, through the professional learning modules, had become embedded in school practices.

Reading to Learn

Program Description
This intervention is underpinned by the scaffolding approach developed initially by Brian Gray, David Rose and Wendy Cowey from work in Indigenous education programs in Central and South Australia and at the University of Canberra (Culican, 2006). This work led to the development of the intervention known as *Accelerated Literacy. Reading to Learn* is now conceptually distinct from *Accelerated Literacy*.

The whole-class approach to supporting students to read and write challenging texts at their year level uses pedagogy that draws on reading theory, functional linguistics and genre approaches to writing. *Reading to Learn* is a system of literacy teaching strategies that enables learners with weak literacy skills to learn to read and write at levels appropriate to their age and the area of study. In primary school setting, *Reading to Learn* includes three levels of learning support, preparing before reading and modelling writing; detailed reading and rewriting; sentence making, spelling and sentence writing (Dione-Rogers, 2012b). The strategies have been used by schools across Australia, and internationally (Acevedo, 2010).

The intervention is designed for middle years students, that is, the upper primary and junior secondary years of schooling. It has been included in this review because of the design of their six stage teaching cycle, and as an example of an intervention which connects both reading and writing. The *Reading to Learn* curriculum cycle comprises:

1. Preparing before reading.

2. Detailed reading
3. Preparing for writing
4. Joint rewriting
5. Individual rewriting
6. Independent writing (Culican, 2008).

Research Evidence

The development of the *Reading to Learn* intervention incorporated a strong research base that shaped the central classroom strategies. Evidence of effectiveness, in terms of impact on student achievement, is found in the external, independent program evaluation undertaken under the National Partnership on Literacy and Numeracy (Dione-Rogers, 2012b).

This evaluation study reported that comparisons between the performance demonstrated in external achievement data and the perceptions of many school stakeholders regarding the effectiveness of the intervention, revealed a significant mismatch. Variation in implementation patterns across schools meant it was not possible to assume students had had consistent exposure to *Reading to Learn* during 2010 and 2011 (Dione-Rogers, 2012b). The overall set of data, including both external achievement data and the perceptions of school stakeholders, suggested that student learning outcomes had been observed to improve. This was more strongly evident in teachers', parents' and students' impressions of effective learning than in broad scale testing measures.

Results were reported for NAPLAN Reading in the 'all students' cohort in Year 3 in 2008 and 2009, and in Year 5 in 2010 and 2011. Overall, these data showed that students in *Reading to Learn* schools had *similar performance in Years 3 and 5 when compared to the whole of the state, with the exception that Aboriginal students in those schools improved their performance slightly in 2011* (Dione-Rogers, 2012b).

The NPLN assessment data indicated that the gain scores for *Reading to Learn* students were about the same as those for other NPLN programs. Broad scale comparisons were limited as testing was only conducted in NPLN schools, and the candidature for NPLN assessments was uncertain and varied.

Resources Required by Schools for Implementation

This intervention includes a professional learning program delivered in four two-day blocks, a set for resource books, and a training DVD. Schools require sets of individual white boards and consumable activity resources such as cardboard strips and highlighters for classroom activities.

In summary, the resource requirements of implementing *Reading to Learn* are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Resource books Training DVD
Specialist teachers	May be needed depending on school context
General classroom teachers	Participation in 4 two-day workshops Replacement teachers for teacher workshop participation School-based activities
Other personnel inputs	External consultants
Licence fee	Not applicable
Other inputs	Consumables

Dione-Rogers (2012b) reported that the costs of the professional learning program were approximately $100 per teacher, on average per workshop day, and $120 per teacher for the resource pack of training books and DVDs. The costs of teacher release time were not specified.

Evaluation of Evidence
Overall, the research evidence for the impact of the intervention on student achievement is inconclusive. No cost-effectiveness studies of *Reading to Learn* were identified.

Reading Matters

Program Description
The *Learning Matters* resources, comprising *ESL*, *Reading* and *Numeracy Matters* are flexible, online professional learning targeting Years 3–6, each comprised of ten modules completed in approximately 50 hours. The *Reading Matters* resource aims to increase teacher knowledge of the development of reading, to better equip them to assess students' reading development, and to employ appropriate instructional strategies for learning to read. The resources provide an approach through which individual teachers, leadership teams, and leadership teams facilitating whole group learning can readily access professional learning on early reading. Individual teachers access the resources in their own time. Leadership teams first complete the *leading learning* category, which introduces each *Learning Matters* resource and provides training for the leadership team in facilitating whole-school professional learning. Leadership teams also complete the *leadership team* category which encourages discussion within the team on their vision for promoting learning in reading in their school.

Research Evidence
During the course of this review, no detailed public information about the content of the *Reading Matters* intervention, or any research evidence, was identified to assess the efficacy of *Reading Matters* in improving student achievement in literacy.

Resources Required by Schools for Implementation
Reading Matters is freely available to Catholic schools in the Archdiocese of Sydney. Online delivery of the resource provides a flexible approach for schools implementing this professional learning module. Teachers who undertake the professional learning individually complete the modules in their own time. Implementation of the learning by teachers in the classroom setting may require additional time to conduct reading assessments.

The resource requirements of implementing the *Reading Matters* intervention are as follows:

Classroom modification	Not needed
Special equipment	Computers for individual learning or a data projector for group learning
Materials	Teaching materials as required
Specialist teachers	Not needed
General classroom teachers	Completion of online professional learning comprising 10 modules completed in approximately 50 hours The online delivery reduces the need for classroom time release, individual teachers complete the modules in their own time Time release to conduct assessments
Other personnel inputs	Leadership teams may also undertake the professional learning or facilitate whole-school-delivery
Licence fee	Not applicable
Other inputs	Not needed

Evaluation of Evidence
At the time of the current review there was no publicly available research evidence to assess the efficacy of *Reading Matters.* No cost-effectiveness studies were identified.

Successful Language Learners Pilot Programs in Low SES Schools

The *DEEWR Literacy and Numeracy Pilots in Low Socio-economic Status Communities*, which concluded in 2010, included the NSW*: Whole-school ESL language and literary practices* pilot program. This project consisted of four major initiatives: targeted support for students, professional learning for teachers, school leadership development, and schools as centres for community activity. The scope and nature of *Successful Language Learners* means that it is appropriate to include it as a Tier 1 intervention

Program Description
The *Successful Language Learners* pilot was one of three pilot projects using national funding for literacy numeracy pilot projects in low socio-economic communities implemented in NSW. The focus of the pilot was targeted support for students of English as a Second Language, including refugees at key transition points. Strategies featured in the intervention included ESL informed pedagogy, professional learning and team teaching, whole class and individual learning plans, student profiles, reporting to parents, and the development of homework and co-curricular support for targeted students.

The professional learning for teachers covered key aspects of ESL pedagogy, the language, literacy and numeracy demands of the curriculum, the nature of the refugee experience, and the use of technology. An online professional learning network was established to encourage sharing of resources and teaching strategies between schools.

Another key component of the program was professional learning for school leadership teams through workshops conducted each term. These workshops focused on effective ESL pedagogy, school leadership, building community participation for members of culturally and linguistically diverse backgrounds. A network of pilot school leaders was established to drive the pilot and to share learning between schools. Assessments of student progress were undertaken regularly throughout the two years of the pilot. The ESL scales were used to assess the English language competence of all ESL students on four occasions during the two-year pilot.

Research Evidence
An evaluation of the pilot was conducted over two years, seeking evidence of language and literacy outcomes for students, and the extent of improvement that could be attributed to the pilot. The evaluation also investigated the impact on the capacity of teachers and school leaders. The effectiveness of the interaction of the four elements of the intervention was a key focus: targeted support for students, professional learning for teachers, development of school leadership, and schools as centres of community activity. Current knowledge of Web 2.0 technologies was drawn on.

Key findings of the evaluation were derived from the analysis of the ESL Scale scores, and from analysis of NAPLAN results. Additionally results from the Assessment Bank were also reported. The ESL Scale scores showed a range of competency on each of oral interaction, reading and responding and writing. Comparisons were made of NAPLAN scale scores for students in the *Successful Language Learners* pilot schools and the scores for all students in

NSW. Analysis indicated that growth in literacy was greater than would be expected (ARTD Consultants, 2011).

Resources Required by Schools for Implementation

This was a multidimensional project, and required a wide range of resources. The professional learning workshops, leadership network meetings, development of individual language learning plans for students, and community activities all required significant allocations of time. Other resources included the ESL Scales and Assessment Bank materials, and the support and direction of the Coordinating Committee.

In summary, the resource requirements of implementing the *Successful Language Learners* intervention are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Assessment materials Teaching and learning materials Materials for parents
Specialist teachers	Participation in professional learning activities Planning and school-based activities
General classroom teachers	Participation in professional learning activities; the quantity and delivery mode are not specified although there is an emphasis on school-based activities Replacement teachers for teacher workshop participation Planning and school-based activities
Other personnel inputs	External consultants
Licence fee	Not applicable
Other inputs	Consumables

Evaluation of Evidence

Research evidence for the efficacy of *Successful Language Learners* is based on three measures of student achievement. The first of these was the assessment of all ESL students in Years K-6 using the ESL Scales at four points during the project. The second assessment was the *Successful Language Learners* Assessment Banks, administered to all students in Years 3-6 at four points. Thirdly, NAPLAN results for Year 5 students in 2010 were compared with the NAPLAN results for the same students when they were in Year 3 in 2008 (Colmar Brunton Social Research, 2011).

The results for each of the assessments were positive. The Colmar Brunton Social Research (2011) meta-analysis reported *significant improvements in English language proficiency, longitudinally for cohorts measured, across each assessment instrument: ESL Scales, assessment bank and NAPLAN. Increases were greater than if no intervention had occurred (compared to state increases).* The report noted that although some of this growth could have been attributed to student maturation and increased length of time in Australia, the rate of growth suggested that students' English language development had been assisted by the teaching provided by schools during the project. The data for matched students' for Year 3 (2008) and Year 5 (2010) showed significant growth across the *Successful Language Learners* schools, and that growth for *Successful Language Learners* schools was greater than the growth for achievement against the NAPLAN national minimum standard for literacy and numeracy (Colmar Brunton, 2011). The meta-evaluation rated this as strongly positive change in student results.

The meta-evaluation presents a qualified comparison of intervention efficacy (suggesting a strong positive change in student results) in relation to program funding and the number of sites at which the intervention was implemented. These data are significantly qualified by difficulties gaining complete information on the type of resourcing and limitations in student achievement data, thus making a rigorous cost-effectiveness analysis difficult.

Tier 2 Literacy Interventions

MINILIT

Program Description
MINILIT, 'Meeting Initial Needs in Literacy', is an intervention for a younger group of students than the *MULTILIT* intervention, and utilises some components of the *MULTIIT* program, including word attack skills and sight words. *MINILIT* provides an approach for teaching reading skills to young students that includes a two-day professional development workshop together with the required resources to implement the program in the form of a comprehensive Starter Kit. *MINILIT* targets the bottom 25% of students and low achieving Year 1 readers, but may also be appropriate for low achieving Kindergarten and Year 2 students. It is a Tier 2 school-based small group intervention delivered daily to up to four students per group within a Response to Intervention Framework. By 2012 it had been under development for five years as on ongoing research and development program by a specialist team from Macquarie University.

MINILIT incorporates the teaching of phonemic awareness, phonics, sight words, fluency, comprehension and vocabulary in an integrated and balanced program of 80 carefully structured lessons, divided into two levels of forty lessons each:

- Level 1: Teaching the basics of letter/sound knowledge and decoding skills for consonant-vowel-consonant words.
- Level 2: Extending word attack knowledge by teaching commonly used digraphs and longer words.

The program takes around 20 weeks to complete, with four lessons of up to 60 minutes per week, and includes regular curriculum-based measures to monitor the progress of the students. Entry point into the program is based on students' assessment scores, and can occur at any stage within the 80 lessons. Each lesson comprises three main components:

- Sounds and Words Activities
- Text Reading
- Story Book Reading

These three components are taught daily.

The two-day *MINILIT* Training Course provides professional development in effective reading instruction, practical advice, a video of live demonstrations, practice through small group role-play, and assistance in developing a *MINILIT* implementation plan.

Research Evidence
The developers of *MULTILIT* and *MINILIT* at Macquarie University have undertaken research into this intervention since its inception. Several studies were reported in 2007, on the nature of *MINILIT* as a ramp to reading for young at-risk readers (Reynolds, Wheldall, & Madelaine, 2007).

A randomised experimental study was carried out over 20 weeks at one school with a group of 16 Year 1 boys who had been identified by teachers as 'struggling readers'. The report of this study (Reynolds, Wheldall & Madalaine, 2010) indicated that this was the first time that *MINILIT* had been implemented where the intervention had not been conducted by the university research unit, but by trained personnel. Students in the group were randomly assigned to a treatment group or a control group. The control group received regular reading instruction in the class, and the intervention group attended tutoring sessions for 45 minutes daily, for 10 weeks. This differed from earlier pilot studies of *MINILIT*, which provided 60 minute daily sessions.

A number of standardised tests were used to measure change in student achievement, including the Wechsler Individual Achievement Test, second edition (WIAT-11) which was used because of its appropriateness for students in the first two years of schooling, and the Wheldall Assessment of Reading List (WARL) used as measure of reading achievement. Each test was administered at three testing points. The results showed no statistically significant differences between the experimental and control groups in the basic comparisons, although *effect sizes were large and generally greater for the experimental group* (Reynolds et al., 2010). The small sample size, and the selection of students by the school were limitations to this study, but the study achieved its purpose of providing initial information about the implementation of *MINILIT* is a regular setting, rather than a specialised setting outside the school. Overall, the results provided some evidence for the efficacy of *MINILIT*, but it was acknowledged that further research with more subjects was needed.

A recent study reported pre- and post-test data on multiple assessments for 161 students who had attended the *MINILIT* program at Exodus centres in Sydney and Darwin during 2009-2011 (Wheldall, Beaman, Madalaine, & McMurtry, 2012). It was found that these students made large and significant gains on six literacy measures (single word reading, word spelling, phonological awareness, list reading fluency, phonological recoding and receptive vocabulary). The effect sizes were large ($\geq$0.8) for all measures (ranging from 0.83 -1.67) (Wheldall et al, 2012). The main conclusions of the report were *that the gains made provided convincing, consistent evidence of the continuing high efficacy of the MULTILIT and MINILIT programs (as delivered by the Exodus Foundation) in redressing reading difficulties in socially disadvantaged and Indigenous children* (Wheldall et al, 2012). These gains were reported to be consistent across sites and populations, Indigenous and non-Indigenous groups of students made very similar and very large gains in reading and related skills, and the programs appeared to be as effective for Indigenous as for non-Indigenous students.

Resources Required by Schools for Implementation
A *MINILIT* professional development workshop and starter kit is required for each school.

The resource requirements of implementing the *MINILIT* program are as follows:

Classroom modification	Area for small group teaching
Special equipment	Not needed
Materials	Starter Kit comprising teacher and student materials Parent and teacher resources
Specialist teachers	Not needed, but can participate in the program
General classroom teachers	Participation by at least one staff member per school (general teacher, specialist teacher, aide, school leader) in a 2-day training course Possible replacement teachers for training course 80 lessons of up to 60 minutes each, over a 20 week period to small groups or one-to-one
Other personnel inputs	Program provider
Licence fee	Not applicable
Other inputs	Ongoing support and materials depending on needs

Evaluation of Evidence
The available published research on *MINILIT* provided evidence of positive outcomes for students, including the use of pre- and post-test data on multiple assessments that indicated large and significant gains. No cost-effectiveness studies were identified.

MULTILIT Reading Tutor Program

Program Description
Making Up Lost Time in Literacy Reading Tutor Program (hereafter referred to as *MULTILIT*), an intensive one-to-one tutoring program, is a literacy intervention that targets low-progress students in Year 2 and above. It comprises three elements; *MULTILIT* Word Attack Skills (synthetic phonics), *MULTILIT* Sight Words (200 most frequently occurring words, and *MULTILIT* Reinforced Reading (using a revised Pause, Praise, Prompt procedure). Professional development and consultancy support is available. Program delivery entails one-to-one tutoring, 30-40 minutes each for four days every week: 10 minutes *MULTILIT* Word Attack, 5–10 minutes *MULTILIT* Sight Words, 20 minutes *MULTILIT* Reinforced Reading, for a period of 20 weeks.

This range of activities is intended to provide effective reading instruction for low-progress readers in a supportive context. The key elements of the intervention are the phonic word attack skills program; opportunities to acquire and practise a bank of useful, high frequency sight words; and regular practice in reading meaningful, connected text.

Student assessment is a regular part of the program, using WARP (Wheldall Assessment of Reading Passages; Reynolds, Wheldall & Madelaine, 2009). A number of other assessments have also been used, including the Neale Analysis, the Burt Word Reading Test and the South Australian Spelling Test. Students are assessed after two terms on the program, and at six-monthly intervals subsequently in order to monitor progress.

Research Evidence
The program developers reported their findings over a three year evaluation period, using the cumulative data from 142 students (Wheldall & Beaman, 2000). Students typically gained 12-15 months on assessments listed above, and while these gains were maintained for six months and even a year after completion of the program, little further progress occurred. Students were identified who maintained their gains from the program, together with those who did not maintain gains, and those who continued to develop.

An evaluation of the progress of 34 low-progress Years 5 and 6 readers who attended a MULITLIT tutorial centre included 14 students who identified as being Aboriginal (Wheldall, Beaman & Langstaff, 2010). Pre- and post- test data were analysed to determine the efficacy of the program. The group as a whole made large and significant gains on all measures of reading accuracy, comprehension, single word reading, non-word reading, spelling and oral reading fluency. It was reported *that there were no significant differences in gain between the two subgroups indicating that the programme instruction was equally beneficial for both Aboriginal and non-Aboriginal students* (Wheldall, Beaman & Langstaff, 2010, p. 1).

As part of the evaluation of key programs implemented through the National Partnership on Literacy and Numeracy, Urbis assessed the impact of the intervention on students' outcomes in schools implementing *MULTILIT* within their schools. NAPLAN data was collected from two cohorts: students in Year 3 in 2008 and Year 5 in 2010, and students in Year 3 in 2009 and Year 5 in 2011. NPLN data was collected from three cohorts of students:

- Students in Year 2 2009, Year 3 2010, Year 4 2011
- Students in Year 3 2009, Year 4 2010, Year 5 2011
- Students in Year 4 2009, Year 5 2010, Year 6 2011

However, the small sample size of Aboriginal students in these cohorts limited the validity and reliability of the outcomes for Aboriginal students (Wallace, 2012a).

Key findings in relation to student achievement (Wallace, 2012a) included:

- Gains in mean reading scores as recorded using both NAPLAN and NPLN assessment data were observed for all cohorts at *MULTILIT* schools. However, the extent of those gains varied compared to those observed for all NPLN literacy-focus schools, and for all State schools (NAPLAN data only).
- In both NAPLAN cohorts (students in Year 3 in 2008 and 2009) students at *MULTILIT* schools achieved slightly higher reading gain scores than for students across the State as a whole. In all cohorts, the reading growth observed for students at *MULTILIT* schools was generally in line with the gains achieved across all NPLN literacy focus schools.
- Overall, the reading gains in NAPLAN and NPLN Assessments for Aboriginal students were in line with those for non-Aboriginal students (Wallace, 2012a, p. 27).

The external evaluation (Wallace, 2012a) concluded that, although there were limited findings from the NAPLAN and NPLN assessment data, some strengths of the *MULTILIT* intervention were evident in analyses of other evaluation data, such as surveys and site visits. Identified strengths included increased student confidence; the way the approach engaged students, particularly younger students in Years 2–5; and the one-to-one approach.

Resources Required by Schools for Implementation
The resource requirements of implementing the *MULTILIT Reading Tutor Program* are as follows:

Classroom modification	Area for small group teaching
Special equipment	Not needed
Materials	Starter Kit comprising teacher and student materials Parent and teacher resources
Specialist teachers	Not needed, but can participate in the program
General classroom teachers	Participation by at least one staff member per school (general teacher, specialist teacher, aide, school leader) in a 3-day training course Possible replacement teachers for training course 80 lessons of up to 40 minutes each delivered one-to-one, over a 20 week period
Other personnel inputs	Program provider
Licence fee	Not applicable
Other inputs	Ongoing support and materials depending on needs

Evaluation of Evidence
The program developers have undertaken a series of detailed studies of the impact of the *MULTILIT* intervention on students, providing extensive monitoring of its effectiveness. The external evaluation of *MULTILIT* as one of the NSW programs funded under the National Partnership Agreement on Literacy and Numeracy (NPLN) provides an independent assessment of the effectiveness of the program, and of the extent to which it improved educational outcomes of Aboriginal students (Wallace, 2012b). The analysis showed that gains in literacy were being made at the local level, and there is reference to school reports of students' improved test scores and reading levels. Overall, the schools implementing *MULTILIT* achieved gains in NAPLAN and NPLN that were equivalent to all NPLN literacy-focused schools. This study found that although the *MULTILIT* methodology is prescriptive, most schools did not implement it strictly as recommended. This is a limitation in the research evidence.

The evaluation reported qualitative results from surveys, with the majority of respondents believing that *MULTILIT* had been effective in improving literacy, mainly in the areas of decoding and confidence in reading.

No cost-effectiveness studies were identified.

The conclusions drawn from the evaluation of *MULTILIT* are cautious, indicating that the data from NAPLAN and NPLN assessments are not conclusive. The finding that some students made greater and faster gains, while gains for others were slower or minimal has implications regarding the targeting of the intervention which need to be further explored. The research evidence for the effectiveness of the program is sound, but suggests that there is scope for ongoing monitoring of aspects of the design of the intervention, such as the value of the withdrawal approach, and implementation issues.

QuickSmart Literacy

Program Description
QuickSmart, which focuses on both literacy and numeracy, was developed at the National Centre of Science, Information and Communication Technology and Mathematics Education for Rural and Regional Australia (SiMERR) at the University of New England. The

intervention was initially funded during 2001 by the federal Department of Education, Science and Training (DEST) under the Innovative Programs in Literacy and Numeracy scheme, and was supported by an Australian Research Council (Discovery) grant in 2003-2005. It has been under development and continuous improvement since 2001. *QuickSmart Literacy* is aimed at middle years students in Australia, and is designed to improve students' fluency and facility with basic academic aspects of reading (Graham, Pegg & Alder, 2007). Although it is outside the K–3 focus of the review, is included as it involves remediation for students who have experienced learning difficulties in the earlier years of schooling, and may offer insights useful for earlier interventions.

The program is implemented in a small class instructional setting with two students, using a specially constructed program supported by extensive material and computer-based resources. The technology incorporated in *QuickSmart Literacy* was developed at the Laboratory for the Assessment and Training of Academic Skills (LATAS) at the University of Massachusetts. The Computer-Based Academic Assessment System (CASS) is a unique component of the program, and provides ongoing monitoring of students' skills, and supports the instructional focus of the intervention (Graham, Pegg & Alder, 2007). The program runs for three 30-minute lessons per week, over 30 weeks.

QuickSmart Literacy emphasises comprehension skills and encourages students to become quick in their response speed and smart in their understanding and strategy use. The intervention aims to improve students' information retrieval times to levels that free working memory capacity from an excessive focus on mundane or routine tasks. The activities fostering automaticity; time, accuracy and understanding are incorporated as key dimensions of learning and an emphasis is placed on ensuring maximum student on-task time. The lessons are designed to develop the learners' abilities to monitor their own learning and to set realistic goals for themselves.

QuickSmart Literacy focuses on improving students' automaticity of word recognition and fluency in reading connected texts. The reading intervention sessions are structured to include a number of short and focused activities aimed at improving students' speed of word recognition, reading fluency, and comprehension skills. Instruction is organised into units of three-to-four weeks' duration (i.e. 9–12 lessons) that centre on sets of focus words. The sets of focus words are either linked to a curriculum learning area, a quality literary text, or a theme of interest to the students. The focus words are incorporated in two or more passages of connected text relevant to the topic.

Research Evidence

Research evidence was selected that provided some evidence of the impact of the *QuickSmart Literacy* intervention on literacy outcomes for targeted students. Three reports were reviewed, from 2003, 2007 and 2011. The first study presented research on the role of automaticity in developing students' fluency and facility with basic academic facts (Graham, Pegg, Bellert, Thomas, 2004).

The second of these research reports provided analyses of data that had been recorded for a cohort of 47 students, from a NSW disadvantaged high school, who completed the *QuickSmart Literacy* program over three school terms during 2005-2006. This cohort included nine Aboriginal and Torres Strait Island students. Fifteen per cent of students enrolled at the school came from unemployed family backgrounds, and 11 per cent identified as Aboriginal or Torres Strait Islander. The school received funding in 2005 through the

Priority School Program, when the decision was made to implement the *QuickSmart Literacy* program in the school. A range of data was collected by SiMERR researchers (Graham, Pegg, Alder, 2007) at the conclusion of the *QuickSmart Literacy* program, including the ACER Progressive Achievement Test (PAT) of reading comprehension and the CASS.

The average percentile score for *QuickSmart Literacy* students on PAT for the pre-test was 34.42 compared with 52.7 percentile points for the post-test. Statistical analysis using a one-way analysis of variance indicated that this was a highly significant increase in test performance (Graham, Pegg, Alder, 2007).The CASS data collected before and after the intervention showed that all individual participants showed speed improvements and accuracy maintenance or improvement in most of the CASS sub-tests.

In the third, more recent, report, assessment results (state-wide or standardised tests) gathered by SiMERR program developers from *QuickSmart* (N=331) and comparison students (N=139) during 2011 demonstrated student growth of two to four years' improvement over a 30-week period as measured by effect size statistics. This report indicated that for all analyses undertaken, the achievement gap narrowed between *QuickSmart Literacy* students and their average-performing comparison group peers (SiMERR, 2011). Interviews and surveys of students, parents, teachers, and principals gathered positive qualitative data, indicating improvements for *QuickSmart Literacy* students in class, in their attitudes to school, their attendance rates and their levels of confidence in and out of the classroom. Longitudinal gains in the years after program completion were also claimed (SiMERR, 2011) but no evidence supporting this statement could be found.

Resources Required by Schools for Implementation

QuickSmart Literacy requires initial professional learning for the teachers or teacher aides who implement the program, and the purchase and replacement of *QuickSmart Literacy* resources. Regular access to technology is required to utilise the CASS software package. Funding is also required for ongoing time release for teachers to conduct *QuickSmart Literacy* sessions. Funding for training teachers new to the school may also be required, particularly in schools where there is high staff turnover.

The resource requirements of implementing the *QuickSmart Literacy* program are as follows:

Classroom modification	Area for small group teaching Computer facilities
Special equipment	Computers and Computer-Based Academic Assessment System (CASS) software
Materials	Purchase and replacement of *QuickSmart* materials
Specialist teachers	Not specifically required, but may participate Three 2-day professional development workshops if participating
General classroom teachers	Three 2-day professional development workshops if participating Three 30-minute lessons per week over 30 weeks, delivered to groups of 2 students Possible replacement of teachers conducting the sessions
Other personnel inputs	Provider support
Licence fee	Not applicable
Other inputs	Not specified

Evaluation of Evidence
The evidence found for this review indicated improvements in tests of speed and accuracy in specific aspects of reading for *QuickSmart Literacy*. The use of the PAT reading comprehension assessment provided data about this key aspect of literacy for success in the middle years. Qualitative data indicating maintenance of improvement over time was cited in the 2011 SiMERR report. The published reports from three different times, between 2003 and 2011, based on quantitative data over the period from 2003-2011, provide some evidence of positive outcomes for students. No cost-effectiveness studies were identified.

Tier 2 International Literacy Interventions

Literacy Lessons

Program Description
The *Literacy Lessons* intervention is based on the teaching approaches presented in the two volumes of *Literacy Lessons Designed for Individuals* (Clay, 2005a; 2005b). These books are companion volumes to *An Observation Survey of Early Literacy Achievement* (Clay, 2002). The aim is to share the repertoire of teaching strategies and literacy processing theory of *Reading Recovery* with a broader audience of teachers and a wider target group of students beyond Year 1. *Literacy Lessons* fits within the overall *Reading Recovery* intervention, but targets a new audience and different groups of students.

Literacy Lessons can be used to provide daily one-to-one instruction for students in Years 1–4 identified as experiencing significant difficulties in literacy learning. Reading Recovery tutors may provide support and extended professional learning for participating teachers. The main objective of the professional learning is to build the capacity of teachers in teaching, assessing, monitoring and planning further learning in literacy. The two *Literacy Lessons* books (Clay, 2005a; 2005b) provide practical advice, teaching procedures and explanations for the observations and teaching practices used in the daily individual sessions. These books are a key resource for this intervention.

The *Literacy Lessons* intervention provides a series of lessons for individual children designed after a detailed observation of the ways that each child responds to language as written code. The focus is on *learning to read and write* because a reciprocal relationship between these two sets of competencies allows them to support each other. In individual daily lessons, the child learns to select from several approaches to problem-solving, to work effectively with the written language code. The program starts from what the child can already do. Teachers use *the Observation Survey of Early Literacy Achievement* (Clay, 2002) to guide planning for each individual student's lesson.

Research Evidence
Literacy Lessons is an extension of Reading Recovery, and not a separate intervention. The two volumes of *Literacy Lessons Designed for Individuals* (Clay, 2005a; 2005b) introduce new procedures, and clarify existing Reading Recovery procedures. There are more detailed theoretical explanations, and examples than in the Reading Recovery guidebook. The lesson activities in the second volume *have been progressively refined and revised over 30 years* (Clay, 2005b, p. 1). The research base for *Literacy Lessons* is the same as the Reading Recovery research base, but provides access to this in two books presented in a new, practically focused format for a broader teaching audience. No published studies of the impact of *Literacy Lessons* as an intervention were located.

Resources Required by Schools for Implementation
Copies of the two *Literacy Lessons* books (Clay, 2005a; 2005b) and the Observation Survey (Clay, 2002) are required for all participating teachers. Funding is needed to enable teachers to attend ongoing professional learning sessions run by *Reading Recovery* tutors, whose time and expertise constitutes a key resource. Teacher time is also required for the daily individual lessons for students identified as needing additional support, and some preparation and planning time is necessary to maintain the targeted individual focus for the lessons.

The resource requirements of implementing the *Literacy Lessons* program are as follows:

Classroom modification	Area for small group teaching
Special equipment	Not needed
Materials	Teaching and assessment materials
Specialist teachers	Teachers trained in Reading Recovery
General classroom teachers	Professional learning support provided to all participating teachers by Reading Recovery tutors Possible replacement of teachers during the professional learning sessions
Other personnel inputs	Not specified
Licence fee	Not applicable
Other inputs	Not specified

No cost-effectiveness studies were identified. However, given the similarity of *Literacy Lessons* to *Reading Recovery*, the findings about the latter reported intervention are also likely to apply here (see the section below).

Evaluation of Evidence
As indicated above, *Literacy Lessons* has been derived from the evidence of the efficacy and effectiveness in the *Reading Recovery* research base that has accumulated over time. The extent of evidence for *Reading Recovery* was considered to be medium to large for alphabetics and general reading achievement, and small for fluency and comprehension (What Works Clearinghouse, 2008). *Literacy Lessons* targets different groups of students than *Reading Recovery*, and no specific studies evaluating the impact of *Literacy Lessons* on students' outcomes were located in the course of this review.

Reading Recovery

Program Description
Reading Recovery is an intensive intervention program for students in their second year of school. It was developed and trialled in New Zealand over 20 years ago, and is now implemented in a number of education systems internationally.

Students identified as being amongst the lowest 20 per cent for achievement in literacy learning after one year of schooling have access to this intervention. Trained *Reading Recovery* teachers administer the Observation Survey (Clay, 2002) to identify students whose progress by the end of the first year at school is in the lowest 20%. Selected students receive specialised individual assistance from experienced classroom teachers who have been trained as *Reading Recovery* teachers. The program is delivered to each student for 30 minutes each day of the week for 12–20 weeks. The program comprises reading familiar texts, working with letters and/or words, writing a story, assembling a cut-up story, introducing and reading a new book. Specially trained tutors conduct the training for *Reading Recovery* teachers, which occurs over a period of one year.

Each student is assessed on entering and on leaving the intervention, and his or her intervention outcome is documented as follows:

- Successfully completed – no longer needing support (discontinued),
- Requiring ongoing support referred for further assessment and continuing support (referred),
- Carried over – *RR* support will continue into Year 2, and
- Transferred – the student has moved to another school.

Data collection and records are kept for all *RR* students whose progress is monitored until they are in Year 3.

Research Evidence

There are numerous international and national studies of the effectiveness of *Reading Recovery*. The WWC analysis of these studies met their *What Works Clearinghouse* highest level of evidence, and one study met the standard of evidence 'with reservations'. The WWC report (2008) states the effectiveness of *Reading Recovery* was positive for alphabetic and general reading achievement, and had potentially positive effects on fluency and comprehension.

Shanahan and Barr (1995) presented a systematic analysis of all available empirical work on *Reading Recovery*. They concluded that the evidence at that time supported the conclusion that *Reading Recovery* brought the learning of many children up to that of their average-achieving peers; that learning gains were maintained; but that there had been little or any impact on students' classroom experience. Since then, there have been a large number of international studies of *Reading Recovery*. Allington (2005) noted that *Reading Recovery has more evidence supporting its efficacy than any other intervention in the marketplace*.

Research on the operationalisation of *Reading Recovery* in various school systems over 15 years has been reviewed by Reynolds and Wheldall (2007). The review identified aspects of the programme as implemented in a number of education systems that have been done well, and aspects that have not been done well. Strengths identified by Reynolds and Wheldall (2007) included the effectiveness of *Reading Recovery* as a short term intervention for many students, the optimal timing of the intervention for young learners, and the effective implementation process. Findings about what has not been done well included the lack of evidence that *Reading Recovery* has dramatically reduced literacy failure within education systems, and inequities stemming from the targeting the lowest achieving 20 per cent of students in schools. Reynolds and Wheldall (2007) suggest there is much that could be learned from what has been documented over two decades of *Reading Recovery*.

In the context of the present literature review, two reports from the WWC are relevant. The 2007 WWC Beginning Reading intervention report provided effectiveness ratings for *Reading Recovery* that showed positive effects with strong evidence of a positive effect with no overriding contrary evidence for alphabetics and general reading achievement. For fluency and comprehension, it showed potentially positive effects, with no overriding contrary evidence (What Works Clearinghouse, 2007). The extent of evidence for alphabetics, fluency and comprehension was small, but for general reading effectiveness was medium to large. The updated WWC Beginning Reading intervention report (What Works

Clearinghouse, 2008), showed positive effects for *Reading Recovery* for both alphabetics and general reading achievement, and potentially positive for fluency and comprehension.

Resources Required by Schools for Implementation
In summary, the resource requirements of implementing *Reading Recovery* are as follows:

Classroom modification	Area for small group teaching
Special equipment	Not needed
Materials	Teaching and assessment materials
Specialist teachers	Teachers trained in Reading Recovery over a year-long period
General classroom teachers	Professional learning support provided to all participating teachers by Reading Recovery tutors Possible replacement of teachers during the professional learning sessions
Other personnel inputs	Not specified
Licence fee	Not applicable
Other inputs	Not specified

The cost-effectiveness of *Reading Recovery* has been the subject of more research than for any of the other interventions reviewed in this report.

In the United States, an evaluation of evidence by Dyer and Binkley (1995) concluded that *Reading Recovery* reduced the need for costly special education programs, and Swartz (1992) found that *Reading Recovery* was cost-effective compared to remedial reading programs or grade retention (with both these interventions being relatively costly) and provided better learning gains than small group withdrawal. Lyons and Beaver (1995) concluded that by extent of grade repetition RR provided substantial savings to school districts. In the United Kingdom the *Every Child a Reader Program* (through which RR was provided) was found to generate substantial returns on the initial investment by reducing referrals and placements in special education and limiting the amount of grade repetition (Every Child a Chance Trust, 2009).

The most comprehensive and detailed cost-effectiveness study is by Simon (2011) in the United States who examined four early literacy programs that the WWC had determined showed evidence of effectiveness: *Accelerated Reader; Classwide Peer Tutoring; Reading Recovery;* and *Success for All*. The effect sizes for *Reading Recovery* are substantially larger than for the other three programs on each outcome measure considered in her study. Simon put considerable effort into estimating the costs of the programs, including the use of teacher time; such detail has generally been lacking in the other research. Not surprisingly, the small add-on programs intended for school-wide delivery, *Accelerated Reader* and *Classwide Peer Tutoring*, were found to be far less costly on a per-student basis for the students involved than *Reading Recovery* or *Success for All*. The latter was by far the most expensive program.

When the data on effect sizes and average costs per student were expressed as ratios, Simon (2011) found that the relatively small programs *Accelerated Reader* and *Classwide Peer Tutoring* appear to be more cost-effective than either *Reading Recovery* or *Success for All. The Success for All* program was estimated to be the least cost-effective approach because of the substantial school-wide involvement of staff it required and the fact that its effect sizes were not as large as those for *Reading Recovery* and *Classwide Peer Tutoring*.

The evaluations used by Simon (2011) focused on the immediate achievement gains, not those that are evident over the longer term. *Reading Recovery* was found to have substantially higher effect sizes, on average, than the other three programs analysed.

Evaluation of Evidence
The two WWC intervention reports of the effectiveness of *Reading Recover*y (What Works Clearinghouse, 2007; 2008) meet high evidence standards. Other large-scale studies of the long-term effects of *Reading Recovery*, comparing the achievement of students who participated in the intervention with the remainder of the year-level cohort in the US, indicated that gains from *Reading Recovery* were maintained (Schwartz, Hobsbaum, Briggs & Scull, 2009).

The extensive international research on the effectiveness of *Reading Recovery* presents multiple perspectives as to its value, but includes the research, cited above, which indicated it met high evidence standards on effectiveness, particularly over the longer term.

Literacy intervention products to address literacy teaching and learning

A range of literacy products and resources is used to support teaching and may also be adapted and used as forms of classroom intervention. Commonly used examples include *Lexia Reading, Corrective Reading, Spalding, Jolly Phonics, Phonics Alive!, Ants in the Apple* and *Reading Eggs*. The extent of their use in NSW schools is not clear. Many of these products have been developed and used internationally, and evidence of their efficacy tends to be confined to international sources.

A large body of research evidence about these products was found in the literature searches, including three studies that met the WWC standards of evidence for research. A brief discussion of these studies is included in order to indicate the impact of these products.

Lexia Reading is also known in the US as *Reading Plus*. The program is a web-based reading intervention aimed at providing individualised practice in silent reading for students in Year 3 and above. A 2010 WWC intervention report of adolescent literacy reported one research study that fell within WWC evidence standards, but with the reservations that the extent of evidence was small for the reading comprehension domain (What Works Clearinghouse, 2010). This study did not examine the effectiveness of *Reading Plus*® on adolescent learners in the alphabetic, reading fluency, or general literacy achievement domains, nor on the development of such domains in the early years of schooling.

Corrective Reading was included in the 2007 WWC Topic Report on beginning reading (What Works Clearinghouse, 2007) and received an effectiveness rating of 'potentially positive' for alphabetics and fluency, based on one study (Torgesen et al., 2006); noting however, that the extent of evidence was small. No discernible effects were reported for comprehension, also due to the small extent of evidence that met the WWC criteria.

The 2012 WWC Beginning Reading Intervention Report on *The Spalding Method*® (What Works Clearinghouse, 2012) found no studies that fell within the WWC evidence standards, and it was therefore unable to draw conclusions about the effectiveness of this intervention. For that WWC review, 17 studies of the intervention (which uses explicit instruction in grades K–3 to teach spelling, reading and writing) were identified that had been published since 1983. Two of these studies were within the scope of the WWC Beginning Reading

Protocol, but did not meet the necessary evidence standards. Both those studies used a quasi-experimental design, but they did not establish that the comparison group was comparable to the intervention group prior to the start of the intervention (What Works Clearinghouse, 2012).

The wide range of available literacy intervention products includes a variety of professional development programs and classroom materials. Some products focus on the teaching of specific aspects of literacy, while others integrate several key aspects of literacy. *Jolly Phonics* and *Phonics Alive,* for example, are products with a specific focus on phonics. Other programs, such as *Ants in the Apple* and *Reading Eggs* offer broader programs.

The professional development program and materials in *Jolly Phonics* support systematic, direct and explicit teaching of phonics to children in the early years of school. The approach is designed to contribute to the development of phonemic awareness, fluency, vocabulary and comprehension. Whole-school workshop sessions are available to support teachers' use of the teaching materials which include lesson plans and decodable readers. *Phonics Alive!* is a set of computer resources in structured phonics education, designed for use in the classroom and at home. *Phonics Alive!* introduces all letter shapes and sounds. Students complete modules and are awarded certificates on successful completion. The program has the capacity to diagnose a student's performance in a module and to determine whether the student needs further revision or can proceed to the next module.

Ants in the Apple is a product which offers phonics and phonemic awareness based spelling, reading, comprehension and handwriting teaching programs which are designed so they can be combined into an integrated literacy program.

Reading Eggs provides a series of lessons in a computer reading program. The lessons are designed to develop skills in the five key aspects of phonemic awareness and phonics**,** sight words**,** vocabulary**,** fluency and comprehension**.** The computer program includes 'driving lessons' that assess reading skills, such as high-frequency sight word knowledge, phonic skills (letters and sounds), and content area vocabulary.

Limited evidence of the effectiveness of *Jolly Phonics, Phonics Alive, Ants in the Apple* and *Reading Eggs* is available. Some anecdotal evidence and testimonials are provided by the respective developers of the interventions, and from school-level case studies. No publicly available evidence of independent evaluations meeting the criteria used in this review was located.

2.2 General Principles of Effective Literacy Intervention in the Early Years

Critical aspects of effective literacy interventions in the early years are reported in the Australian and international literature. This section summarises key findings from that research in order to contextualise the findings about interventions currently used in NSW schools.

The 1998 report of the committee established by the US National Academy of Sciences, *The Prevention of Reading Difficulties in Young Children* (Snow et al., 1998) focused on reading in the early years of school. The following common features were found to be shared by successful literacy interventions:

- *Duration of the intervention – generally occurring on a daily basis for the duration of the school year or a good portion of the school year.*
- *The amount of instructional time – all successful interventions involve more time for reading and writing than for children not at risk – but extra time is not sufficient itself.*
- *In each case, there is an array of activities that generally consist of some reading (and rereading) of continuous text. In addition, each intervention features some form of word study. In some cases, specific strategies for decoding are incorporated.*
- *In all cases, writing is an important feature. However, the writing activity is not simply support while engaging in invented spelling; it is typically conducted in a more systematic manner.*
- *Although materials vary among the interventions, in each case there is careful attention paid to the characteristics of the material used, whether they are characterized as predictable, patterned, sequenced from easy to more difficult, or phonologically protected. There is a focus on using text that children will find interesting and engaging.*
- *Each program includes carefully planned assessments that closely monitor the response of each child to the intervention* (Snow et al., 1998, pp. 272–273).

The report also emphasised how professional development was integral to effective intervention programs, taking account of the importance of the relationship between the skill of the teachers and children's responses to early intervention (Snow et al., 1998).

Further research on the features of effective interventions is noted by Hughes and Dexter (2011) on the basis of studies that reported some level of reading improvement. Supporting factors common to most of the studies included:

- extensive and ongoing professional development;
- administrative support;
- teacher buy-in; and
- adequate meeting time for coordination.

It is interesting to note the emphasis placed by Hughes and Dexter on the first of these factors, the integral role of professional learning, which is in agreement with the emphasis placed by Snow et al. (1998). The three factors refer to school-level factors, indicating that it is not only the design of the intervention that contributes to its effectiveness, but also to the context in which an intervention is implemented.

Another key source of evidence of the impact of interventions on improving student literacy achievement was found in a number of meta-analyses and best-evidence syntheses. Hattie (2009) summarised 50 meta-analyses on reading research, based on over 2000 studies and about 5 million students with an average effect size of 0.51. His meta-analysis shows the significance and value of actively teaching the skills and strategies of reading across all years of schooling, and the need for planned, deliberate, explicit, and active programs to teach specific skills. A key finding was that some programs, particularly those based on skills and strategies, were successful, while programs without such emphases had very minimal effects (Hattie, 2009).

In a review of 45 literacy intervention schemes in use in the UK, Brooks (2007; 2012 in press) found that 'ordinary teaching' (i.e. 'no intervention') did not enable children with literacy difficulties to catch up. His review pointed to the need for phonological skills for reading to be embedded within a broad approach. Brooks reviewed intervention schemes which incorporated follow-up studies, and the review showed that the children maintained their gains or even made further gains. Brooks sees the implications of this additional finding as pointing to classroom teachers needing to be aware of the progress of children in intervention schemes, and raising their expectations in line with that progress. Lasting benefits from effective intervention schemes depend on these connections, between the intervention and general classroom teaching. This finding fits with the importance of the school-level contextual factors identified by Hughes and Dexter (2011).

The best evidence synthesis undertaken by Slavin, Lake, Davis and Madden (2011) identified 96 studies that met the criteria of a) randomised or well-matched control groups, b) study duration of at least 12 weeks, and c) the use of valid measures of independent treatments. Three of the key findings of the review were that:

- Small group tutorials can be effective, but one-to-one tutoring works better. Teachers are more effective as tutors than teaching assistants or volunteers, and an emphasis on phonics greatly improves tutoring outcomes.
- Effects last into the upper primary years only if classroom interventions continue beyond an initial period of Kindergarten–Year 1.
- Classroom teaching process approaches, especially co-operative learning and structured phonetic models, have strong effects for low achievers (as well as other pupils).

Slavin, Lake, Chambers, Cheung, and Davis (2009) reported 63 studies of beginning reading programs and 79 studies of upper elementary reading programs that met stringent methodological requirements and provided educators and policy makers with several robust approaches towards improving students' reading performance. This research also identified types of approaches that have not been successful in improving elementary reading performance. Slavin et al. (2009) found that for both beginning and upper elementary reading, there was extensive evidence supporting forms of cooperative learning in which students work in small groups to help one another master reading skills, and also for ones in which the success of the team depends on the individual learning of each team member.

Gersten et al. (2009) in the Institute of Education Sciences report *Assisting students struggling with reading: Response to Intervention and multi-tier intervention for reading in the primary grades* compiled specific recommendations (and their corresponding levels of evidence) about reading intervention based on their analyses of the research evidence. Table 2.3 provides a summary of the five recommendations in Gersten et al. (2009). The levels of evidence in Table 2.3 refer to a categorisation of the strength of the research evidence for reading intervention based primarily on WWC evidence. Strong evidence requires consistent evidence of intervention effects across multiple well-designed studies with a sound basis for generalising the findings. Moderate evidence may be derived from well-designed studies with limited scope for generalisation or less clear evidence for the efficacy of the intervention. Evidence for the efficacy of an intervention is low if it does not meet moderate or strong standards of evidence.

Table 2.3. Gersten et al.'s (2009, p. 6) recommendations and corresponding levels of evidence for reading interventions

Recommendation		Level of evidence
Tier 1 intervention/general education		
1.	*Screen all students for potential reading problems at the beginning of the year and again in the middle of the year*. Regularly monitor the progress of students at risk for developing reading disabilities.	**Moderate**
Tier 2 intervention		
2.	*Provide time for differentiated reading instruction for all students based on assessments of students' current reading level.*	**Low**
3.	*Provide intensive, systematic instruction on up to three foundational reading skills in small groups to students who score below the benchmark score on universal screening*. Typically, these groups meet between three and five times a week, for 20 to 40 minutes.	**Strong**
4.	*Monitor the progress of tier 2 students at least once a month.* Use these data to determine whether students still require intervention. For those students still making insufficient progress, schoolwide teams should design a tier 3 intervention plan.	**Low**
Tier 3 intervention		
5.	*Provide intensive instruction on a daily basis that promotes the development of the various components of reading proficiency to students who show minimal progress after reasonable time in tier 2 small group instruction (tier 3).*	**Low**

Source: Gersten, Compton, Connor, Dimino, Santoro, Linan-Thompson, and Tilly's (2009) compilation based on analysis described in their text.

Literacy interventions focused on reading

The evidence-based assessment of research literature on reading conducted by the US National Reading Panel (2000) was focused on the question of how classroom instruction is best provided in improving reading achievement, not specifically on the effectiveness of literacy interventions. However, the findings of the National Reading Panel have some clear implications for the focus of literacy interventions with the primary purpose of providing support for students experiencing difficulties in learning to read. The Panel's assessment was that *systematic phonics instruction in Kindergarten and 1st grade is highly beneficial*. The report also pointed out that phonics should not *become the dominant component in the reading program, neither in the amount of time devoted to it nor in the significance attached* (National Reading Panel, 2000).

Eight specific comprehension strategies were found to be effective for classroom instruction. The Panel found that when teachers learnt how to teach these strategies effectively students' comprehension improved.

1. *Comprehension self-monitoring*
2. *Co-operative and peer learning through context reading strategies*
3. *Graphic and semantic organizers to aid word and text understanding.*
4. *Story structure scaffolding strategies.*
5. *Question answering and feedback response.*
6. *Reader questioning generated about the text.*
7. *Reader summarization of main ideas.*
8. *Teaching about multiple-strategies (*National Reading Panel, 2000*).*

The strong evidence of the value of these strategies in improving students' reading comprehension has relevance both for general classroom teaching, and for interventions.

Planning for literacy interventions

A further element of the work of Snow et al. (1998) that is relevant to the present literature review is the listing of overarching considerations that need to be addressed in the planning, selection and implementation stages of all literacy interventions. The first of these refers to the importance of considering the intervention in the light of available financial, instructional and cultural resources. These are matters of costs and cost-effectiveness, and the importance of the timing of an intervention, at what stage of schooling an intervention might be most effective, and the duration of specific interventions.

Snow et al. (1998) emphasise the importance of assessing existing factors that influence learning before simply adding an intervention to the school program. For example, the adequacy of existing instructional practices must be considered before deciding to implement any intervention. They also identify the need to assess the adequacy of existing instructional practices before deciding to implement any intervention has implications for the way in which student needs are identified and diagnosed, in order to ensure the targeting of an intervention to these needs.

Although encompassing a broader focus, it is helpful to consider the work of Paris (2005) on the development of reading skills, and the implications of this work for planning effective literacy interventions. He argues that a reinterpretation of the development of reading skills is required because of the lack of attention to fundamental differences in the developmental trajectories of reading skills: *these different trajectories are manifested in different time of skill onset, different durations of acquisition, and different asymptotic levels of performance* (Paris, 2005). The constraints that influence analyses of reading development fall into three categories: letter knowledge, phonics, and concepts of print are highly constrained; phonemic awareness and oral reading fluency are less constrained; and vocabulary and comprehension are least constrained.

One of the developmental constraints that Paris identifies is mastery.

> *Some reading skills, such as learning the alphabet are mastered completely, whereas other skills, such as vocabulary, are not. Whether the learning occurs during childhood or adulthood does not change the fact that the degree of learning is complete. Moreover, the duration of learning of mastered skills is relatively brief. These temporal constraints are not evident in unconstrained skills that continue to develop over the life course* (Paris, 2005).

There are a number of implications for the prioritising, timing and planning of literacy interventions to be drawn from this work. Effective interventions should embrace both constrained and unconstrained skills, depending on the individual needs of participating students. It is likely that, for many students, attention to the constrained skills may be more frequent in interventions in the early years of schooling, whereas interventions to strengthen the least constrained skills, such as comprehension, are relevant across the years of early primary, primary and secondary school.

Furthermore, while noting *that constrained skills need to be mastered because they are necessary but not sufficient for other reading skills*, Paris warns that *excessive testing of constrained skills may lead to an overemphasis on these skills to the exclusion of unconstrained skills such as vocabulary and comprehension* (Paris, 2005).

Several findings from these studies above offer insights into aspects of intervention programs that contribute to their effectiveness. These include:

- The importance of attending to all aspects of good reading instruction rather than focusing on a single aspect (Hattie, 2009; Paris, 2005).
- Evidence that adequate ordinary teaching, without intervention did not provide adequate support for students with literacy difficulties (Brooks, 2007).
- The importance of connections between intervention schemes and normal classroom teaching (Brooks, 2007).
- The influence of maintaining the effects of interventions and the continuation of classroom interventions beyond the first two years of school (Slavin, Lake, Davis & Madden, 2009).
- The importance of teacher professional learning (Snow et al., 1998; Hughes & Dexter, 2011).

Teacher professional learning and effective interventions

A large scale review of studies addressing the effect of teacher professional development on student achievement in the three content areas of mathematics, science, and reading and English/language arts (Yoon, Duncan, Lee, Scarloss, & Shapley, 2007) is of interest to this review in relation to the emphasis placed by this study on teacher professional learning in interventions. More than 1,300 studies were identified as potentially addressing the effect of teacher professional development on student achievement, but only nine met the WWC standards, attesting to the paucity of rigorous studies that addressed the question of the effect of teacher professional development on student achievement.

The nine studies in the Yoon et al. (2007) review, ranging from 1986 to 2003, focused on primary school teachers and their students, and half of these were Kindergarten and first grade. Four of the studies focused on student achievement in reading and English/language arts. The results of these nine studies showed that average control group students would have increased their achievement by 21 percentile points if their teacher had received substantial professional development, indicating *that providing professional development to teachers had a moderate effect on student achievement across the nine studies. The effect size was fairly consistent across the three content areas reviewed* (Yoon et al., 2007). The average effect size in reading and English/language arts was 0.53. This report provides further support for the significance of teacher professional learning in improving student achievement.

While the cost of the teacher professional learning components in intervention programs can be significant, the benefits to students can be considerable. The Yoon et al. (2007) study also highlights the need to increase the number of rigorous studies of the links between professional development and student achievement in assessing the efficacy and effectiveness of literacy interventions, and the field of intervention more broadly.

2.3 In Conclusion

Mapping the Territory, the national Australian research study of primary students with learning difficulties (Louden et al., 2000) drew attention to the relative absence of formal evaluations of the effectiveness of programs, and the ways in which this reflected the complexity of the phenomena being evaluated. From the available literature, the report identified questions to be asked about the effectiveness of interventions, and these questions are indicative of wherein effectiveness lies:

- *Does the intervention lead to improvements in students' performance?*
- *Are new skills or strategies transferred to situations other than post-intervention assessments?*
- *Are gains maintained?*
- *Does improved performance lead to improvements in other kinds of learning?* (Louden et al., 2000)

If these questions can be answered in the affirmative, an intervention might be described as effective. Without the evidence of independent, external and rigorous evaluations, it is difficult to answer such questions.

This review of a wide range of interventions has highlighted the diversity of approaches to supporting students' literacy learning in the early years of schooling, and beyond. It has also identified the complexity of the elements necessary for effective intervention. There is a clear need for more evidence of the impact of an intervention from rigorous evaluations, both for informing educators at all levels of the implications of selecting an intervention, and for the continuing refinement and improvement of resources, teaching and learning strategies, and the ongoing monitoring of targeted students' progress over time.

Beyond the early years, the value of effective literacy skills is integral to learning in all areas of the curriculum, and the literacy demands of the more differentiated curriculum-specific work in upper primary and secondary school. An increase in the collection of longitudinal data about targeted students' literacy progress throughout the years of schooling the early years, and into the upper primary and secondary years would add considerably to educators' understanding of the full range of long term benefits of effective literacy intervention.

3. NUMERACY INTERVENTIONS IN THE EARLY YEARS OF SCHOOLING

The purpose of this section of the literature review is to assess the available research evidence for the efficacy and effectiveness of a range of numeracy intervention programs currently implemented (or which could be implemented) in New South Wales (NSW). The focus for the review is primarily on relevant Australian interventions; however, the review includes selected international interventions for which there was evidence of the efficacy of the intervention. A thorough analysis and critique of the research evidence specific to individual interventions is presented in Section 3.1. Section 3.2 extends the review of individual interventions by describing general principles underlying effective intervention in numeracy.

3.1 Research Evidence for Selected Numeracy Interventions

Table 3.1 lists the 21 numeracy interventions reviewed according to whether the intervention was Australian or international and whether the intervention was best described as Tier 1 or 2 in the *RtI* framework.

Table 3.1: Overview of the numeracy interventions reviewed

Australian Numeracy Interventions	
Tier 1	**Origin**
Count Me in Too (CMIT)	New South Wales
Count Me in Too Indigenous (CMITI)	New South Wales
First Steps in Mathematics	Western Australia
Learning in Early Numeracy (LIEN)	New South Wales
Mathematics in Indigenous Contexts Project	New South Wales
Numeracy Matters	New South Wales
Success in Numeracy Education (SINE)	Victoria
Taking off with Numeracy (TOWN)	New South Wales
Tier 2	**Origin**
Best Start Targeted Early Numeracy (TEN)	New South Wales
Extending Mathematical Understanding Intervention (EMU)	Victoria
Getting Ready in Numeracy (GRIN)	Victoria
Mathematics Intervention	Victoria
Mathematics Recovery	New South Wales
Numeracy Intervention Project (NIP)	New South Wales
Numeracy Intervention Research Project (NIRP)	Victoria
QuickSmart Numeracy	New South Wales
Taking off with Numeracy (TOWN)	New South Wales
Train a Maths Tutor Program	Queensland
International Numeracy Interventions	
Tier 1	**Origin**
Building Blocks	United States
Everyday Mathematics	United States
Tier 2	**Origin**
Numeracy Recovery (Catch Up Numeracy)	England
Number Rockets	United States

In general, there is a paucity of strong research evidence describing the efficacy of specific interventions to improve children's numeracy understanding in the first four years of school. For many widely used numeracy intervention programs, there is limited or very limited evidence that the program improves student achievement in mathematics (see for instance Project Seed, What Works Clearinghouse, 2012a). The current review drew on a wide range of evidence in compiling the analyses of individual programs, and has endeavoured to draw together information from different sources (e.g. published academic research, program evaluations, policy documents, program guidelines) to describe the purpose of interventions and to complete evaluations of intervention efficacy.

It should be emphasised that the literature review focused on the *strength of the evidence* for specific numeracy interventions. A lack of evidence for an intervention does not necessarily indicate that the intervention is ineffective; instead, it may indicate the need to collect more rigorous data to evaluate whether the intervention achieves its intended aims. It is not the intention of the review to develop a proposition about the most effective numeracy interventions of those currently implemented in NSW. Instead, the review aims for a thorough critique of the existing research evidence for the effectiveness of specific interventions, as well as a review of the evidence for specific general principles of effective intervention in numeracy in the early years of schooling. Where research evidence for a specific numeracy intervention is lacking, there may be sufficient evidence that the intervention incorporates general principles of effective numeracy intervention, which suggests that the intervention is likely to be successful.

Owing to the extremely wide variation in the availability of evidence for specific interventions, the length and depth of the discussion of each intervention varies. These differences are due to variations in available evidence and do not reflect the perceived importance of any particular intervention. The section on each intervention briefly describes the following:

- the key features of the initiative,
- a synthesis of the available research evidence for the efficacy of the program,
- the resources required by schools to implement the intervention (these details are summarised in a table), and
- an evaluation of the research evidence.

The program descriptions highlight known structural features of each intervention, including the theoretical grounding of the intervention, specific target groups, the mathematical focus of the intervention, the instructional approach, student assessment methodologies and the duration of the intervention. Table 3.2 classifies the main elements of each program. Table 3.2 was populated based on information obtained from publicly available research, evaluation reports, and program guidelines. In some cases, information was limited to the report of a pilot study of the program. It is probable that, over time, the program developers and/or schools may have modified and adapted the intervention to suit individual school contexts and in light of feedback on the strengths and weaknesses of implementation. So for instance, the developers of a pilot of a numeracy intervention at a single year level could have extended the intervention later to target a wider range of students.

Most programs listed in Table 3.2 target children from K–3. In a small number of cases, the review describes numeracy intervention programs for older children. For example, *QuickSmart Numeracy* addresses the needs of children in Years 5–8; however, the program

was included in the review for the following reasons. First, *QuickSmart Numeracy* is an Australian numeracy intervention program that has been the subject of reasonably extensive research and evaluation, which provides useful data in the context of generally sparse research evidence. Second, the relatively narrow focus of *QuickSmart Numeracy* on automaticity and speed of retrieval for basic facts serves as a contrast to some of the reviewed numeracy intervention programs with a broader focus. An explicit rationale for the inclusion of other numeracy intervention programs for older children is included in the text of individual program descriptions.

Overview of Numeracy Intervention Programs

The numeracy interventions discussed in this section represent a broad range of approaches to improving children's numeracy learning. Different intervention types represented in this section include system-wide education sector initiatives, small academic research projects, academic research projects that education authorities subsequently implemented on a wider scale, and numeracy intervention products, some of which may have developed as part of funded academic research. Despite very different origins, numeracy intervention programs in Australia have significant commonalities, often sharing similar conceptual underpinnings (e.g. the importance of professional learning in promoting teachers' understanding of children's arithmetical development, the use of the clinical one-to-one interview as a means of diagnosing children's current understanding, and theoretical frameworks drawn from mathematical cognition about the way children acquire numerical concepts). Many of the programs also owe much to two influential numeracy projects in Australia: the *Count Me in Too* project in NSW (originated in 1996 as *Count Me In*) and the *Early Numeracy Research Project (ENRP)*[8] implemented in Victoria in 1999. In this section, a brief background to the history of some currently operating numeracy intervention programs is provided as a way of contextualising the review of the efficacy of these programs.

Research conducted by academics from Southern Cross University underpins or influences most of the programs currently being provided in NSW for students mathematically 'at risk' and needing additional support. *Mathematics Recovery* was the outcome of a three-year research and development project at Southern Cross University in northern NSW, conducted in 1992–5. The project received funding from the Australian Research Council and major contributions in the form of teacher time, from government and Catholic school systems. Over the 3-year period, the project involved working in 18 schools with 20 teachers and approximately 200 participating first-grade students (Wright, 2000). The theoretical origins of *Mathematics Recovery* derive from the research program of Les Steffe, who is a professor in mathematics education at the University of Georgia in the United States. In the 1970s and 1980s, Steffe's research focused almost exclusively on early number learning (e.g. Steffe, 1992; Steffe, Cobb, & Von Glasersfeld, 1988), with the overarching goal of this research program to develop psychological models to explain and predict students' mathematical learning and development.

Initial research on *Mathematics Recovery* informed the development of *Mathematics Intervention* (Pearn & Merrifield, 1995, 1996; Pearn, Merrifield, & Mihalic, 1994). In NSW, the *Count Me In*, *Count Me In Too*, and *Counting On* numeracy programs shared the research base, learning framework and assessment approach of *Mathematics Recovery* and included

[8] Early Numeracy Research Project (1999–2001) Summary of the Final Report available at http://www.eduweb.vic.gov.au/edulibrary/public/teachlearn/student/enrpsummaryreport.pdf

extensive professional development for teachers based on the *Mathematics Recovery* model (Wright, 2002). The principles underlying *Mathematics Recovery* have been influential in the development of a number of other numeracy intervention programs, and it has been very successful in other countries, most notably the United Kingdom and the United States (Wright, 2002).

After 1993, there were ongoing discussions between mathematics researchers and the Victorian Department of Education about the most appropriate provision of assistance for students needing additional support for mathematics in Year 1. After these discussions, the *ENRP* was funded in 1999. The *ENRP* resulted in Victoria's *Early Numeracy Interview* and the *Framework of Mathematical Learning* developed by the Australian Catholic University (ACU) in Melbourne (Clarke, Mitchell, & Roche, 2005). Victorian primary teachers currently use both the *Early Numeracy Interview* and the *Framework of Mathematical Learning*. At the conclusion of the *ENRP*, one of the educators involved in this project developed the *Extending Mathematical Understanding* (*EMU*) program in 2004, for which ACU continues to offer professional learning. *Success in Numeracy Education* (*SINE),* developed in 2000, also built on the work embedded in *Mathematics Recovery* and *Mathematics Intervention*. *SINE* again highlighted the importance of professional learning for teachers in assisting them to identify the strengths and weaknesses of their students' mathematical knowledge by conducting a one-on-one interview at the appropriate level. Once teachers had identified the strategies their students were using to solve mathematical tasks they were expected to place their students at a level on each of the domains on the *Framework of Mathematical Learning* (Growth Points[9]) and then provide appropriate instructional activities.

In NSW, a K–6 mathematics syllabus provides information on teaching and learning in mathematics. The syllabus is organised around six strands, reflecting process (working mathematically) and content (number, patterns and algebra, data, measurement, and space and geometry) (NSW Board of Studies, 2006). A phased approach to the introduction of the NSW syllabuses for the Australian curriculum is in progress, with the new Mathematics K–10 syllabus due for full implementation in 2015 (NSW Board of Studies, 2012). Mathematical content in the K–6 mathematics syllabus is outlined in stages and describes the knowledge, skills and understanding demonstrated by the typically developing child at the end of the stage.

Key mathematical ideas are embedded in a continuum of learning, which, while represented as a linear progression, clearly articulates the variability in the rate and patterns of children's development. In this context, children who are not making expected progress at key stages will need to be identified and learning activities planned which are designed to promote mathematical understanding in areas of need. In NSW, all children beginning Kindergarten at government schools are assessed individually by their teacher using an early numeracy schedule which profiles children's number knowledge as they enter school. The *Best Start Kindergarten Numeracy Assessment* (NSW Department of Education and Training, 2007) incorporates key ideas from the *Schedule for Early Number Assessment* (developed for *Mathematics Recovery*) and focuses particularly on children's application of counting to solve problems. The data from the *Best Start Kindergarten Numeracy Assessment* provides valuable knowledge to teachers on each child's number knowledge that can inform the development of individualised learning plans (Gould, 2011).

[9] A detailed discussion of the concept of growth points in children's mathematical development appears in Section 3.2.

At present, a range of numeracy intervention programs are utilised in Government, Catholic and Independent schools in NSW. Schools in all sectors have autonomy to make decisions about the implementation of specific interventions and, in the main, evidence for the efficacy of these interventions is collected within individual schools. All education authorities in NSW embed their approach to intervention in an *RtI* framework. Numeracy intervention programs implemented in NSW government schools include *Count Me in Too* (*CMIT*), *QuickSmart Numeracy*, *Best Start Targeted Early Numeracy* (*TEN*), and *Taking off with Numeracy* (*TOWN*). The NSW Department of Education and Communities (NSW DEC) does not collect data from schools on the numeracy intervention programs schools have implemented so there is no overall picture of the distribution of implemented numeracy intervention programs across NSW government schools. Catholic schools in NSW have implemented (or plan to implement) numeracy intervention programs which include *Extending Mathematical Understanding* (*EMU*), *First Steps in Mathematics*, *Numeracy Intervention*, *Numeracy Matters*, *QuickSmart Numeracy*, and *TOWN*. The Association of Independent Schools of NSW nominates *Learning in Early Numeracy* (*LIEN*) and *Learning in Numeracy* as numeracy intervention programs operating in NSW independent schools.[10]

This section provided a brief overview of the development of a range of Australian numeracy intervention programs. The origins of some of these programs and the interrelationships between them were considered. Specific numeracy intervention programs implemented in NSW schools by education authorities were identified, and their implementation in the context of a NSW syllabus and numeracy continuum outlining expected achievement at key stages was considered. The following section contains a comprehensive review of the purposes of a range of numeracy intervention programs and assesses the research evidence for their efficacy. Table 3.2, which classifies the main elements of the interventions reviewed, is presented first to summarise the characteristics of the reviewed interventions.

Interventions described in Section 3.1 provide examples of commonly used interventions (e.g. *CMIT*), supplemented by descriptions of selected pilot programs and some international interventions. These reviews focused primarily on describing interventions identified by NSW education authorities as currently implemented in NSW schools. A selection of additional interventions provided a wider perspective on approaches to numeracy intervention in Australia and internationally.

The current review almost exclusively provides evidence for numeracy interventions designed to improve the performance of students with low achievement in numeracy. In a small number of cases interventions were reviewed that focused on the achievement of specific groups (e.g. Aboriginal students), but there were no interventions identified that specifically targeted students from language backgrounds other than English.

[10] Information provided by the NSW DEC, Catholic Education Commission NSW and The Association of Independent Schools of NSW in their submissions to the MAGLN.

Table 3.2: Classification of the major features of the numeracy interventions reviewed

Australian Numeracy Interventions					
Tier 1					
Numeracy Intervention	**Origin**	**Target Group**	**Year level**	**Intervention Focus**	**Kinds and forms of student assessment**
Count Me in Too	New South Wales	All students	K–6	Through professional learning, teachers develop a better understanding of how children learn arithmetic. They then develop teaching strategies based on their understanding of each child's development in terms of the *Learning Framework in Number (LFIN)*	Schedule for Early Number Assessment (SENA)
Count Me in Too Indigenous	New South Wales	Aboriginal and Torres Strait Islander students	K–2	The principles of *CMIT* were adapted to be culturally appropriate for Aboriginal children	Modified SENA
First Steps in Mathematics	Western Australia	All students	Foundation–Year 2	Professional learning focuses on enhancing teacher knowledge in the four strands of mathematics and to better understand children's mathematical difficulties	Diagnostic map included with resources
Learning in Early Numeracy	New South Wales	All students	K–4	Professional learning for teachers enhances their understanding of children's development of number concepts in the context of growth points of the ENRP so as to better intervene to promote children's understanding	Clinical interviews[11] with all students

[11] Clinical interview methods are one-on-one interviews conducted to diagnose children's current mathematical understanding. An individual interview allows scope to explore children's thinking in detail and link their understanding to specific frameworks of mathematical development. The assessment method is discussed in more detail in Section 3.2.

Australian Numeracy Interventions					
Tier 1					
Numeracy Intervention	**Origin**	**Target Group**	**Year level**	**Intervention Focus**	**Kinds and forms of student assessment**
Mathematics in Indigenous Contexts Project	New South Wales	Aboriginal and Torres Strait Island students	Initially K–6, other implementations occurred in a secondary context	Learning teams in schools comprising teachers, parents and mentors (both internal and external) collaborated to develop mathematics units of work contextualised for Aboriginal students.	SENA
Numeracy Matters	New South Wales	All students	3–6	Online professional learning for teachers to develop shared understanding of numeracy development is part of a whole school approach to improve the teaching of numeracy.	Clinical interview for selected students considered at risk in K–4
Success in Early Numeracy	Victoria	All students	Foundation–6	Professional learning to develop teachers' understanding of children's mathematical development using clinical interviews to assess children's understanding and the growth points of the *ENRP* to describe children's achievement.	Clinical interview
Tier 2					
Best Start Targeted Early Numeracy	New South Wales	Students with low attainment in mathematics	K–2	Professional learning provided to *TEN* facilitators who in turn provide professional learning to teachers to improve their understanding of mathematical development, and to support teachers to identify and address the learning needs of targeted students.	TEN assessment

Australian Numeracy Interventions					
Tier 2					
Numeracy Intervention	**Origin**	**Target Group**	**Year level**	**Intervention Focus**	**Kinds and forms of student assessment**
Extending Mathematical Understanding Intervention	Victoria	Students with low attainment in mathematics	1–2	Professional learning for specialist teachers to improve their understanding of mathematical development, equip them to administer the one-to-one interview and describe children's understanding in relation to growth points.	Mathematics Assessment Interview
Getting Ready in Numeracy	Victoria	Students with low attainment in mathematics	3	*GRIN* tutors withdraw students in small groups and undertake short sessions which familiarise them with the content of their upcoming mathematics lesson.	Not known
Mathematics Intervention	Victoria	Students with low attainment in mathematics	1–4	Teachers undertake professional learning to gain familiarity with the clinical interview method. Teachers work with small groups of students using tasks designed to progress children's understanding on Steffe and colleagues counting stages.	Clinical interview
Mathematics Recovery	New South Wales	Students with low attainment in mathematics	1	Teachers trained in the *Mathematics Recovery* method assess children, describe their current number knowledge using the *SEAL* and work with them individually and intensively using targeted instructional strategies designed to progress their understanding	Clinical interview

Australian Numeracy Interventions					
Tier 2					
Numeracy Intervention	**Origin**	**Target Group**	**Year level**	**Intervention Focus**	**Kinds and forms of student assessment**
Numeracy Intervention Project	New South Wales	Students with low attainment in mathematics, low SES schools	1, 4, 8	Teachers undertake professional learning to increase their understanding of mathematical development and gain familiarity with the SENA. They work individually and intensively with students selected for the intervention.	SENA
Numeracy Intervention Research Project	Victoria	Students with low attainment in mathematics	3–4	Teachers worked intensively with individual students or with small groups, with the aim of developing effective instructional approaches to facilitating number development among low attaining students.	Not known
QuickSmart Numeracy	New South Wales	Students with low attainment in mathematics	5–8	Students are withdrawn from class in pairs and undertake an intensive intervention designed to improve automaticity and speed of retrieval for basic arithmetic facts.	Cognitive Aptitude Assessment System
Taking off with Numeracy[12]	New South Wales	All children, students targeted as having low attainment in mathematics	3–6	Teachers undertake professional learning to improve their understanding of how children develop mathematical understanding. In class intervention for targeted students is designed to help them develop more efficient strategies and higher-order mathematical thinking.	Whole class assessment and student progress monitoring
Train a Maths Tutor Program	Queensland	Aboriginal and Torres Strait Islander students	Primary, secondary	Focus on training IEWs to better understand mathematical concepts so as to better assist Aboriginal and Torres Strait Islander children in the classroom	Not applicable

[12] TOWN is also a Tier 1 numeracy intervention program.

International Numeracy Interventions					
Tier 1					
Numeracy Intervention	**Origin**	**Target Group**	**Year level**	**Intervention Focus**	**Kinds and forms of student assessment**
Building Blocks	United States	All students	Preschool–2	The program uses the framework of learning trajectories for the development of children's mathematical thinking, with activities embedded in the program designed to encourage the development of conceptual thinking on these trajectories.	Building Blocks student assessments
Everyday Mathematics	United States	All students	Preschool–6	Professional learning for teachers supports the implementation of the program, which focuses on developing students' informal knowledge of mathematics and assisting them to make connections to formal mathematical concepts. Small group work, problem solving, discussion and the use of concrete manipulatives are features of the program.	Everyday Mathematics student assessments
Tier 2					
Numeracy Recovery (Catch Up Numeracy)	England	Students with low attainment in mathematics	2	Teachers undertake professional learning to implement the intervention, which involves identifying specific areas of need in ten components of early numeracy and developing individualised instruction to promote learning in these areas.	Formative assessments to develop a learner profile
Number Rockets	United States	Students with low attainment in mathematics	1	Teachers undertake professional learning focused on implementing the initiative. Students receive additional mathematics instruction in small groups with content focused on the development of number sense.	Formative assessments

Tier 1 Australian numeracy interventions

Count Me in Too

Program Description

CMIT is a whole class numeracy intervention for children K–6 supported by a school-based professional learning program that aims to improve teacher understanding of the development of children's mathematical knowledge. The program commenced in NSW in 1996 as *Count Me In* and continues to operate across schools in NSW and the ACT as a support for the K–6 Curriculum. *CMIT* is closely related to the *Mathematics Recovery* program from which it adopted the *LFIN* and the *SENA* (Stewart, Wright, & Gould, 1998). *CMIT* was used as the basis for developing the *New Zealand Numeracy Project* for children in Years 1–3 in 2000–2001 (Tozer & Holmes, 2005) and the *Numeracy Development Projects* for children in Year 1–10 (Young-Loveridge, 2011). Developers of the *Early Numeracy Research Project* (*ENRP*) in Victoria–from which the Mathematics Assessment Interview developed–drew substantially on *CMIT* in developing their project design (Clarke, 2001).

CMIT has the aim of building effective instructional practices for children K–6. To achieve this aim, the program focuses on building teacher's mathematics knowledge through professional learning, draws on the theory of number development embedded in the *LFIN*, and utilises an assessment schedule designed to position children's understanding in the framework (White, Mitchelmore, Branca, & Maxon, 2004). Classroom teachers implement *CMIT* in regularly scheduled numeracy blocks, with the sessions structured as small group work focused on the *CMIT* games. After initial professional learning, a district *CMIT* consultant supports teachers implementing *CMIT* in the school (Bobis et al., 2005). The *LFIN* provides a theoretical basis for describing children's number development. Teachers employ the *SENA* with all children in their classroom, which is a one-to-one diagnostic interview providing an approach to observing and recording children's problem solving strategies. *SENA* reflects the stages in the *LFIN* and provides teachers with a detailed account of children's development on these stages (Perry, 2000). These initial interviews allow teachers to better understanding children's thinking on number-related tasks. The explicit links to the development sequence in the *LFIN* then provide guidance for planning teaching that will assist students to develop their understanding (Mulligan, Bobis, & Francis, 1999).

Research Evidence

CMIT has been the subject of ongoing research and evaluation. Eleven reports are included on the *CMIT* website and a number of additional research articles and conference papers are available. These reviews of the efficacy of *CMIT* focus on different aspects of the implementation, impact and sustainability of *CMIT* (e.g. Bobis, 2004; Bobis, 2004a; Bobis, 2009; Bobis, 2011), utilising a variety of methodologies to demonstrate the impact of *CMIT* against stated objectives.

A number of the findings described in *CMIT* reports are primarily descriptive, emphasising the variability of children's achievement in the early years and improvements over the course of participating in *CMIT*, without comparing achievement for *CMIT* with expected development (Bobis, 1996; Bobis et al., 2005; Gould, 2000; Stewart et al., 1998).

The 2001 evaluation of *CMIT* (Bobis, 2001) reports NSW Basic Skills test scores for three schools participating in *CMIT* and qualitative data from school informants on the degree to which they believe any improvements are attributable to *CMIT*. These data indicated improvements on the Year 3 Basic Skills test scores since the implementation of *CMIT*, compared with a relatively stable state average. School informants regarded *CMIT* positively, but it is difficult to support the causal links between *CMIT* and the improved scores suggested by the authors. Other approaches to describing the impact of *CMIT* include comparisons of the achievement of small numbers of students undertaking *CMIT* against a comparison group from a different school not undertaking *CMIT* (Bobis & Gould, 1999; Owens, 2002). In the Bobis and Gould (1999) study, 21 Year 1 children undertaking *CMIT* are observed to perform significantly better at the end of the trial than 23 Year 1 students from a comparison school.

The work of Mitchelmore and White (2002; 2003) showed substantial variability between 1996–2002 in Basic Skills Test scores at Year 3 and 5 in 71 schools implementing *CMIT*. No clear increase in average scores was evident at the time of implementation of the program. There was substantial between school variations in change in Basic Skills Test scores from the year prior to implementation of *CMIT*. A substantial increase in Year 3 numeracy in 2001 could be interpreted as a cumulative effect of the implementation of *CMIT*, although evidence of sustained growth would provide more compelling evidence of this causal link. Separating the impact of the intervention from contextual factors is difficult. For instance, there is variation in test scores between schools with high and low proportions of Aboriginal students and students from non-English speaking backgrounds. The data in this study is descriptive, with causal links drawn through inference rather than statistical control of contextual factors that could determine the contribution of the intervention over and above contextual factors.

Resources Required by Schools for Implementation

To implement *CMIT* schools must allocate resourcing to professional learning for teachers, provide time release for teachers to administer the SENA, and commit to purchase additional resources for *CMIT* activities (Anderson, 2005). Additional evidence suggests a substantial investment of resources (both time and financial) in organising, purchasing and constructing resources to support the program in the classroom (Bobis, 2006; Bobis, 2010).

The resource requirements of implementing the *CMIT* intervention are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Teaching materials as required
Specialist teachers	Not needed
General classroom teachers	Attendance at professional learning sessions Possible teacher replacement during professional learning sessions Time to administer one-to-one SENA assessments to students
Other personnel inputs	May require a coordination position within the school; schools without a coordinator can access on-line training without cost DEC currently funds a state CMIT coordinator
Licence fee	Not applicable
Other inputs	Replacement cost of numeracy consumables

Evaluation of Evidence

There is a range of research evidence documenting the development and implementation of *CMIT*. Study designs vary widely and do not always focus on the impact of *CMIT* on student achievement, but reflect consistent efforts to gather a range of data on the implementation, impact, and sustainability of *CMIT*. The evidence of improved student outcomes in a number of studies that coincides with the implementation of *CMIT* warrants further consideration. No cost-effectiveness studies were identified.

Count Me in Too Indigenous

Program Description

CMITI was a NSW Department of Education research project for children in preschool to Year 2 that utilised the principles of *CMIT* to focus on effective teaching of numeracy to Aboriginal and Torres Strait Island children in the early years. The project aimed to adapt the *CMIT* materials (*SENA* and program activities) to make them more culturally and contextually relevant for Aboriginal children (Howard & Perry, 2002).

Research Evidence

Two evaluations were conducted of the *CMITI* project (Howard & Perry, 2002; Perry & Howard, 2003). As far as can be determined, these evaluations are the only available evidence on the efficacy of *CMITI* as an intervention designed to enhance numeracy learning for Aboriginal students. Five NSW primary schools participated in the implementation of *CMITI* as a small pilot project in 2001. The only student achievement data available to assess the efficacy of *CMITI* is relatively incomplete aggregated *SENA* data (Howard & Perry, 2002). These data suggest growth in understanding across the period of intervention, but the poor quality of the data and the lack of a control group make it difficult to infer that growth is directly attributable to the intervention. Perhaps more importantly, some personnel at schools involved in the project indicated that they were unable to see how *CMITI* uniquely provided for the needs of Aboriginal children beyond *CMIT*.

Resources Required by Schools for Implementation

Resourcing for *CMITI* is likely to be broadly similar to *CMIT*. Additional resourcing could be anticipated to support teacher time to redevelop *CMIT* materials for use with Aboriginal children and to promote *CMIT* in Aboriginal communities.

The resource requirements of implementing the *CMITI* intervention are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Adaptation of CMIT materials for use with Aboriginal students
Specialist teachers	Not needed
General classroom teachers	Attendance at professional learning sessions Possible teacher replacement during professional learning sessions Time to administer one-to-one assessments to students
Other personnel inputs	If the school has a CMIT coordination position it may require additional time to tailor support and materials for Aboriginal and Torres Strait Islander students; DEC currently funds a state CMIT coordinator
Licence fee	Not applicable
Other inputs	Time and materials to promote CMIT in Aboriginal communities

Evaluation of Evidence

There is very limited evidence available to assess whether *CMITI* provided an effective approach to improving numeracy achievement among the Aboriginal children who participated in the project. No cost-effectiveness studies were identified.

First Steps in Mathematics

Program Description

First Steps in Mathematics focuses on the first three years of school and, by virtue of its focus on the four strands of mathematics, had a broader emphasis than programs such as *CMIT* in its original implementation (Bobis, 1999). The program originated in Western Australia in the late 1990s through collaboration between the Western Australian Department of Education and researchers at Murdoch University. *STEPS* professional development, a subsidiary of Edith Cowan University in Western Australia, provided the professional development course *First Steps in Mathematics* to support the *First Steps* teacher resource books. The organisation provided facilitator training based on a train-the-trainer model and teacher training in the four strands of number, measurement, space, and chance and data. Professional learning focused on enhancing teachers' understanding of children's mathematical learning in order to better equip them with strategies to diagnose children's mathematical difficulties, implement plans for student learning and evaluate their outcome. The *First Steps* teacher resource books follow a consistent structure across all the mathematical strands. The structure comprises a diagnostic map aimed at helping teachers judge student's level of mathematical understanding, and key understandings aimed at increasing teacher's knowledge of the mathematics related to major outcomes and improving their understanding of the development of mathematical ideas. The resource books also include learning activities suitable for individual students or for groups that are designed to develop key understandings, sample lessons, and a "Did you know?" section highlighting common misconceptions.

Research Evidence

As far as can be determined, there is no independent evaluation of the efficacy of *First Steps in Mathematics* in improving student achievement in numeracy. In the Western Australian Getting it Right–Literacy and Numeracy Strategy (*GiR–LNS*), *First Steps in Mathematics* resources were

used for delivering the numeracy component of the initiative. A specific finding of the evaluation of *GiR–LNS* was that the *First Steps in Mathematics* resources were complex and the Specialist Teacher trained as part of the initiative undertook a critical role in ensuring classroom teachers adopted the resources in the school (Meiers, Ingvarson, Beavis, Hogan, & Kleinhenz, 2008). However, the evaluators of *GiR–LNS* did not seek to address the efficacy of *First Steps in Mathematics* in improving student achievement in numeracy.

Resources Required by Schools for Implementation

A series of professional development courses in the strands of number, measurement, space, and chance and data for both teachers and facilitators were available until the end of 2012 (*STEPS* professional development ceased trading on December 31st 2012 and the implications of this for supporting the implementation of *First Steps* are unclear). Facilitator courses used a train-the-trainer model and provided schools with a more cost-effective approach to implementing *First Steps in Mathematics* in the school. *First Steps in Mathematics* is supported by a series of resource books focusing on the four strands. Other costs may include the resourcing of additional numeracy materials to support the implementation of the program. The resources required by schools for implementation outlined in the table include reference to the professional learning component of the intervention, but it is not clear whether *First Steps* professional learning will be available after 2012.

The resource requirements of implementing the *First Steps in Mathematics* intervention are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	First Steps in Mathematics teacher resource books
Specialist teachers	Not needed
General classroom teachers	A 2-3 day classroom teacher program was available for each strand Schools could chose to have a First Steps facilitator trained for each strand (4-7 days duration per strand) who was then responsible for in-school training, or send teachers to be trained in each strand Possible teacher replacement during training sessions
Other personnel inputs	Where an in-school First Steps facilitator is used, there would be costs of their time release for training and the time needed to coordinate the intervention within the school
Licence fee	Not applicable
Other inputs	Replacement cost of consumables

Evaluation of Evidence

During the current review, no research evidence was identified which enabled an assessment of the efficacy of *First Steps in Mathematics* in improving student achievement in numeracy. No cost-effectiveness studies were identified.

Learning in Early Numeracy

Program Description

Learning in Early Numeracy (LIEN) (Years K–4) and *Learning in Numeracy* (Years 5–8) are programs of professional development supported by The Association of Independent Schools,

NSW. The findings of the *ENRP* informed the development of both interventions, which utilise the same learning framework of number development as the *ENRP*. The aim of these professional development programs is to promote teacher understanding of how children develop understanding of number concepts, provide skills in diagnosing children's understanding through the use of a clinical interview, and enhance teacher knowledge of how to develop individual children's understanding. Diagnostic tools for *LIN* and *LIEN* are based on the growth points of the *ENRP* and are mapped to the NSW Board of Studies syllabus outcomes (Anderson, 2006).

Professional development for teachers occurs for a minimum of six days and up to eight days in total. The professional learning is entirely school-based and is conducted as a whole day of professional learning for all teachers in the school followed by five days (spaced over time) where teachers team-teach with a consultant during the day, followed by two hours of additional professional learning after school on each of these days. The first professional development day focuses on developing teachers' understanding of the learning framework and training them to conduct one-to-one interviews to assign children to growth points in each of four domains. Teachers return to their classrooms after this initial training and conduct the one-to-one assessments with their students. During the five subsequent days of professional learning, teachers practise strategies they have learned in their classroom teaching while they have in-class support. An additional two days of professional learning are available for schools that require more support.

Research Evidence

As far as can be determined, there is no available research evidence on the efficacy of *LIEN* in improving student achievement in numeracy. Assessment data collected for *LIEN* are held in participating schools and presented in aggregated form for Commonwealth reports. There is also very little available evidence on the structure or implementation of *LIEN*; however, the intervention has features in common with a number of other widely implemented programs (e.g. *SINE, EMU*) that have derived from the *ENRP*. The independent evaluation of *LIN* suggests that student data collected over the course of one school year showed improvement for participating students (Anderson, 2006). It is difficult to assess this claim as there is no indication of the number of participating students and no quantitative data are provided as evidence of improved achievement.

Resources Required by Schools for Implementation

The implementation of *LIEN* requires schools to resource a minimum of six days of within school professional learning (two additional days are optional). Teacher replacement costs apply only to the first day as subsequent days are in the form of supported classroom teaching. Additional variable costs include time release for teachers to undertake one-to-one assessments, the purchase of interview kits and the costs of consumables.

The resource requirements of implementing the *LIEN* intervention are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Interview resource kit Teaching materials as required
Specialist teachers	Not needed
General classroom teachers	A 6 day program of professional learning. An additional 2 days are available for schools that need additional support. Only the first day requires classroom time release to enable all teachers to participate in professional learning at the school; the subsequent days are classroom-based with teachers team teaching with a consultant, and 2 hours of after school professional learning Time release to conduct one-to-one assessments. The program requires one day per teacher so that 6-8 students can be assessed. Subsequent time release for assessments is arranged by individual schools
Other personnel inputs	Trained consultant
Licence fee	Not applicable
Other inputs	Replacement cost of consumables

Evaluation of Evidence
No publicly available research evidence was identified during the course of the current review to enable an assessment of the efficacy of *LIEN*. No cost-effectiveness studies were identified.

Mathematics in Indigenous Contexts Project

Program Description
The *Mathematics in Indigenous Contexts* project was a research project initiated in 1999 by the NSW Board of Studies in anticipation of the implementation of the NSW K–6 mathematics syllabus in 2002 (NSW Board of Studies, 2003; Howard, Perry, Lowe, & Ziems, 2003). *Mathematics in Indigenous Contexts* was a collaborative project between the Board of Studies NSW, NSW Department of Education and Training (DET), ACU and the University of Western Sydney (Howard & Perry, 2007). Overall, the project aimed to establish a whole school approach to improve Aboriginal students' achievement in numeracy by providing professional learning for teachers, and through schools collaborating with parents of Aboriginal children in enhancing the numeracy experiences of their children. Through this process, the project aimed to produce units of work for the new syllabus which were contextualised for Aboriginal students, that is, ensuring that mathematical teaching was relevant and recognisable to Aboriginal students and built on their everyday mathematics experiences outside the classroom (NSW Board of Studies, 2003; Howard, Perry, Butcher, & Jeffery, 2006; Matthews, Howard, & Perry, 2003).

The project comprised three phases over the period 1999–2003. In the first two phases of the project, literature reviews were commissioned which explored the causes of Aboriginal students' difficulties in learning mathematics and approaches to improving numeracy outcomes. The first of these reviews for the *Mathematics in Indigenous Contexts* project (Frigo, 1999), provided a framework for research exploring successful strategies in teaching and learning for Aboriginal students. The research documented case studies of approaches to improving literacy and numeracy achievement in seven NSW primary schools (NSW Board of Studies, 2000). These case studies were distributed widely to primary schools across NSW with high numbers of

Aboriginal students. The second review for the *Mathematics in Indigenous Contexts* project (Frigo & Simpson, 2000), outlined the needs of Aboriginal learners and provided specific recommendations about how these needs could be addressed in the context of the implementation of the syllabus.

The project was implemented in 2002 in one urban and one rural primary school in NSW with high proportions of Aboriginal students, and focused on the K–6 syllabus. A second implementation in 2003–2004, focused on Years 6–8 and occurred in two rural locations in NSW in both primary and secondary schools (Matthews et al., 2003). In the 2002 pilot project, the first stage of implementation involved establishing learning networks comprising teachers, parents and mentors (teachers in schools had a peer with K–6 mathematics expertise acting as a mentor, and a university research team provided mentorship for all project participants) (Howard et al., 2003). These learning teams worked together with mentor support over the course of the project to create contextualised units of work. For example, one teacher decided to use the local park as the focus of her mathematics unit, and sought to integrate the experiences of local Aboriginals into the mathematics unit. All teachers at this school spoke with the Aboriginal Education Assistant (AEA) to better understand the culture of local Aboriginals and to gain her support in liaising with the local community, they attended Aboriginal Student Support Parent Association (ASSPA) committee meetings to talk with parents, and promoted mathematics at National Aborigines and Islanders Day Observance Committee (NAIDOC) week and at mathematics workshops (Howard et al., 2003). Two sharing days involved project participants from both schools meeting to present their progress on the project and to describe those elements of the project which both supported and hindered progress.

A further implementation in seven NSW primary schools in 2006 coincided with the full implementation of the K–6 syllabus in NSW and had a particular focus on K–2 and the prior to school to school transition (Erebus, 2007).

Research Evidence

A range of different research articles exist which focus on describing the rationale of *Mathematics in Indigenous Contexts* and in presenting qualitative data on participant responses to involvement in the project (see for instance Howard & Perry, 2007; Howard et al., 2006; Howard et al., 2003; Matthews et al., 2003; Perry & Peter, 2008). Descriptions of the project rationale, implementation and outcomes are available on the NSW Board of Studies website, and include units of work produced by teachers as part of the project, as well as related literature (such as the project framework research documents). The focus of all of these sources is on the process by which teachers and communities undertook the development of mathematics units, with little emphasis on the impact on students of the implementation of the project in their school.

The NSW Board of Studies commissioned an evaluation of the 2006 implementation of *Mathematics in Indigenous Contexts*. The evaluation focused primarily on the achievement of project objectives related to increased awareness among teachers of Aboriginal students learning needs, success in building home-school partnerships, and in creating units of work to support Aboriginal students' numeracy learning. Embedded in the last objective were intended outcomes related to monitoring student achievement, by using growth on the SENA from the beginning to

the end of the project, and through analysing student work samples collected at three points over the duration of the project (Erebus, 2007). Only data related to SENA are analysed in the evaluation. SENA data were presented in highly aggregated form (collapsed across school and classroom) from an unspecified number of children. These analyses are likely to overlook the significant impact of school context in this intervention, as the implementation of the project within schools was highly school specific (Erebus, 2007).

Although on average, there appears to be growth on the SENA from the beginning to the end of the project (which is greater for Aboriginal students compared with non-Aboriginal students), the significance of these changes in relation to expected growth is unclear. For many students (approximately 50% or more of the Aboriginal students assessed on four of the five SENA subscales), there was no growth in achievement over the course of the project (Erebus, 2007). The sampling of students to participate in assessments also varied between schools. In some schools, teachers assessed all students in a classroom, and in other schools, only a proportion of students were assessed (and the criteria by which students were selected to participate were not clear). Interpretation of these data specifically in relation to the impact on student achievement of the *Mathematics in Indigenous Contexts* project is further distorted by the fact that all participating schools were also implementing *Count Me in Too* in classrooms. Nonetheless, a stated benefit of the project was that teachers gained familiarity with the SENA to assess their students' numeracy understanding and they felt that they had gained from the experience. The diagnostic assessment allowed students to elaborate their responses and teachers gained a greater understanding of their abilities.

Resources Required by Schools for Implementation

Specific resources related to the project are likely to be flexible and dependent on the implementation model chosen by specific schools. For instance, the initial pilot project utilised university teams as external mentors, but schools choosing to implement the model independently may not desire or have available such resources. The largest resourcing component related to the intervention is time release for general classroom teachers, the extent of which will depend on planned activities. For instance, a school may choose to undertake structured professional learning from an external provider, or may develop their own internal professional learning program.

The resource requirements of implementing the *Mathematics in Indigenous Contexts* intervention are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Teaching materials dependent on units developed
Specialist teachers	Not needed
General classroom teachers	Teacher time release to meet with mentors, and the community, plan units of work, and undertake sharing days
Other personnel inputs	External consultants
Licence fee	Not applicable
Other inputs	Replacement cost of consumables

Evaluation of Evidence

As far as can be determined, the program evaluation of the 2006 implementation of *Mathematics in Indigenous Contexts* is the only research evidence for the impact of the intervention on Aboriginal students (Erebus, 2007). The data on SENA collected for some students participating in the project provides very limited evidence of the efficacy of the intervention for improving student achievement. There were no cost effectiveness studies identified.

Numeracy Matters

Program Description

Numeracy Matters is a component of the Archdiocese of Sydney *Numeracy Strategy* implemented as part of the *Smarter Schools National Partnerships*. First implemented in 2002, the *Numeracy Strategy* focused on numeracy learning in the early years of schooling (K–4). In 2006, it progressed into the middle years and saw the development of action research projects in mathematics targeting students in Years 5–8. More recently, the *Numeracy Strategy* has been extended to encompass all years of schooling (K–12).

Key features of the *Numeracy Strategy* include the use of the *Clinical Interview* for particular students in K–4 to determine the need for intervention, to inform selection of intervention strategies, the implementation of an action-research project, and efforts to strengthen the leadership capacity of Key Numeracy Focus teachers in primary schools. The early years work (K–4) is based on the *Success in Numeracy Education* (*SINE*) program developed by the Catholic Education Office (CEO) in Victoria. Documents such as 'Descriptors of Effective Implementation' (based on the Hill & Crevola 1997 model which outlined approaches to improving student learning outcomes) used in the context of numeracy, provided the framework for whole-school approaches to improving learning outcomes. The *Year 5 to Year 8 Mathematics Project* initiative is based on the model of Teacher-Led Development Work (Frost & Durrant, 2003). This model draws upon action research approaches to professional learning, reflective practice, evidence-based school improvement and teacher leadership.

The *Learning Matters* resources, comprising *ESL*, *Reading* and *Numeracy Matters* are flexible online professional learning targeting Years 3–6, each comprised of ten modules completed in approximately 50 hours. The *Numeracy Matters* professional learning aims to develop understanding among teachers of the characteristics of effective numeracy teaching. The resources place a particular emphasis on strengthening teacher understanding of the NSW K–6 syllabus and in enhancing teacher's skills in using the clinical interview to gauge children's progress against growth points. *Numeracy Matters* is available to individual teachers, to leadership teams or to whole groups guided in their learning by the school leadership team. The modules focus exclusively on the number strand (e.g. counting and place value, addition and subtraction, multiplication and division), but make connections to other strands.

Research Evidence

There is no detailed public information available about the content of the *Numeracy Matters* intervention or any research evidence to assess the efficacy of *Numeracy Matters* in improving student achievement in numeracy.

Resources Required by Schools for Implementation

Numeracy Matters is freely available to Catholic schools in the Archdiocese of Sydney. The online delivery of the resource allows some flexibility for schools in allocating time for professional learning. Teachers accessing the resource for individual professional learning do so in their own time. Additional resources may be required to fund teacher time to conduct individual assessments and to purchase consumables.

The resource requirements of implementing the *Numeracy Matters* intervention are as follows:

Classroom modification	Not needed
Special equipment	Computers for individual learning or a data projector for group learning
Materials	Teaching materials as required
Specialist teachers	Not needed
General classroom teachers	Completion of online professional learning comprising 10 modules completed in approximately 50 hours The online delivery reduces the need for classroom time release Time release to conduct one-to-one assessments
Other personnel inputs	Not required
Licence fee	Not applicable
Other inputs	Replacement cost of consumables

Evaluation of Evidence

As far as could be determined, at the time of the current review there was no available research evidence to assess the efficacy of *Numeracy Matters.* No cost-effectiveness studies were identified.

Success in Numeracy Education

Program Description

SINE is a long-running whole-school approach to improving children's numeracy outcomes developed by staff at the CEO, Melbourne through a pilot project in 1999 which targeted children in Prep–Year 4. *SINE Prep–4* and *SINE 5–8* were modified more recently and the suite of programs now comprise *Success in Mathematics Education* (*SME*) *Prep–2*, *SME 3–4* and *SME 5–6*. *SINE* focuses on teacher professional learning in the four strands of number, measurement, space and reasoning and strategies and on equipping teachers to better understand the development of children's mathematical thinking (Clarke, Lewis, Stephens, & Downton, 2005). *SINE* shares similar features with other education authority numeracy intervention programs (e.g. *CMIT*) developed at a similar time. Specifically, the initiative embedded research findings on the development of children's mathematical thinking in teacher professional learning. In particular, growth points derived from the *ENRP* are used to map the development of children's achievement in mathematics. Teachers are trained in the one-to-one clinical interview as a means of exploring in detail children's understanding of mathematics concepts and there was extended professional learning for focus teachers, who were then responsible for delivering professional learning to classroom teachers at their schools (Clarke et al., 2005).

Research Evidence
The Australian Catholic University conducted an evaluation of *SINE* in 2004, a summary of which is available in a Mathematics Education Research Group of Australia (MERGA) conference paper (Clarke et al., 2005). The evaluators used the *ENRP* interview for 1010 students randomly selected from 47 schools randomly selected from those participating in *SINE*. The progress of students in *SINE* schools on the growth points of the assessment interview could then be contrasted with students in *ENRP* schools and those in control schools. Clarke et al. (2005) described the results of analyses to determine the progress of students in each condition, but did not report the results of statistical analyses or descriptive data to enable calculation of effect sizes. Clear evidence of the impact of *SINE* on student achievement is lacking in this description, with the achievement for children in *SINE* schools consistently falling below that of *ENRP* schools and sometimes below the achievement of children in control schools. In most domains measured by the assessment interview, more time spent in the *SINE* program did not have a greater impact on student achievement.

Resources Required by Schools for Implementation
SINE requires resources allocated to teacher professional learning and teacher time release to allow classroom teachers to attend professional learning and administer one-to-one assessments. Resources may be required to purchase additional numeracy materials.

The resource requirements of implementing the *SINE* intervention are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Teaching materials as required
Specialist teachers	Not needed
General classroom teachers	Professional learning time in the four stands, the development of students' mathematical thinking, and training in one-to-one clinical interviewing, tailored to reflect school and teacher needs; information is not available on the quantity of professional learning and training or the method of delivery Possible classroom release time for professional learning Time release to conduct one-to-one assessments
Other personnel inputs	External consultants
Licence fee	Not applicable
Other inputs	Replacement cost of consumables

Evaluation of Evidence
The research identified for the current review is very limited, and is not sufficient evidence to determine the impact of *SINE* on the achievement of students in participating schools. No cost-effectiveness studies were identified.

Tier 2 Australian numeracy interventions

Best Start Targeted Early Numeracy

Program Description
Best Start Targeted Early Numeracy (*TEN*) is a NSW DEC intervention program focused on providing additional assistance to children in K–2 who are having difficulties in mathematics,

particularly those from low SES schools. *TEN* is a relatively new strategy (commencing late 2009), which complements *CMIT* and the *Best Start Kindergarten Numeracy Assessment*. In the 2010–2011 implementations, one or two *TEN* facilitators were chosen through a competitive selection process to be strategically located across NSW to support government schools. These facilitators were chosen based on being experienced teachers with deep understanding of children's numeracy development. Facilitators were further supported through extended professional learning. Participating schools were chosen on the basis of factors such as NAPLAN results, numbers of students enrolled in the early years and an analysis of factors that may influence schools' capacity to engage with the program.

TEN facilitators worked with a group of schools and provided professional learning to teachers to improve teachers' understanding of children's mathematical development, provided support in the classroom and worked to improve teachers' use of assessment data to allow them to identify and assist children with difficulties. Initial piloting involved 41 schools (235 teachers) in 2010 and an additional 61 schools (434 teachers) in 2011. The program operates in conjunction with the regular classroom program *CMIT*. Teachers identify students to include in the *TEN* intervention group, administer a *TEN* assessment, diagnose children's learning needs, develop a numeracy learning plan and instruction to identify each child's needs. Students undertaking *TEN* are not withdrawn from class, but receive additional in-class assistance in small groups during regularly scheduled numeracy blocks and throughout the day. These sessions are of relatively short duration (10 minutes) and integrate explicit and systematic teaching focussed on early arithmetical strategies in counting, addition and subtraction. Assessment of student progress at regular intervals is used to monitor progress and to plan future learning needs.

Research Evidence

As a relatively new initiative, there is no independent evaluation of the efficacy of the *TEN* intervention. Evidence on the efficacy of *TEN* comprises evidence from the NSW DEC and a selection of case studies from participating schools. Information supplied by the NSW DEC reports substantial decreases in the numbers of students targeted by the intervention in *TEN* schools over a relatively short period (February–June 2010). Seventy-two per cent of targeted Kindergarten children were on track at the end of this period (compared with 57% of Year 1 and 48% of Year 2 students). A lack of information precludes evaluation of these data. For instance, nothing is known about the characteristics of targeted children at the beginning of the intervention or the criteria by which they were deemed to be no longer the subject of ongoing intervention.

Case studies prepared by schools are primarily descriptive of particular activities implemented as part of the *TEN* intervention or of the school's reaction to participating. These case studies present a favourable perspective of the impact of *TEN*; however, reference to impact on student achievement is usually descriptive (e.g. greater understanding of numerical concepts) and specific data on student achievement is rarely cited. In school case studies which include student achievement data, quite substantial decreases in targeted students across 2011 are evident (e.g. 35% targeted in Kindergarten, reduced to 1% targeted over the year).

Resources Required by Schools for Implementation
To support the implementation of *TEN*, schools may need to allocate resources to support teacher professional learning and to provide time release for teachers for professional provided during school hours. Additional resourcing may be required to cover teacher time to administer assessments.

The resource requirements of implementing the *TEN* intervention are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Teaching materials as required
Specialist teachers	Not needed
General classroom teachers	Professional learning time; the amount required is not specified Funding support for approximately 3 days of teacher relief per classroom is provided by DEC Time release to conduct one-to-one assessments
Other personnel inputs	10 facilitators are based in DEC regions
Licence fee	Not applicable
Other inputs	Replacement cost of consumables

Evaluation of Evidence
The available data provides limited evidence of the efficacy of *TEN* in improving student achievement. Early indicators of improved achievement of students participating in *TEN* warrant investigation with more rigorous research approaches. No cost-effectiveness studies were identified.

Extending Mathematical Understanding Intervention

Program Description
Dr Ann Gervasoni at the Australian Catholic University developed the *Extending Mathematical Understanding* (*EMU*) numeracy intervention project. The program evolved from the work of the developer in the *Early Numeracy Research Project* (*ENRP*) and involves training of specialist teachers to implement an intervention program for students with low attainment in mathematics (Gervasoni, 2001, 2002). The focus of the program is on early identification of children whose progress in mathematics is not as expected. Teachers use the *Early Numeracy Interview* (originally the *EMU Assessment Interview*), developed as part of the *ENRP*, to assess children's progress against growth points. The *Mathematics Assessment Interview* remains widely used in the early years as a focus for diagnostic assessment of the development of early numeracy in Victoria. *LIEN* implemented in NSW also developed from the work of the *ENRP*.

EMU provides for six days of professional learning, followed by in-school implementation of *EMU* and daily sessions of 30-minutes with children targeted for intervention. A typical session included approximately 10 minutes of activity focused on counting and place value, 15 minutes of problem solving activities (with a focus on addition and subtraction, multiplication and division) and 5 minutes of reflection on learnings from the session (Gervasoni, 2001).

In the original *ENRP*, classroom teachers were able to decide whether to implement the intervention individually or in small groups, and whether students in Year 1 or Year 2 would be the target of the intervention. Specialist teachers implemented the intervention, conducting two 30-minute daily sessions for between 10–20 weeks, depending on the child's needs. Over the course of the intervention, there was ongoing diagnosis of the child's learning needs, the development of a structured learning plan for each child and regular communication between the specialist and classroom teacher on each child's progress.

Research Evidence

EMU and the *ENRP* are strongly grounded in research evidence that the needs of students with mathematical difficulties are diverse and that any intervention must be sufficiently flexible to cater for specific understandings of individual learners (Gervasoni, 2001, 2005, 2011; Gervasoni et al., 2012; Gervasoni & Sullivan, 2007). For example, among 35 Year 1 and 60 Year 2 students from 22 schools implementing *EMU*, Gervasoni (2005) demonstrated wide variation in the profile of vulnerability in the mathematics domains of counting, place value, addition and subtraction, and multiplication and division. A higher proportion of Year 2 students were vulnerable in three of the four domains compared with Year 1 students, indicating the importance of very early intervention. Wide variability in the profiles of vulnerability across domains means, for example, that children may have difficulties in counting and addition and subtraction, while others have reasonable counting skills, but are vulnerable in the understanding of place value and multiplication and division (Gervasoni et al., 2012). Data of this kind emphasises the importance of providing teachers with the skills to personalise intervention approaches to address individual needs.

Specific evidence for the efficacy of *EMU* is outlined by Gervasoni (2001), in which she analysed the outcomes for 44 year 1 and 67 Year 2 students who participated in the *EMU* trial during 2000. The study compared students participating in *EMU*, with students at the same schools with the same initial profile of growth points who did not undertake the *EMU* intervention. Students participated in *EMU* either in a small group or as an individual intervention. The study focused on the addition and subtraction growth points as a measure of improvement. Mean growth for Year 2 students in the small-group *EMU* intervention exceeded that of Year 2 students in a comparison group and that of all students in trial schools. Year 1 *EMU* students had similar mean growth to those students in the comparison group. Mean growth for the small group *EMU* intervention exceeded that of children participating in the individual *EMU* program at Year 1 and Year 2.

There are a number of considerations which limit the strength of the evidence for the efficacy of *EMU*. First, the study is limited to commentary on the addition and subtraction growth points as an illustration of the effectiveness of the intervention and second, the intervention groups are relatively small and teachers purposively selected these children because the teachers judged them as likely to benefit from the intervention. Third, reporting average growth points is problematic on a scale that is unlikely to have interval level properties such that comparisons across year levels and groups may not be valid (Rowley & Horne, 2000).

More recently, Gervasoni et al. (2010) reported the growth points of the *Early Numeracy Interview* for nine children from one low SES school in Victoria who participated in *EMU* in their second year of school. These data included beginning and end of year growth points for children who participated in *EMU*, other Year 1 children at the same school, and all other children participating in the *ENRP*. The primary purpose of the data analysis is descriptive and the article presents no clear evidence of the impact of *EMU* over and above regular classroom teaching. Gervasoni (2012) also presented descriptive data on the addition and subtraction and multiplication and division growth points for 42 Year 1 students participating in *EMU* compared with all other Year 1 students at 44 schools participating in the project. These data suggest that before starting the intervention, lower growth points included a higher proportion of intervention students compared with all other students. The following year, the growth point distributions of intervention students was similar to that of all other students. Typical growth for Year 1 students (as assessed in the *ENRP*) is about one growth point in each domain. The majority of the students in Gervasoni's (2012) study progressed two growth points, although seven students made no progress over the year. Thus, there is reasonable evidence that participating in *EMU* provided some benefits to participating students. Nonetheless, these findings would be more compelling had they provided a comparison of growth of *EMU* students against another group of low achieving students who did not participate in *EMU*.

Resources Required by Schools for Implementation

Schools implementing *EMU* must resource teachers' attendance at six days of professional learning and accommodate teacher time release for these days. There may be some flexibility in the implementation of *EMU* in schools that will affect the requirements for additional resources. Schools may choose to resource a specialist *EMU* teacher to undertake assessments and conduct the intervention. Classroom teachers who undertake the intervention require time release. Additional resourcing may be required to purchase consumables.

The resource requirements of implementing the *EMU* intervention are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Teaching materials as required
Specialist teachers	Optional; schools may chose to pay for training a specialist EMU teacher to conduct the intervention
General classroom teachers	Schools may choose to pay for training classroom teachers to conduct the intervention; this involves 6 days of professional learning followed by in-school implementation of EMU Daily sessions of 30 minutes with students targeted for intervention Time release to conduct one-to-one assessments and possibly to enable the daily interventions
Other personnel inputs	External consultants
Licence fee	Not applicable
Other inputs	Replacement cost of consumables

Evaluation of Evidence

Overall, there is some research evidence, conducted primarily by the program developer, for the efficacy of *EMU*. The research is often descriptive, using small samples and considering growth only on selected domains. There is some evidence of growth among students participating in

EMU, although the extent of improvement in relation to other students in sometimes difficult to gauge. Consistent evidence for the impact of *EMU* is not always apparent across studies, although in part this may be attributed to design features (e.g. small purposively selected samples, possible lack of sensitivity of growth points as an outcome measure). No cost-effectiveness studies were identified.

Getting Ready in Numeracy

Program Description

Getting Ready in Numeracy (*GRIN*) is a program developed by staff at the Education Faculty at Monash University. Schools in the Western Region of Victoria first implemented the program in 2010. *GRIN* involves training selected teachers in the intervention model to be *GRIN* tutors. Teachers familiarise students with the concepts and vocabulary of their upcoming mathematics lesson and provide modelling of activities to be encountered. Tutors then withdrew students in small groups to participate in short sessions (15–25 minutes) prior to their regular mathematics block. The focus of the intervention is the mathematics that children encounter in class when they return to their regular mathematics session. By preparing children for the mathematics content they will encounter in their classroom, it is thought that increased familiarity will increase their chances of effectively engaging with the material and increase their confidence in their learning capability (Sullivan, 2011).

Research Evidence

There is minimal evidence available to assess the efficacy of *GRIN*. Sullivan and Gunningham (2011), the program developers, described average gain (in VELS levels) for participating students in four primary schools against those who did not participate; however, these data do not provide compelling evidence of the impact of the intervention on student achievement. In two schools, mean gains on VELS of *GRIN* students exceeded those who were not tutored, in one school mean gains were similar, and in one school students who were not tutored improved more than those who participated in the intervention. The number of *GRIN* students at each school was small (between 11 and 22) and the degree to which the study matched tutored and untutored students in ability at the beginning of the intervention is unclear.

Resources Required by Schools for Implementation

To implement *GRIN* schools would need to resource the costs of professional learning (of unknown duration) and the associated costs of teacher time release. The intervention model entails training specialist teachers so resourcing would likely only cover the training of one or two teachers. Subsequent resourcing would then support the salary of the *GRIN* tutor to undertake the intervention. Additional resourcing may be required to purchase consumables.

The resource requirements of implementing the *GRIN* intervention are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Teaching materials as required
Specialist teachers	Specialist training is provided to selected teachers to implement the intervention; the extent or delivery mode of training is not specified Specialist teacher time for small group sessions of 15-25 minutes prior to students' regular mathematics block
General classroom teachers	Coordination with the specialist teacher
Other personnel inputs	External consultants
Licence fee	Not applicable
Other inputs	Replacement cost of consumables

Evaluation of Evidence
As far as could be determined during the current review, the research evidence for the efficacy of *GRIN* is very limited and is insufficient to determine whether the intervention influenced student achievement. No cost-effectiveness studies were identified.

Mathematics Intervention

Program Description
Mathematics Intervention aims to identify and assist children in Year 1 at risk of not coping with the mathematics curriculum. *Mathematics Intervention* was a collaborative project developed by mathematics researchers from La Trobe University and teachers from a Victorian state government primary school (Pearn & Merrifield, 1996; Pearn et al., 1994). As noted previously, *Mathematics Intervention* owes much to the principles of *Mathematics Recovery*. Whereas *Mathematics Recovery* was a large project that received significant funding, *Mathematics Intervention* was a small project that received almost no financial support. The Year 1 *Mathematics Intervention* program incorporated mathematical activities and strategies based on recent research about children's early arithmetical learning (Steffe, Von Glasersfeld, Richards, & Cobb, 1983; Wright, 1991) and about the types of strategies used by children to demonstrate their mathematical knowledge (Gray & Tall, 1994). *Mathematics Intervention* also features elements of both *Reading Recovery* and *Mathematics Recovery* (Wright, 1991; Wright, Cowper, Stafford, Stanger, & Stewart, 1994) and offers children the chance to experience success in mathematics by developing the basic concepts of number upon which they can build their understanding of mathematics. The intervention was later extended to Year 3 and 4 due to concerns that students in the middle years of school had ongoing difficulties developing numeracy concepts.

Both the initial assessment and the *Mathematics Intervention* program required teachers to assess the extent of the child's mathematical knowledge by observing and interpreting the child's actions as he/she works on set tasks (Hunting & Doig, 1992). The initial interview required the teacher to assess the extent of the student's mathematical knowledge while the intervention program relied on the teacher's ability to interpret the student's mathematical knowledge and then design or adapt tasks and problems to enable students to progress mathematically. All teachers involved with the initial *Mathematics Intervention* program had attended a six-day course in *Clinical*

Approaches to Mathematics Assessment (see Gibson, Doig, & Hunting, 1993; Hunting & Doig, 1992) to develop and refine their observational and interpretative skills, as teachers identified a need for additional support in this area. Participating teachers believed that training of this kind should be a requirement for teachers working with students 'at risk' in mathematics.

In the implementation of *Mathematics* Intervention, one-on-one interviews were conducted at the beginning of each new school year. A shortened interview was developed for Year 1 students, which was designed to predict accurately those children needing to be included in the program (Pearn et al., 1994; Pearn, Merrifield, Mihalic, & Hunting, 1997). The interview includes verbal counting tasks and two tasks based on the counting stages. Once identified as needing to participate in the *Mathematics Intervention* program children were withdrawn from their classes to work in small groups to develop their mathematical skills and strategies. Most *Mathematics Intervention* sessions were 30 minutes long and conducted three or four times a week. These sessions emphasised the verbal interaction between teacher and students, and between students. Each session built on previous understandings as interpreted by the teacher during the session. The *Clinical Approaches to Mathematics Assessment* course ensured that teachers could observe the student, interpret and act on the student's actions, and then reflect on the intervention.

Research Evidence

Since the original project at a single school, many schools have implemented *Mathematics Intervention* in their schools with reported success; however, these interventions have not been developed as research projects nor have they been described in published articles or presented at research conferences.

Resources Required by Schools for Implementation

Teachers attended a professional learning session for six days to assist them to implement the intervention. Additional resourcing is required to allow time release for teachers to conduct assessments and to implement the intervention. Additional resourcing may be required to purchase consumables.

The resource requirements of implementing the *Mathematics Intervention* are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Teaching materials as required
Specialist teachers	Not needed
General classroom teachers	Six days of professional learning sessions Time release to enable teachers to participate in professional learning Time release to conduct one-to-one assessments and the intervention with small groups
Other personnel inputs	External consultants
Licence fee	Not applicable
Other inputs	Replacement cost of consumables

Evaluation of Evidence

There is no available research evidence to assess the efficacy of *Mathematics Intervention.* No cost-effectiveness studies were identified.

Mathematics Recovery

Program Description

Bob Wright developed *Mathematics Recovery* in Australia as a university based research and development project in the early 1990s. Australian schools have extensively implemented the intervention and it has been adopted internationally. *Mathematics Recovery* is delivered individually by trained teachers and is aimed at children who have not demonstrated expected progress after one year at school (Wright, 2000).

Mathematics Recovery is grounded in the research of Steffe and colleagues and the intervention adopted the one-to-one assessment interview as a means of describing children's current number knowledge and of informing the development of their profile on the *Stages of Early Arithmetical Learning* (*SEAL*) (Wright, 2003), which is based largely on Steffe's *LFIN*. The *SEAL* describes five stages in the development of number knowledge, focused on increasing sophistication in the understanding and use of counting to solve problems. In the initial implementation of *Mathematics Recovery*, teachers assessed and profiled children's current knowledge and then developed their own instructional strategies. Acknowledging that this process was often time consuming, Wright and colleagues subsequently developed an instructional framework which linked to the learning framework and provided specific instructional procedures within three strands (counting, grouping, and number words and numerals) (Wright, 2003). *Mathematics Recovery* informed the development of *CMIT*, with the latter also grounded in the research base of the *LFIN*, focused on intensive professional learning for teachers and the use of one-to-one assessment (Wright, 2002). Intensive professional learning for teachers is a major emphasis of the intervention, providing teachers with in-depth understanding of the theoretical basis of the intervention, and skills to assess and diagnose children's current understanding and developed targeted instruction (Phillips, Leonard, Horton, Wright, & Stafford, 2003). *Mathematics Recovery* is an intensive intervention which aims for daily lessons of 30 minutes for 12–15 weeks (Wright, 2003). Earlier implementations of *Mathematics Recovery* describe shorter interventions, with four lessons per week for eight weeks (a maximum of 32 individual lessons) delivered in schools in 1992-1993 (Wright et al., 1994).

Research Evidence

There is little rigorous research evidence on the effectiveness of the *Mathematics Recovery* program. Available data on *Mathematics Recovery* are primarily descriptive, limited to small samples and provided little information on the research design or the fidelity of the implementation (see for instance Phillips et al., 2003; Willey, Holliday, & Martland, 2007; Wright et al., 1994). Willey et al. (2007) and Wright et al. (1994) assessed the efficacy of the intervention in terms of the number of stages gained on the *SEAL*. Willey et al. (2007) stated that across two cohorts of approximately 200 students in total, more than 60 per cent of students in the intervention gained two stages or more, with the majority of the remainder gaining one stage. Similar data reported by Wright et al. (1994) for two groups of children (n = 24 and n = 32) suggested that approximately 40 per cent of children gained two or three stages. Comparison with 'counterparts' suggested superior growth for the *Mathematics Recovery* students, but the usefulness of the comparison group is questionable given that it is not clear that this group received the same regular classroom teaching as the *Mathematics Recovery* group. The growth measure for these two studies also reflected progress on the stages targeted through the

intervention. Philips et al. (2003) also asserted that a small group of *Mathematics Recovery* students showed greater growth on the stages than a control group at a different school. The two groups exhibited similar scores on a standardised test at the beginning of the intervention, but the profile of the two schools was quite different, so it is difficult to ascertain the relative input of school characteristics to achievement. Overall, *Mathematics Recovery* lacks rigorous evidence on its efficacy as an intervention strategy.

Resources Required by Schools for Implementation

Mathematics Recovery requires a specialist teacher to be trained and funded to implement the intensive interventions in the school. Information on the training implemented for Australian *Mathematics Recovery* could not be identified during the current review, but UK *Mathematics Recovery* offers eight days of professional learning for prospective specialists. Additional resourcing may be required to purchase consumables.

The resource requirements of implementing the *Mathematics Recovery* intervention are as follows:

Classroom modification	Possibly required for small group withdrawal
Special equipment	Not needed
Materials	Teaching materials as required
Specialist teachers	Specialist teachers require professional learning to implement the intervention; in the UK 8 days is offered Time for a specialist teacher to assess students on a one-to-one basis Time for a specialist teacher to implement the intervention – commonly daily lessons of 30 minutes for 12-15 weeks
General classroom teachers	Coordination with the specialist teacher
Other personnel inputs	External consultants
Licence fee	Not applicable
Other inputs	Replacement cost of consumables

Evaluation of Evidence

The research evidence for the efficacy of *Mathematics Recovery* identified during the course of the current review provides limited evidence of the impact of the intervention on student achievement. No cost-effectiveness studies were identified.

Numeracy Intervention Project

Program Description

The *Numeracy Intervention Project* (*NIP*) was an initiative that operated as a pilot project of the Catholic Archdiocese of Canberra and Goulburn in 2009–2010, as part of the as part of the DEEWR National Partnership Literacy and Numeracy Pilots for Low Socioeconomic (SES) School Communities. Ten schools participated in the pilot (with up to 12 students at each school dependent on school size), with a particular focus on schools with a high proportion of low SES students. Participating children were in Years 1, 4 or Year 8. The project drew on a variety of sources of information about interventions in numeracy to inform teaching approaches, but did not specify that teachers should adopt any particular approach. A *Reading Recovery* model informed the structure of the intervention as well as some selected concepts from 'brain based

learning' (Thornton, Quinane, Galluzzo, & Taylor, 2010). Teachers completed a number of professional development days (including two days prior to commencing the intervention) in order to increase their knowledge about research in number development and to familiarise them with the *SENA*. In implementing the intervention, teachers conducted 30-minute lessons four times per week for 13 weeks with students selected to participate in the project. These lessons were targeted to meet the needs of individual students. NIP teachers received a dedicated time allocation (0.4FTE) to provide intervention to students. In the second phase of the project, NIP teachers had an additional time allocation which enabled them to provide mentoring and training to classroom teachers and learning support assistants (Thornton et al., 2010).

Research Evidence

Research evidence for the effectiveness of *NIP* is limited to the work of Thornton et al. (2010) which describes the pilot study, and summary data included in the meta-evaluation of all DEEWR literacy and numeracy pilot projects undertaken in low SES schools (Colmar Brunton Social Research, 2011). Summary data provided in the meta-evaluation suggests that the impact on student achievement over the course of *NIP* reflected a strong positive change; however, there is little detail provided in the meta-evaluation to enable an assessment of the quality of evidence. The meta-evaluation also provided a qualified judgement of the strong positive effect on student achievement of *NIP* in relation to the size of the pilot and known resourcing costs. These analyses of cost effectiveness give an imprecise assessment of the intervention owing to limitations in obtaining complete data on resourcing and difficulties in assessing the impact on student achievement.

Year 4 and 8 students in Thornton et al's., study (2010) completed the *Progressive Achievement Test in Mathematics* (*PATMaths*) prior to and at the completion of the intervention. These students appeared to improve their scores compared to students who did not participate in the *NIP*. However, the authors aggregated data across year levels and did not take account of initial demonstrated ability in the intervention and non-intervention groups. Classroom teachers judged whether Year 1 children had improved on core number skills over the course of the intervention. On most elements considered, teachers regarded the majority of students as making significant improvements over the course of the intervention (e.g. counting to 10, recognising numerals). It is not possible to make firm conclusions about the efficacy of the *NIP* intervention from the available evidence. For Year 1 children, evidence of the efficacy of the intervention is limited for three reasons. First, the assessment of efficacy is limited to teacher judgement of progression, rather than independent assessments of understanding at the beginning and end of the intervention. Second, the skills considered are primarily procedural and third, the assessment focused narrowly on skills that the intervention targeted. It is less clear whether children in the intervention were able to apply these skills to progress further in numeracy understanding.

Resources Required by Schools for Implementation

Resources are allocated to professional learning for teachers (*NIP* involved at least two days of professional learning). Each *NIP* teacher also received a 0.4FTE allocation. To enable classroom teachers to conduct assessments and daily intervention sessions with students, schools must allocate funds to support this time release. Additional resourcing may be required to purchase consumables.

The resource requirements of implementing the *NIP* intervention are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Teaching materials as required
Specialist teachers	Not needed
General classroom teachers	NIP teachers participate in professional learning activities including 2 days prior to commencing the intervention; the number of other days is not specified. NIP teachers have a 0.4 time allocation. Daily lessons of 30 minutes on an individual or small group basis Time release to enable teachers to conduct assessments and daily interventions
Other personnel inputs	Not needed
Licence fee	Not applicable
Other inputs	Replacement cost of consumables

Evaluation of Evidence
The research identified during this review provided very limited evidence for the efficacy of *NIP* in improving student achievement in numeracy, and of its cost effectiveness.

Numeracy Intervention Research Project

The *Numeracy Intervention Research Project* (*NIRP*) was an Australian Research Council funded Linkage project conducted by researchers from Southern Cross University. The CEO in Melbourne acted as the industry partner (2004–2006). *NIRP* was a three-year project consisting of yearly cycles. In each cycle, teachers in different Victorian schools (approximately 8–9 in total) administered screening tests to all Year 3 and 4 students at their school. Twelve students were identified in each school as low attaining in mathematics and during Term 2 these students undertook individual assessment interviews with the intervention teacher. During Term 3, each teacher undertook intensive intervention teaching cycles with eight of these low-attaining students. Intervention cycles spanned 10 weeks with four sessions per week of 30 minutes duration. Teachers taught two of the eight students individually and the remainder attended the intervention in groups of three. In Term 4, all 12 low attaining students undertook another assessment (Wright, Ellemor-Collins, & Lewis, 2007).

NIRP aimed to develop pedagogical tools for intervention in the number learning of low-attaining students in Year 3–4 (Ellemor-Collins & Wright, 2009a). These tools included schedules of diagnostic video-taped assessment tasks, and a learning framework for profiling students' number knowledge. A major outcome of the project is an experimental framework for instruction (see for example Wright et al., 2007). The framework consists of five aspects: number words and numerals, structuring numbers to 20, conceptual place value, addition and subtraction to 100, and early multiplication and division. The descriptions of the aspects include a discussion of low-attaining students' knowledge and difficulties and details of instructional approaches developed in the project.

A particular focus of study has been the assessment of student knowledge of multi-digit addition and subtraction (Ellemor-Collins, Wright, & Lewis, 2007). On many tasks, students had significant difficulties and responded in a range of different ways. Ellmore-Collins and Wright

(2009) used an experimental design focused on instruction to support low-attaining Year 3–4 students' development of conceptual place value (CPV). The authors advance CPV as an instructional domain to support learning of multi-digit mental calculation.

Research Evidence
There is no research evidence that assesses the efficacy of *NIRP* in improving students' achievement in mathematics. The available studies are descriptive of the conceptual framework of the project and its assessment tasks, but evidence of impact is limited to case study analyses for impact on individual students (Ellemor-Collins & Wright, 2008, 2009, 2009a; Ellemor-Collins & Wright, 2011; Ellemor-Collins et al., 2007).

Resources Required by Schools for Implementation
To implement this project, resourcing would be required to provide time release for teachers to conduct screening assessments with all students and to conduct the intensive interventions. Additional resourcing may be required to purchase consumables.

The resource requirements of implementing the *NIRP* intervention are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Teaching materials as required
Specialist teachers	Not needed
General classroom teachers	Teachers participate in professional learning activities; the number of days and delivery mode are not specified Four sessions per week of 30 minutes duration for 10 weeks; 2 of the students are taught individually and the others in 2 groups of 3 students Time release to enable teachers to conduct assessments and daily interventions
Other personnel inputs	External consultants
Licence fee	Not applicable
Other inputs	Replacement cost of consumables

Evaluation of Evidence
During the course of the current review, no research evidence was identified which provided an assessment of the efficacy of *NIRP*. No cost-effectiveness studies were identified.

***QuickSmart* Numeracy**

Program Description
Researchers at the University of New England developed the *QuickSmart Numeracy* intervention program as an approach to improving fluency in numeracy by increasing the speed of retrieval for basic arithmetic facts. *QuickSmart Numeracy* was initially funded by the Commonwealth Government in 2001 and has subsequently received additional funding, in the form of research grants and government funding, to contribute to ongoing research and development of the program (Pegg & Graham, 2007). The premise of *QuickSmart Numeracy* is that difficulties automating basic mathematical facts, impaired speed of processing and inefficient strategy choice are key features of children with mathematical learning disabilities (Graham, Bellert, & Pegg, 2007). By designing an intervention to increase automaticity and speed of retrieval for

basic facts, the authors argued that *QuickSmart Numeracy* can free resources and allow students to succeed at more complex mathematical problem solving tasks (Graham, Bellert, Thomas, & Pegg, 2007; Graham, Pegg, Bellert, & Thomas, 2004).

The developers designed a similar intervention for reading difficulties (*QuickSmart Literacy*) founded on similar principles of increasing automaticity (Graham, Pegg, & Alder, 2007). *Building Accuracy and Speed in Core Skills (BASICS)* (a trial program implemented in Brisbane in 2009), aligned closely to the *QuickSmart Numeracy* framework.[13]

Students participating in *QuickSmart Numeracy* are withdrawn from the classroom in pairs for three sessions per week of around 30 minutes over approximately 30 weeks. *QuickSmart Numeracy* targets children in Years 5–8. Students complete a computer based assessment of skills, focused on retrieval times for basic facts, prior to starting the intervention (*Cognitive Aptitude Assessment System* or *CASS*), which is repeated at the end of the intervention (Pegg & Graham, 2007). Implementation of *QuickSmart Numeracy* involves three 2-day professional development workshops for teachers, a one-day workshop for principals, establishment of a *QuickSmart Numeracy* team at the school and use of the numeracy materials purchased from the developers.

Research Evidence

The developers of the intervention provide the majority of the research evidence for the efficacy of *QuickSmart Numeracy*, primarily in a series of annual reports and conference papers, and to a lesser extent, academic publications. Efforts to collect data to establish the efficacy of *QuickSmart* are extensive, with data collected to show the impact on the skills addressed by the intervention (speed and accuracy in basic facts) as well as data to support claims that these improvements will permit transfer to mathematics achievement more broadly.

The main sources of evidence for the efficacy of the intervention are quantitative data on retrieval latencies measured using *CASS* and standardised test scores derived from the *Progressive Achievement Test in Mathematics* (*PATMaths*, ACER), as well as qualitative data derived from observations of individual learners to infer impacts on affective responses to mathematics (Graham et al., 2004). These data are contrasted with a group of students of average ability from the same classroom. The program developers present a range of data in support of the efficacy of *QuickSmart Numeracy* in improving response latencies and performance on standardised achievement test, although the depth of data presented to support their claims varies across publications. For example, speed and accuracy for *CASS* is described as significantly different for *QuickSmart Numeracy* compared with comparison students, but no descriptive statistics or effect sizes are provided (SiMERR, 2010a). Gain on *PATMaths* scores

[13] *BASICS* aimed to improve accuracy and speed of retrieval for basic mathematical facts for secondary students with low achievement in mathematics or a learning disability. Students targeted for intervention in the *BASIC* trial attended a specialist mathematics classroom and received significant direct instruction aimed at helping students to master basic rules, skills and concepts. Mastery of these core skills was seen as foundational to progressing through to a second and third level of instruction, which focused on direct instruction of problem-solving skills and hands on small group inquiry based learning. Available evidence on the efficacy of *BASIC* in improving student achievement in mathematics is limited to the work of Byers (2009). Evidence for the efficacy of the program is restricted to a reported increase in the number of students transitioning from a supported environment to a core mathematics class and improvement in average results for supported classrooms over the course of the *BASIC* trial.

over the course of the intervention exceeded on average, those of the comparison group. A range of schools participating in *QuickSmart Numeracy* (SiMERR, 2010a) evidenced relatively large effect sizes, but the justification for selecting these schools is not apparent and there is no measure of typical growth with which to assess the strength of improvement.

The report based on *QuickSmart Numeracy* data collected from 2001–2008 appears to be the most comprehensive analysis of program efficacy; however, the developers have also presented evidence from smaller scale studies in a range of journals (see for instance Bellert, 2009; Graham, Bellert, Thomas et al., 2007; Graham et al., 2004). There is also an amount of repetition of the same results across different publications (e.g, Graham & Pegg, 2011). Pegg and Graham's (2007) study is primarily descriptive and while it presents data from approximately 300 students participating in the intervention in 2006 against the achievement of comparison students, these data are limited to comparing achievement on the *Basic Skills Test*. There have also been efforts to demonstrate the impact of *QuickSmart Numeracy* on Aboriginal and Torres Strait Islander students (Pegg & Graham, 2013; SiMERR, 2010b, 2011) and to analyse NAPLAN results for students in *QuickSmart Numeracy* compared with a comparison group (Student Engagement and Program Evaluation Bureau, 2012). Overall, however, the reporting of data across studies varies considerably. For instance, some publications (e.g. Graham & Pegg, 2010) report evidence of effectiveness (e.g. as effect sizes) but do not include associated sample sizes and descriptive data in order to able to assess the strength of the claims.

Reporting of results in two annual reports conducted by the developers in 2010 and 2011 tends to show a pattern of increased speed of retrieval in conjunction with increased accuracy for *QuickSmart Numeracy* participants, such that post-intervention performance for *QuickSmart Numeracy* participants is similar to that of a comparison group (SiMERR, 2010b, 2011). Additional data included in these annual reports reflects that of the 2001–2008 report, *QuickSmart Numeracy* students record average gains on *PATMaths* which exceeded those of the comparison group (SiMERR, 2010b, 2011).

The recent external evaluation of *QuickSmart Numeracy* provides a range of additional data in support of the intervention based on schools that adopted the program as part of the NPLN (Student Engagement and Program Evaluation Bureau, 2012). Almost all staff involved in the professional learning agreed that it was useful and most agreed that *QuickSmart Numeracy* had improved numeracy achievement for students in their class. Achievement in mathematics as assessed through NAPLAN and NPLN assessments showed growth in achievement for *QuickSmart Numeracy* participants, but the degree to which participation in *QuickSmart Numeracy* is responsible for these gains is unclear. There is wide variation across schools in implementation fidelity and comparison groups both within schools and across the state experienced a wide range of numeracy programs, leading to difficulties in interpreting these data. No stringent test of the hypothesis that improving automaticity through *QuickSmart Numeracy* transfers to improved performance on more complex mathematical tasks has been undertaken, nor is there evidence that children who undertake the *QuickSmart Numeracy* program continue to improve their mathematical understanding over time.

QuickSmart Numeracy was also implemented in 11 Catholic schools as part of the DEEWR Literacy and numeracy pilots in low SES schools. A qualified categorisation of program costs in relation to the number of sites and student outcomes undertaken as part of a meta-evaluation suggested that *QuickSmart* achieved strong positive change in student achievement in relation to moderate resourcing for the number of school sites (Colmar Brunton Social Research, 2011). These conclusions have significant qualifications because of incomplete information on other resource inputs and difficulties assessing the degree to which student achievement improved, as well as the small scale of the pilot, which was exclusive to low SES schools. A significant consideration is the degree to which the program is sustainable in schools. The meta-evaluation suggests that in pilot schools the program could continue using teachers who had already received training, but that overall the program was not sustainable without ongoing funding.

Resources Required by Schools for Implementation

To support the implementation of *QuickSmart Numeracy*, schools provide time release for teachers to attend six days of professional learning with one day of training for the principal. *QuickSmart Numeracy* requires a licence, and the resources required by schools to implement the intervention are purchased in a kit from the developers. Additional time release for teachers implementing the intervention is dependent on the way in which the school structures the program. Classroom teachers implementing the program require time release to undertake the intervention.

The resource requirements of implementing the *QuickSmart Numeracy* intervention are as follows:

Classroom modification	Possibly required for small group withdrawal
Special equipment	Computer based assessment (Cognitive Aptitude Assessment) prior to starting the intervention
Materials	Teaching materials as required
Specialist teachers	Not needed
General classroom teachers	Teachers attend three 2-day professional learning workshops to implement the intervention Students are withdrawn from the classroom in pairs for 3 sessions per week of 30 minutes over about 30 weeks Time release to enable teachers to conduct assessments and daily interventions Establishment of a QuickSmart team in the school
Other personnel inputs	Principal attends 1-day professional learning workshop External consultants
Licence fee	Required
Other inputs	Replacement cost of consumables

Evaluation of Evidence

QuickSmart Numeracy is one of the few numeracy interventions currently implemented in NSW for which there is a wide range of sources of evidence for the efficacy of the program. The quality of the research evidence for *QuickSmart Numeracy* varies widely and there is a need to explore further the claims that the narrow focus of the intervention on automaticity promotes broader improvement in mathematics. Although a focus on automaticity alone may be insufficient to promote understanding of more complex mathematical problems, there is moderate evidence that effective numeracy intervention at any year level should include a

proportion of time devoted to practising fluent retrieval of basic facts (Gersten et al., 2009a). An evaluation of cost-effectiveness of a small pilot program suggested strong positive change in student achievement, but this conclusion is qualified by the lack of completeness of the data on which the analysis is based.

Taking off with Numeracy

Program Description

Taking off with Numeracy (*TOWN*) is a NSW DEC professional learning program implemented as part of the NPLN. The professional learning program aimed to help teachers to identify children's current numeracy achievement and to provide teaching strategies to assist children in Years 3–6 progress their mathematical understanding (Gould, 2010). The intervention consists of two phases. In the first phase, participating teachers undertook school-based professional learning coordinated by a school team leader and in the second phase, teachers implemented a whole-class intervention supported by an additional six days of professional learning. Teachers undertake Phase 1 over one and a half terms and Phase 2 over two and a half terms. *TOWN* Phase 2 is only available to schools that have completed Phase 1. *TOWN* is available as a whole class program and as an individualised intervention. The whole class program involves undertaking student assessments and identifying target students with lower than expected achievement. These students receive targeted activities in the context of regular numeracy blocks with a particular focus on addressing the persistence of inefficient calculation strategies (Gould, 2010). The individual intervention comprised an individual case management component. Video-recorded interactions between teachers and children in the intervention are uploaded to the *TOWN* website. *TOWN* case managers, selected for having expertise in teaching numeracy, provided feedback on the recorded interaction to teachers via email. In the initial implementation of *TOWN*, schools were selected to participate based on underachievement in numeracy in the 2008 NAPLAN assessment (see the evaluation of TOWN conducted by Urbis, 2012).

TOWN has a specific focus on place value and in focusing on teaching children to move beyond inefficient counting strategies (such as counting by ones) to develop more efficient strategies and higher-order mathematical understanding (Gould, 2010). *TOWN* has a strong research basis and closely aligns with the frameworks established through the *CMIT* program.

Research Evidence

Urbis conducted an independent evaluation of the *TOWN* program in 2012. The evaluation employed a range of qualitative and quantitative data collection methods to accumulate evidence for the efficacy of the implementation of *TOWN*, its impact on teacher knowledge, skills and abilities and its impact on student achievement. On balance, the evaluation provided good evidence for a positive impact of *TOWN* on, for example, improving teachers understanding of numeracy learning, their knowledge about numeracy teaching practice, and their ability to provide diagnosis of needs and intervention for students with mathematics difficulties. Teachers regarded *TOWN* coordinators as a key component of this success. Thus, those participants surveyed believed that the professional learning component of *TOWN* equipped them with skills to enhance their numeracy teaching for all students. In contrast, the individual intervention component of *TOWN* was rarely used (137 students in total) with participants identifying

difficulties negotiating the technical requirements of the activity (e.g. recording interactions, uploading files to the website) and dissatisfaction with the quality of feedback received.

The *TOWN* evaluators acknowledged the inherent difficulties in using system-wide student achievement data to monitor the efficacy of the intervention. It is clear that, on average, schools participating in *TOWN* improved their performance in numeracy over time; however, the degree to which such improvements can be directly attributed to *TOWN* are questionable. The wide range of interventions implemented in the control group mean that comparisons with the *TOWN* group are difficult to interpret. It is not possible to interpret these comparisons unambiguously as a measure of the efficacy of *TOWN* versus no intervention. As a predominantly whole-school program, distilling the evidence for the impact of *TOWN* on children whose numeracy development does not meet expected levels is not possible within the context of this evaluation. As such, evidence for the efficacy of the *TOWN* program on student achievement is limited. It is also not clear whether *TOWN* will have a long-term impact on student achievement. The program is resource intensive for schools and there was a sense that the withdrawal of the initial funding for the program would influence program sustainability in participating schools.

Combined Year 3 and 5 NAPLAN data for 2008 and 2011 provided by the NSW DEC for schools participating in *TOWN* suggests a trend of improved performance. In 2008, eight schools were placed in the lowest 20 per cent of all schools on NAPLAN, whereas in 2011 only one school was placed in the lowest 20 per cent. In 2011, 16 schools were in the top 50 per cent of schools (up from three in 2008). Aggregated data of this kind has many limitations in that the impact of students with low achievement cannot be determined. One interpretation of an overall effect is that improved performance could be due to average and high achieving students, rather than those with mathematical difficulties.

Resources Required by Schools for Implementation

The resourcing of *TOWN* requires support for the school-based professional learning and any associated time release for teachers. Time release is also necessary to enable teachers to undertake assessments of students in their class, and to undertake individual assessments. Additional resourcing may be required to purchase consumables.

The resource requirements of implementing the *TOWN* intervention are as follows:

Classroom modification	Not needed
Special equipment	Teachers videotape interactions with students and upload the file to the *TOWN* website
Materials	Teaching materials as required
Specialist teachers	Not needed
General classroom teachers	In Phase 1 participating teachers undertake school-based professional learning coordinated by a school team leader; the number of days is not specified; Phase 1 involves 1.5 terms In Phase 2 participating teachers undertake 6 additional days of professional learning while implementing the program; Phase 2 involve 2.5 terms Time release to enable teachers to conduct assessments and any individual interventions
Other personnel inputs	TOWN case managers external to the school and selected for their expertise in teaching numeracy
Licence fee	Not applicable
Other inputs	Replacement cost of consumables

Evaluation of Evidence

Research evidence for the efficacy of *TOWN* focuses primarily on teacher belief in the impact of the professional learning program in improving their effectiveness as a teacher. These findings reflect positively on the impact of the professional learning program; however, the data presented in support of the impact on student achievement are limited. The individualised *TOWN* intervention was rarely used, which, while not reflecting on the intervention's efficacy, does imply limited teacher support for the individual intervention. No cost-effectiveness studies were identified.

Train a Maths Tutor Program

Program Description

Baturo and Cooper (2006) developed a training program for Indigenous Education Workers (IEWs) in two Queensland schools to enhance their understanding of numeracy. The authors noted that there was great scope for IEWs to better support Aboriginal students in developing numeracy, but that IEWs usually had minimal numeracy skills and teachers often did not regard IEWs as a teaching resource in the classroom.

Eleven participants in the program attended training sessions on Monday-Thursday for five weeks. These sessions aimed to develop their mathematical understanding by utilising both hands-on and computer-based materials. The training had a secondary purpose in developing a sense of cohesion among participants in the program and elevating their profile in the community. A small number of students in Years 8–10 were selected to act as trainees for the tutors. The IEWs in this research worked mainly with secondary school children. Research evidence for the intervention is included in this review because the program is one of the few to specifically focus on improving achievement for Aboriginal students and because the program methodology could be adapted for IEWs who work with children in K–3.

Research Evidence

For this relatively small pilot project, there was good evidence that IEWs benefited from participating, both in terms of mathematical knowledge and in their confidence in improving outcomes for students. Other positive benefits of the program included increased recognition of the tutors in the community. Independent observers rated IEWs skills in tutoring, their mathematical knowledge and pedagogical content knowledge as significantly improved after participating in the program. Evidence for the program's efficacy in terms of impacts on student learning were primarily anecdotal (e.g. students were more attentive, or the IEW was more involved in mathematics lessons) as no systematic pre-post intervention student achievement data was available.

Resources Required by Schools for Implementation

A program modelled on the *Train a Maths Tutor Program* would be required to resource the costs of professional learning and the associated costs of time release for the participants.

The resource requirements of implementing the *Train a Maths Tutor Program* are as follows:

Classroom modification	Not needed
Special equipment	Computers
Materials	Learning materials for participating Indigenous Education Workers
Specialist teachers	May possibly be needed to support the IEWs in schools
General classroom teachers	Participants attend 20 days over training sessions spread over 4 weeks May require time release support to cover other responsibilities of IEWs
Other personnel inputs	External trainers
Licence fee	Not applicable
Other inputs	Replacement cost of consumables

Evaluation of Evidence
Research evidence for the efficacy of the *Train a Maths Tutor Program* is limited to descriptions of beneficial effects on participating IEWs, but there is no evidence that IEWs trained through this process were instrumental in improving student achievement. No cost-effectiveness studies were identified.

Tier 1 International Numeracy Interventions

Building Blocks

Program Description
Clements and Sarama (2007; 2008; Clements, Sarama, Spitler, Lange, & Wolfe, 2011) developed *Building Blocks for Math* in the United States through a National Science Foundation grant to produce and assess the efficacy of mathematics curricula for young children. Evaluations of the efficacy of specific curriculums implemented in schools for improving mathematics achievement are rare (Clements & Sarama, 2008). *Building Blocks* and *Everyday Mathematics* (described in the next section) are included in this review because they provide examples of internationally-developed funded research programs that have been widely implemented in schools, and for which there is some research evidence for their efficacy.

Building Blocks is strongly grounded in the notion of learning trajectories for each of the core topics in the curriculum (Clements & Sarama, 2007). The authors derived learning trajectories for mathematical concepts from synthesising research on the development of children's conceptual understanding. They then devised activities designed to encourage children's learning on specific trajectories. The intervention focuses strongly on developing children's informal mathematical knowledge and helping them to build connections to formal mathematical understanding. Learning trajectories for mathematical concepts are embedded in supporting computer-based activities (Sarama & Clements, 2002). *Building Blocks* was subsequently developed as a numeracy intervention product and is available as a suite of materials which includes software licenses, teacher resource books, student assessment booklets, student textbooks, and manipulatives.

Research Evidence
The developers of *Building Blocks* embedded program evaluation in the project's developmental framework. Evaluation of the intervention's efficacy comprised several levels from small-scale formative evaluations of useability to large-scale summative evaluations. The authors designed

Building Blocks as a curriculum for preschool to Year 2, yet assessments of program efficacy are limited to the impact on preschool children. The WWC (2007a) undertook an intervention report of Clements and Samara's *Building Blocks for Math* program, and concluded that the program had a positive effect on mathematics achievement for preschool children; although the extent of the evidence was small (only two studies met WWC evidence standards).

Resources Required by Schools for Implementation
There is a suite of software available to support implementation of the curriculum. These include one-off costs for electronic versions of teacher textbooks, annual site licence fees, and annual costs for student textbooks. Different versions of materials such as texts, planners and assessments are available at each year level from K–6. Implementation would also need to consider the availability of computers to make the programs available to students. No cost-effectiveness studies were identified.

The resource requirements of implementing *Building Blocks* are as follows:

Classroom modification	Not needed
Special equipment	Computers
Materials	Includes electronic versions of teacher guides, assessments, presentations, textbooks
Specialist teachers	Not needed
General classroom teachers	Teachers may require time to become familiar with the program or plan for classroom use
Other personnel inputs	Not needed
Licence fee	Annual school software licences (per student or per building), annual student subscriptions to etextbooks
Other inputs	Replacement cost of consumables

Evaluation of Evidence
There is limited evidence that *Building Blocks* is effective in improving numeracy achievement for preschool children and no evidence available to assess the impact for older students.

Everyday Mathematics

Program Description
Everyday Mathematics is a very widely used core curriculum for mathematics for children from preschool to Year 6 in the United States developed by the University of Chicago School Mathematics Project (funded through the National Science Foundation) which was subsequently commercialised.

Everyday Mathematics embeds a number of research principles into the program design which embodies a constructivist approach and aligns with the standards of the United States National Council of Teachers of Mathematics (Fuson, Carroll, & Drueck, 2000). Children frequently work in small groups or pairs and undertake activities designed to develop and build upon children's informal knowledge of mathematics. They are encouraged to actively engage in solving mathematical problems by using a range of strategies and are assisted to scaffold their understanding through the use of concrete manipulatives and with frequent discussion of their ideas (Fuson et al., 2000).

The University of Chicago Center for Elementary Mathematics and Science Education supports the implementation of *Everyday Mathematics* through the provision of tailored teacher professional learning and ongoing support in the form of classroom coaching. Four day workshops are available for new users of *Everyday Mathematics* in both general classroom and special education contexts in K–5, as well as one day professional learning focused on a single year level. One day workshops are also available for those with experience of *Everyday Mathematics* who wish to develop greater understanding of the mathematics and pedagogy underlying the curriculum.

Research Evidence

A WWC intervention report (2010b) identified only one study (Waite, 2000) that met the WWC evidence standards, though with reservations, and showed potentially positive effects of *Everyday Mathematics* for children in Years 3–5. There was no appropriate evidence for the efficacy of the program among children in years K–2. Another 71 studies identified at the time of the 2010 review did not meet WWC evidence standards, primarily because the studies either did not establish that intervention or comparison groups were equivalent at the beginning of the study, or because the study did not include a comparison group.

Resources Required by Schools for Implementation

To implement the *Everyday Mathematics* curriculum in schools would require schools to resource the professional learning component (flexible options are available for the location and duration of training) and to purchase the associated materials. Additional teacher time may be required for planning implementation.

The resource requirements of implementing *Everyday Mathematics* are as follows:

Classroom modification	Not needed
Special equipment	Computers
Materials	Includes teacher reference manuals, lesson guides, assessment handbooks, classroom kits
Specialist teachers	Not needed
General classroom teachers	Four days of professional learning for new users, one day is available for new users focusing on implementation at a single year level
Other personnel inputs	Not needed
Licence fee	Annual classroom or building licence for software
Other inputs	Replacement cost of consumables

Evaluation of Evidence

During the course of this review, no evidence was identified which demonstrated that *Everyday Mathematics* improves numeracy outcomes for students in Years K–2. There is very limited evidence available to assess the impact of *Everyday Mathematics* on the achievement of students in Years 3–5, and no cost effectiveness studies were identified in the current review.

Tier 2 International numeracy interventions

Numeracy Recovery (Catch up Numeracy)

Program Description

Numeracy Recovery originated in the UK as a funded research project devised by Ann Dowker from the University of Oxford. Dowker's (1998, 2005b) findings on the significant individual differences in children's mathematical development informed the development of the intervention. In the original pilot program, classroom teachers assessed children identified as having difficulties with mathematics on eight components of early numeracy for which there was strong research evidence as to their importance to numeracy development (Dowker, 2007). These components included principled and procedural understanding of counting, written mathematical symbols, place value, word problems, translation between concrete, verbal and numerical formats, use of derived fact strategies for calculation, estimation and number facts (Dowker, 2001). Children received weekly individual intervention from their classroom teacher in the areas of need identified in an initial assessment. Each session ran for approximately 30 minutes with total intervention duration of up to 30 weeks. Classroom teachers conducted the interventions during approximately half a day each week of time release. Teachers implemented interventions based on strategies suggested by Dowker (2001) and occasional use of published materials. For instance, Dowker (2001) suggests principled and procedural understanding of counting involves rote counting skill, applying counting to work out how many objects in a set, understanding of the principles underlying counting, and repeated addition and subtraction by one. She suggested that difficulties understanding that the order in which objects are counted does not change the number of objects (order-irrelevance principle) and repeated addition and subtraction by one are likely to be the most substantive issues for children in Year 2 (Dowker, 2001). Her suggested intervention to improve children's understanding of order irrelevance involved counting practise with very small sets and answering cardinality and order irrelevance questions. Children then practised with larger sets. To improve understanding of repeated addition and subtraction by one, Dowker suggested that children observe and predict the results for repeated addition and subtraction by one (for up to 20 items). The teacher then challenged children to answer verbal 'number before' and 'number after' problems.

The *Numeracy Recovery* program was subsequently adapted and modified for wider implementation in association with the Caxton Trust (a not-for-profit company in the UK operating as Catch Up) and renamed *Catch Up Numeracy*. *Catch Up Numeracy* targets children who are experiencing numeracy difficulties in Years 2–6. The implementation of *Catch Up Numeracy* in schools is supported by a four-stage approach to professional learning for schools. Professional learning consists of an initial 90 minute session for school leadership teams, three half day sessions of professional learning to train teachers to deliver the intervention, a 90-minute session for those who manage *Catch Up Numeracy* in schools, and a one-day review and extension course for experienced deliverers of *Catch Up Numeracy.* Teachers undertake formative assessments of children's difficulties in ten components of mathematics and use these assessments to develop a learner profile to guide the focus of teaching. The formative assessments allow teachers to assign a *Catch Up Numeracy* level (1-12) to each component, where 1 represents the lowest level of achievement and 12 the highest level. Children undertake

two 15-minute individual intervention sessions per week where the focus is initially on components with levels below 3 (Dowker & Sigley, 2010).

Research Evidence

Two strengths of Dowker's research are the research basis for the conceptual underpinning for the components of the intervention, and the targeting of the intervention at specific difficulties exhibited by the child. Multidisciplinary research on the development of children's mathematical ability has been instrumental in understanding how children acquire mathematical concepts and in describing the large individual differences in children's numeracy understanding (Dowker, 2007). Dowker's intervention is also one of the few interventions where details of instructional approaches to intervention for specific components (see for instance Dowker, 2001; Dowker & Sigley, 2010), thereby allowing this critical element of the intervention to be evaluated.

Numeracy Recovery was piloted with a relatively small sample of Year 2 children (n = 168) in six schools in Oxford (Dowker, 2001; Dowker & Sigley, 2010). Classroom teachers identified these children as having difficulties with numeracy. Teachers measured students' growth in achievement over the course of the intervention using standardised pre and post tests of mathematical ability. Use of standardised tests to measure growth in achievement is positive as it attempts to establish the efficacy of the intervention beyond measures of skills practised in the intervention.

Evidence for the efficacy of *Numeracy Recovery* is, however, fairly limited. The pilot data examined by Dowker (2001; Dowker & Sigley, 2010) included only an intervention group and did not provide a standard for growth in a comparable group of students. Dowker (2005; 2005a) refers to data from a group of children who did not participate in the initiative and who showed no growth on standardised tests; however, these data are only superficially described and important information is omitted. For example, it is unclear whether these children had similar baseline achievement to children in the intervention group. Subsequent evaluations of *Catch Up Numeracy* intervention (Evans, 2007, 2008) are primarily qualitative and focus on school personnel perceptions of the implementation of the initiative, its strengths and weaknesses and overall impact, rather than impact on student achievement.

Resources Required by Schools for Implementation

Schools wishing to implement *Numeracy Recovery/Catch Up Numeracy* would need to resource teacher professional learning and associated teacher release costs, as well as resource teacher time to enable them to conduct individual assessments and the intervention with selected students. Other costs may include the resourcing of additional numeracy materials to support the implementation of the program.

The resource requirements of implementing *Numeracy Recovery/Catch Up Numeracy* are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Teaching materials as required
Specialist teachers	Not needed
General classroom teachers	*Catch Up Numeracy* offers 90 minutes of introductory professional learning for school leadership teams, three half day sessions for teachers, a 90-minute session for coordinators of *catch Up Numeracy*, and a one-day review and extension course for experienced deliverers of *Catch Up Numeracy.* Time release to enable teachers to conduct assessments and any individual interventions
Other personnel inputs	Not needed
Licence fee	Not applicable
Other inputs	Replacement cost of consumables

Evaluation of Evidence

The research identified during the course of this review provided limited evidence to assess the efficacy of *Numeracy Recovery* in improving student achievement. No cost-effectiveness studies were identified.

Number Rockets

Program Description

Number Rockets is a numeracy intervention for students in Year 1 at risk of mathematical difficulties, which Fuchs et al. (2005) developed in the United States. The intervention is included in this review because it provides an international case study of a numeracy intervention originally conducted as a small-scale academic project (Fuchs et al., 2005) which was subsequently evaluated as part of a larger system implementation.

Students selected to participate in *Number Rockets* are withdrawn from class and undertake the intervention in small groups in addition to (and not replacing) regular classroom instruction in mathematics. Trained tutors conduct the intervention sessions, which comprise 3–6 scripted lessons of 40 minutes (30 minutes of instruction followed by 10 minutes of practice), for each of 17 topics. The developers modelled the instructional component of the intervention on the concrete-representational-abstract model of mathematical conceptual development (Fuchs et al., 2005). The authors intended that the intervention cover the classroom curriculum more comprehensively than other mathematics interventions, with a broad focus on the development of number sense. All topics integrated manipulatives into the teaching of whole number concepts, focused initially on gaining procedural skills and conceptual understanding of counting and the number sequence, facility with simple quantity comparisons, and recognising and writing numerals. More advanced lessons included an understanding of place value and operations. Ongoing assessment is embedded in the lesson delivery embeds ongoing assessment with pacing of lessons aligned with student progress on mastery assessments.

Research Evidence

Fuchs et al. (2005) conducted an initial randomised control study of the efficacy of a small group numeracy intervention, provided in addition to classroom instruction in improving mathematics. The study identified 139 Year 1 students at risk of mathematical difficulties in 10 schools in the United States. The authors randomly assigned these students to an intervention or control group and then contrasted the improvement of the intervention group over the course of intervention with a not-at-risk control group. The study utilised a range of different outcome measures to assess progress over the course of the intervention and on a number of these (e.g. curriculum based measurement computation, Woodcock Johnson calculation, story problems) tutored at-risk students improved more than the not-at-risk control group. In some cases, the rate of improvement of the tutored group exceeded that of the not-at-risk group (e.g. Woodcock Johnson calculation, Year 1 concepts and applications). No effect was evident for fluency in basic facts, with the at-risk control and tutored groups performing similarly at the end of the intervention. This lack of effect is of some concern given that direct instruction of basic facts comprised approximately 25 per cent of the total intervention time. The performance of tutored at-risk students remained below that of their not-at-risk peers at the end of the school year.

The original trial of *Number Rockets* by the developers showed encouraging effects in improving the skills of students at risk of mathematical difficulties. The implementation of the intervention was however, small scale and thorough training and monitoring of the researchers who conducted the small-group sessions ensured high fidelity of implementation. Rolfus et al's., (2012) evaluation described the implementation of *Number Rockets* in 76 schools in four states, with schools matched on specific criteria (e.g. proportion of free school lunches) and then randomly assigned to a control or intervention condition. There was some degree of control over the selection of schools in the study, none had implemented a Tier 2 numeracy intervention and a core mathematics curriculum was common to schools within a district. Within schools, the process of selecting participating students was not random as students participated only with parental consent. Nonetheless, the intervention and control students exhibited similar achievement on several measures of early numeracy prior to the intervention. Tests of Early Mathematical Ability (3rd edition) (TEMA-3) was used to monitor the impact of the intervention on student achievement. Teachers hired as *Number Rockets* tutors received training to implement the intervention. Training comprised one day of professional learning followed by two 2-hour follow up sessions. The evaluation also incorporated fidelity of implementation measures such as those focused on lesson implementation, which was found to be relatively high (greater than 80 per cent average concordance with scripted lesson plans). Post intervention scores on the TEMA-3 were higher, on average, for the *Number Rockets* intervention group compared with the control group, although the effect size was modest (0.34). Impact of the intervention was unrelated to achievement prior to the intervention or to the number of lessons received. In common with other examinations of Tier 2 interventions, the lack of control for instructional time limits the degree to which effects can be specifically attributed to characteristics of *Number Rockets* (Rolfhus et al., 2012). Nonetheless, the two studies evaluating *Number Rockets* provide some indication of the immediate efficacy of a Tier 2 intervention in improving outcomes for children at risk of mathematical difficulties.

Resources Required by Schools for Implementation
To implement *Number Rockets* would require schools to resource professional learning for teachers and associated time-release costs (of approximately one day per teacher trained). Additional resourcing is required for classroom teachers or trained tutors to implement the intervention for small groups of children (for about 40 minutes per session). Additional resources in the form of consumables may be required. No cost-effectiveness studies were identified.

The resource requirements of implementing *Number Rockets* are as follows:

Classroom modification	Not needed
Special equipment	Not needed
Materials	Teaching materials as required
Specialist teachers	Not needed
General classroom teachers	One day of professional learning, time to undertake the small group intervention. Teacher release costs depend on whether a classroom teacher or a trained tutor administer the intervention
Other personnel inputs	Not needed
Licence fee	Not applicable
Other inputs	Replacement cost of consumables

Evaluation of Evidence
There is some research evidence available to assess the efficacy of *Number Rockets* in improving student achievement, with two high quality studies exploring the impact of the intervention (Fuchs et al., 2005; Rolfhus et al., 2012).

Numeracy intervention products

Numeracy intervention products focused on improving mathematics achievement are less common than those focused on literacy interventions. In Australia, a number of commonly used mathematics resources (e.g. *Maths300*, *Mathletics*, *Elementary Maths Mastery*) may be adapted and used as a form of classroom intervention, although the purpose of use in the classroom is likely to vary substantially. One study was located that assessed the impact of *Mathletics* in enhancing student achievement in mathematics for students in Years 5 and 8 (Doig, 2008), although no analogous research could be identified which focused on younger students. Doig's (2008) report suggested that moderate use of *Mathletics* in addition to classroom teaching had an impact on student achievement (as assessed by *PATMaths*). These conclusions are qualified by evidence of greater impact for some groups (e.g. Year 5 girls), and of variable support from classroom teachers for the implementation of *Mathletics* in the classroom.

Other more specialist numeracy intervention products are available (e.g. *Symphony Math*) but it is not clear the degree to which Australian schools utilise these resources. Evidence of the efficacy of *Symphony Maths* (a K–6 computer-based numeracy intervention for individual students which can be flexibility implemented as a Tier 1–3 intervention) is limited to documentation produced by the program's developers (Symphony Learning, 2011). The program developers claim that the product aligns with the eight recommendations for effective intervention embedded in Gersten et al's., (2009a) report on RtI for elementary and middle schools. It is difficult to make strong conclusions for the efficacy of *Symphony Maths* based on

the small research study conducted by the developers, because of limitations in the study design and analysis. Students in the intervention group (n = 19) used the program for different lengths of time across the school year (from 17–47 hours) with this variation not taken into account in the statistical analysis. Moreover, the intervention and control groups are not comparable at baseline, so the true effect of the intervention over and above regular classroom instruction is difficult to ascertain.

Numeracy intervention products tend to be more widely used internationally and evidence of their efficacy tends to be from international sources. In a recent review, Kroeger, Brown and O'Brien (2012) identified 20 mathematics intervention products that included children from the beginning of school to Year 3 among their target group. Of these, only five had been the subject of empirical, peer-reviewed research. Of these five, only *Accelerated Math (AM)* has been the subject of relatively rigorous research, although few of these studies meet the WWC standards of evidence for research. A brief discussion of evidence for these products is included because it is important to acknowledge the very sparse evidence for the efficacy and effectiveness of any numeracy intervention products.

AM is a computer-based intervention, catering for students in Years 1–12, that provides individual instruction derived from the results of diagnostic assessment. The teacher can assign objectives to specify diagnostic assessment that matches students' current level of ability. The program generates practice questions based on the results of assessment, followed by further problems based on the student's score on the initial task. The program works through repeated cycles of assessment, setting of new objectives and feedback to the teacher to enable progress monitoring. *AM* focuses on the development of number sense, on developing automaticity of retrieval for basic mathematical facts and on multidigit computation.

Kroeger at al.'s (2012) synthesis of the extensive research evidence for the efficacy of *AM* suggests that the program is effective in improving children's achievement in mathematics. The research available provides evidence for efficacy among different groups, provides evidence for the efficacy of *AM* against comparison groups and statistically controls for variables such as SES and gender. It was noted however, that implementation fidelity for the program varied widely and the most significant impacts were evident when teachers implemented *AM* with a high degree of fidelity (Kroeger et al., 2012). The WWC intervention report on *AM* for Elementary Schools (What Works Clearinghouse, 2010a) was less positive in its appraisal of *AM*. At the time of the report, only three published studies met the WWC evidence standards and of these, only one focused on the early years of schooling (What Works Clearinghouse, 2010a). Ysseldyke and Bolt's (2007) study established significantly greater gains on standardised mathematics achievement tests for students participating in *AM* than for students in classrooms implementing the standard curriculum without *AM*.

Kroeger et al. (2012) identified *Corrective Math (CM)*, *Fluency and Automaticity through Systematic Teaching with Technology (FASTT) Number Worlds (NW)* and *The Number Race (NR)* as the only other commercial mathematics intervention programs that were appropriate for children in the early years and for which some research evidence was available. None of these programs had yet been subject to a WWC intervention report. The research findings on the efficacy and effectiveness of these programs are varied. Although some interventions appear to

have a strong evidence basis in academic research on children's mathematical cognition (e.g. *NW*, *NR*), the next stage in comprehensively validating the impact of the intervention on children's achievement in mathematics is omitted, or presents as low quality evidence.

Summary of the evidence for the efficacy of numeracy interventions

Overall, there is a lack of high quality research evidence for the efficacy of numeracy interventions implemented in Australia and internationally (for the small number of international interventions reviewed). There is currently no research evidence to enable an assessment of the efficacy of *First Steps*, *LIEN*, *NIRP*, *Numeracy Matters*, *Mathematics Intervention*, or *Train a Maths Tutor*, and there is very limited research on the interventions *CMITI*, *GRIN*, *SINE*, *TEN*, *Mathematics in Indigenous Contexts*, *Mathematics Recovery*, *NIP*, *TOWN*, *Building Blocks*, *Everyday Maths*, and *Numeracy Recovery*. There is some evidence evaluating the efficacy of *CMIT*, *EMU*, and *Number Rockets* and a moderate amount of evidence evaluating *QuickSmart Numeracy*.

In summarising the findings from this section, a number of general points can be made about the quality of research evidence for effective numeracy interventions. In the studies reviewed, researchers often describe superficially the conceptual underpinnings of programs and the links between projected outcomes of an intervention and the strategies to achieve these outcomes. In general, numeracy intervention programs target low achieving students in mathematics and there is little evidence among the interventions reviewed that they are specialised or adapted to target different groups (e.g. ESL students, Aboriginal students). It is evident that a small group of mathematics education researchers developed many of the numeracy interventions in Australia and assessments of the efficacy of the intervention are often limited to research conducted by the program developers.

Funding considerations impose a significant limitation on the type of research evidence of student achievement that academic researchers can collect. Longitudinal study, though important in monitoring long-term outcomes for students who undertake a numeracy intervention, is costly and delays in the opportunity to publish often favours a less powerful cross-sectional design. Numeracy interventions implemented by education authorities are typically subject to external evaluation, but evidence for impact on student achievement is often limited to less sensitive measures of the impact of the intervention and rarely addresses longer-term outcomes. As previously noted, the design of numeracy interventions in this review share substantial commonalities and it is apparent that many of these interventions incorporate general principles in the design of numeracy interventions. In the next section, some of these general principles are highlighted as another approach to assessing the likely efficacy of numeracy interventions implemented in Australia.

3.2 General Principles of Effective Numeracy Intervention in the Early Years

Overview

Increasingly, education authorities have promoted numeracy learning with a common theme in education policy that understanding mathematics and a capacity to apply this understanding in life is critical (Young-Loveridge, 2004). A renewed focus on the importance of numeracy has begun to address a lack of attention to the form and consequences of early mathematical difficulties. Section 3.1 assessed the research evidence for specific whole class numeracy interventions designed to develop all students' numeracy skills (e.g. *CMIT*) and for additional numeracy interventions designed for students with low attainment (e.g. *TEN*). Section 3.2 presents the findings of an extensive review of the academic literature conducted to evaluate the evidence for specific general principles of effective numeracy interventions. As outlined in the first part of this chapter, many numeracy interventions currently implemented (or which could be implemented) in NSW have little published research evidence of their efficacy in improving student achievement. At the same time, the structure and focus of these interventions have many similarities. Assessing the evidence for the efficacy of particular intervention approaches more generally, offers another strategy for assessing the probable usefulness of specific numeracy interventions. Where evidence for specific numeracy interventions is lacking, it is possible to assess the degree to which the intervention incorporates general principles of effective intervention for which there is a strong research base.

Section 3.2 provides a brief general overview of some general principles in the design of effective numeracy interventions for students in the first four years of school. These principles apply to effective numeracy teaching generally, or to intervention at Tiers 1, 2, or 3. Although, no specific Tier 3 numeracy intervention was identified in the individual intervention reviews, reference to relevant general principles at Tier 3 are included for completeness in this section. The discussion of each factor includes a brief description of why the review has identified these principles as critical aspects of early numeracy intervention. Each section presents an analysis of selected research evidence to build a case for the importance of each principle. The general principles highlighted in this section of the literature review are discussed under the following headings:

- Effective instructional approaches in the teaching of mathematics
- Early intervention and number sense
- Professional learning for teaching mathematics
- Assessment approaches
- A conceptual framework for children's mathematical development

This list of factors, which are central to providing good teaching in early numeracy generally and in structuring effective numeracy interventions specifically, is of necessity brief and should not be considered exhaustive. These factors were selected as the focus of this section because they provided the best link to the features of numeracy intervention programs discussed in Section 3.1. Although these factors are discussed under separate headings, they should not be considered independent. Interrelated themes intersect the separate discussions. For instance, highlighting the development of number sense as an important focus of early numeracy interventions implies

that effective teachers of numeracy must have an appreciation of the importance of number sense and a conceptual model for its development. In turn, this suggests that an important component of professional learning in early numeracy may involve providing teachers with knowledge and skills in these areas.

In articulating these general principles, the review draws substantially on a several major research syntheses of the evidence for effective numeracy interventions, with selected supplemental evidence from high quality research studies. The discussion under each heading is broad and where a summary of research evidence of specific principles is provided (e.g. of the components of effective teaching), the review does not attempt to reassess the quality of evidence for each of these principles individually. In some cases, the evidence does not strongly support a recommendation for specific features of interventions (e.g. whether a small group or an individual intervention is more effective, Williams, 2008). In these instances, an extended discussion of the evidence is not considered.

Effective instructional approaches in the teaching of mathematics

Children's acquisition of numeracy skills in the early years of schooling is highly dependent on the effectiveness of classroom teaching. Effective classroom mathematics teaching has a range of potential impacts including improved student learning, enhanced engagement and enjoyment of learning. The relationship between teaching approaches and student outcomes is however, complex. Individual learners may respond to different teaching approaches and different types of learning may require diverse teaching methods. Nonetheless, there has been some progress in identifying instructional approaches shown to be effective in the teaching of mathematics. For example, The *Mathematics Matters* project conducted in the UK by the National Centre for Excellence in the Teaching of Mathematics (Swan et al., 2008) sought to identify a range of teaching approaches which have been shown to be of benefit in promoting valued learning outcomes in mathematics. The authors began with eight research-based principles outlined in *Improving Learning in Mathematics* (DfES, 2005) and modified these after consultations with representatives with interests in mathematics education.

These recommended principles for the effective teaching of mathematics, which are taken from Swan et al. (2008, pp. 19–20) are outlined below.

Teaching is more effective when it....

1. Builds on the knowledge learners already have

   Swan et al. (2008) recommends .... *This means developing formative assessment techniques and adapting our teaching to accommodate individual learning needs….*

2. Exposes and discusses common misconceptions and other surprising phenomena

   Swan et al. (2008) recommends .... *Learning activities should expose current thinking, create misconceptions and other 'tensions' by confronting learners with inconsistencies and surprises, and allow opportunities for resolution through discussion….*

3. Uses higher-order questions

   Swan et al. (2008) recommends .... *Questioning is more effective when it promotes explanation, application and synthesis rather than mere recall….*

4. Makes appropriate use of whole class interactive teaching and cooperative small group work

   Swan et al. (2008) recommends ….*Collaborative group work is more effective after learners have been given an opportunity for individual reflection.*

   Activities are more effective when they encourage critical, constructive discussion, rather than argumentation or uncritical acceptance.

   Shared goals and group accountability are important….

5. Encourages reasoning rather than 'answer getting'

   Swan et al. (2008) recommends .... *Often, learners are more concerned with what they have 'done' than with what they have learned. It is better to aim for depth than for superficial 'coverage'….*

6. Uses rich, collaborative tasks

   Swan et al. (2008) recommends .... *The tasks used should be accessible, extendable, encourage decision-making, promote discussion, encourage creativity, encourage 'what if' and what if not' questions….*

7. Creates connections between topics both within and beyond mathematics and with the real world

   Swan et al. (2008) recommends .... *Learners often find it difficult to generalise and transfer their mathematics learning to other topics and contexts. Related concepts and with the real world (such as division, fraction and ratio) remain unconnected. Effective teachers build bridges between ideas….*

8. Uses resources, including technology, in creative and appropriate ways

   Swan et al. (2008) recommends .... *ICT offers new ways to engage with mathematics. At its best it is dynamic and visual: relationships become more tangible. ICT can provide feedback on actions and enhance interactivity and learner autonomy. Through its connectivity, ICT offers the means to access and share resources and – even more powerfully – the means by which learners can share their ideas within and across classrooms….*

9. Confronts difficulties rather than seeks to avoid or pre-empt them

   Swan et al. (2008) recommends .... *Effective teaching challenges learners and has high expectations of them. It does not seek to 'smooth the path' but creates realistic obstacles to be overcome….*

   Confidence, persistence and learning are not attained through repeating successes, but by struggling with difficulties….

10. Develops mathematical language through communicative activities

    Swan et al. (2008) recommends .... *Mathematics is a language that enables us to describe and model situations, think logically, frame and sustain arguments and communicate ideas with precision. Learners do not know mathematics until they can 'speak' it. Effective teaching therefore focuses on the communicative aspects of mathematics by developing oral and written mathematical language….*

11. Recognises both what has been learned and also how it has been learned

    Swan et al. (2008) recommends .... *What is to be learned cannot always be stated prior to the learning experience. After a learning event, however, it is important to reflect on the learning that has taken place, making this as explicit and memorable as possible. Effective teachers will also reflect on the ways in which learning has taken place, so that learners develop their own capacity to learn….*

Other research has sought to establish evidence for instructional approaches in numeracy interventions that result in improved understanding for students with mathematical difficulties. In a meta-analysis of 44 research studies of numeracy interventions for school-aged children with learning disabilities, the authors established significant effects for five instructional components (Gersten et al., 2009b, 2009c). Of these components, the use of explicit instruction in interventions consistently produced positive effects, irrespective of whether the approach was used in conjunction with other instructional methods.

Gersten et al. (2009c, p. 53) define explicit instruction as a process whereby:

> *a. the teacher demonstrated a step-by-step plan (strategy) for solving the problem;*
> *b. the plan was problem-specific and not a generic, heuristic guide for solving problems; and*
> *c. students were actively encouraged to use the same procedure/steps demonstrated by the teacher*

Similarly, Gersten et al. (2009a) in the Institute of Education Sciences report *Assisting Students Struggling with Mathematics: Response to Intervention (RtI) for Elementary and Middle School Students* identify explicit and systematic instruction for students at the Tier 2 and 3 level as a strong evidence-based best practice recommendation for schools providing mathematics interventions (Gersten et al., 2009a). Gersten et al. (2009a) compiled specific recommendations (and their corresponding levels of evidence) based on their analyses of the research evidence. Table 3.3 provides a summary of the eight recommendations in Gersten et al. (2009a). The levels of evidence in Table 3.3 refer to a categorisation of the strength of the research evidence based primarily on WWC evidence. Strong evidence requires consistent evidence of intervention effects across multiple well-designed studies with a sound basis for generalising the findings. Moderate evidence may be derived from well-designed studies with limited scope for generalisation or less clear evidence for the efficacy of the intervention. Evidence for the efficacy of an intervention is low if it does not meet moderate or strong standards of evidence.

Though highlighting the promise of explicit instruction as an instructional component of effective numeracy interventions, the authors emphasise that there is no evidence to support explicit instruction as the only effective teaching approach. Gersten et al. (2009c) also identify evidence for the use of visual examples, careful attention to the sequencing and selection of examples taught in numeracy interventions, encouraging students to verbalise their thinking in solving problems, and providing feedback to teachers about the progress of intervention students (including their strengths and weaknesses). It is important to note, however, that the meta-analysis includes studies across both primary and secondary schooling, thus, these conclusions do not relate exclusively to numeracy interventions in the first four years of schooling.

Table 3.3. Gersten et al's (2009a, p. 6) Recommendations and corresponding levels of evidence for mathematics interventions

Recommendation		Level of evidence
Tier 1		
1.	Screen all students to identify those at risk for potential mathematics difficulties and provide interventions to students identified as at risk.	**Moderate**
Tiers 2 and 3		
2.	Instructional materials for students receiving interventions should focus intensely on in-depth treatment of whole numbers in Kindergarten through grade 5 and on rational numbers in grades 4 through 8. These materials should be selected by committee.	**Low**
3.	Instruction during the intervention should be explicit and systematic. This includes providing models of proficient problem solving, verbalisation of thought processes, guided practice, corrective feedback, and frequent cumulative review.	**Strong**
4.	Interventions should include instruction on solving word problems that is based on common underlying structures.	**Strong**
5.	Intervention materials should include opportunities for students to work with visual representations of mathematical ideas and interventionists should be proficient in the use of visual representations of mathematical ideas.	**Moderate**
6.	Interventions at all grade levels should devote about 10 minutes in each session to building fluent retrieval of basic arithmetic facts.	**Moderate**
7.	Monitor the progress of students receiving supplemental instruction and other students who are at risk.	**Low**
8.	Include motivational strategies in tier 2 and tier 3 interventions.	**Low**

Source: Gersten, Beckmann, Clarke, Foegen, Marsh, Star, and Witzel's (2009a) compilation based on analysis described in their text.

Early intervention and number sense

The notion that children commence learning mathematics when they enter school has altered significantly in recent years. Instead, children starting school are known to possess a rich system of informal mathematical knowledge derived from everyday experiences (Resnick, 1989). Informal mathematical knowledge has also been shown to vary considerably between children and has led to the proposition that deficiencies in children's mathematical knowledge when they enter school can impact upon the development of formal mathematical knowledge (Starkey & Klein, 2000). Significant individual differences in early mathematical ability are evident even when children commence school, suggesting that without intervention to promote the understanding of low achieving children that this wide gap in achievement will remain (Dowker, 1998, 2003, 2005b). Educational difficulties appear significantly more difficult to address the longer that they continue unaddressed, leading to a focus on prevention, rather than later remediation (Clarke, Baker, Smolkowski, & Chard, 2008). An additional concern is that protracted difficulties may encourage negative attitudes about mathematics to develop, which may further hinder learning (Dowker, 2009). Specific recommendations for early numeracy intervention exist, with a national review of mathematics teaching in the early years and primary schools in the UK suggesting that the timing of interventions should be located in Year 1 or 2 of primary schooling (Williams, 2008).

Central to children's development of mathematical thinking in the early years is number sense. Reasoning about small numbers appears to be evident very early (possibly in infancy) but undergoes prolonged development. A precise definition of number sense is elusive with many different skills suggested as probable components. Kalchman, Moss, and Case (2001, p. 2) synthesised different authors' perspectives in the following way:

> *the characteristics of number sense include: (a) fluency in estimating and judging magnitude, (b) ability to recognise unreasonable results, (c) flexibility when mentally computing, (d) ability to move among different representations and to use the most appropriate representation for a given situation and (e) ability to represent the same number or function in multiple ways, depending on the context or purpose of this representation.*

Number sense includes a capacity to identify small numbers, reason about larger and smaller numbers, and the results of simple transformations (e.g. adding and subtracting one). Children with a well-developed number sense in Kindergarten have a good procedural grasp of the counting sequence, but more importantly children with number sense understand the uses of counting to work out how many and compare different numbers of objects. The sophistication of children's number sense in Kindergarten remains moderately associated with mathematics achievement, even in Years 2–3 (Jordan, Kaplan, Ramineni, & Locuniak, 2009; Locuniak & Jordan, 2008). For these reasons, intervention programs focused on the years prior to school have begun to appear. These interventions (such as Pre-K Mathematics developed by Starkey, Klein, & Wakeley, 2004) are typically Tier 1 interventions designed to redress perceived disadvantages experienced by children who have fewer mathematical experiences in the home and preschool. While evidence for the efficacy of such prior to school interventions is limited (e.g. *Building Blocks*), there is good reason to believe that children who commence school with

poorly developed number sense, are less equipped to take advantage of classroom instruction. Numeracy interventions focused on improving number sense are increasingly common (e.g. Bryant, Bryant, Gersten, Scammacca, & Chavez, 2008; Bryant et al., 2008; Jordan, Dyson, & Glutting, 2011; Jordan, Glutting, Dyson, Hassinger-Das, & Irwin, 2012). At the same time, stringent evidence for the efficacy of interventions with a number sense focus for students in the first four years of schooling is relatively scarce (Gersten et al., 2009a).

Jordan and colleagues have focused on the impact of numeracy interventions for children from low-income schools in the United States. They advocated a small-group number sense intervention to provide foundational skills for children at risk of mathematical difficulties. Jordan et al.'s (2012) recent study presents good evidence that a number sense intervention is successful in improving Kindergarten children's (children who are approximately the age of Australian children in foundation year) mathematics achievement over the course of the intervention and in maintaining those skills subsequent to the intervention. The study included random allocation to conditions and statistical controls for initial understanding. Children in an intervention group focused on improving number sense were compared to two control groups, the first, a business as usual classroom and the second, a small group language intervention. In this way, the authors could examine the impact of the number sense intervention over and above the impact of interaction in a small group setting. In addition to a validated measure of number sense as an outcome measure, the study also included a standardised mathematics achievement measure. Medium and large effects were evident across a range of measures for the number sense intervention relative to children in the control group, with no evidence of an impact on mathematics achievement through undertaking a small group language intervention. However, as the authors acknowledge there is no control for instructional time. Thus, it is not clear whether additional instructional time would result in higher levels of achievement for children in a mainstream classroom.

One argument against early intervention in numeracy is the fluidity of children's number sense skills at young ages. Patterns of understanding that appear problematic at young ages, may not be stable and could resolve spontaneously in the regular classroom environment. For instance, Locuniak and Jordan's (2008) number sense measure identified a high proportion of children in Kindergarten who no longer appeared at risk in Year 2, with about 16 per cent of children manifesting difficulties in Year 2 who had not been detected during screening in Kindergarten. For a proportion of children, performance is variable, with mathematical difficulties evident at one point in time resolved at a later point without intervening intervention (Geary, Hamson, & Hoard, 2000). The reason for this variation is not clear. Children's earlier difficulties may resolve over time as a function of classroom teaching and learning. Alternately, variation may be due to the adequacy of screening for mathematical difficulties. Both Locuniak and Jordan (2008) and Missall et al. (2012) identify quantity discrimination as a better indicator of subsequent risk in mathematics than oral counting tasks. The use of efficient and increasingly sophisticated counting strategies however, appears to effectively discriminate children who experience mathematical difficulties from those who are able to benefit from classroom instruction (Gersten, Jordan, & Flojo, 2005). Nonetheless, the strong relationship between early number sense measures and later mathematical performance are compelling. Evidence of variable performance highlights the importance of good assessment in the diagnosis of children's

mathematical difficulties, rather than invalidating the need to intervene should difficulties be apparent.

Professional learning for teaching mathematics

Teachers are arguably better prepared and more confident in their capacity as effective teachers of literacy than they are as teachers of numeracy. Effective classroom teachers support all students to develop numeracy and play a central role in identifying students who are having difficulties in the classroom and who may require additional support. However, evidence of substantial between class variations in the efficacy of mathematics interventions suggests that teacher preparedness to teach numeracy is a significant concern. For example, Shayer and Adhami (2010) researched the efficacy of a Tier 1 collaborative learning intervention for Year 1 and 2 children focused on advancing their understanding of Piagetian concrete operational concepts. Teachers and researchers from schools in two local education areas in the United Kingdom collaborated to develop and trial lessons focused on concrete operational schema such as classification, seriation, spatial perception, time relations and causality. Teachers implemented the lessons in Year 1 in the classroom by undertaking 20–30 minute sessions with a new group of six children each day of the week. In Year 1, the researchers designed whole-class teaching to support the group activities. In Year 2, only the whole-class teaching continued. On average, the intervention exhibited moderate effects for both a test of spatial relations and a standardised mathematics achievement test. The variation across different classrooms was significant, with some classes showing negligible or weak effects, others moderate and some quite strong effects.

There is evidence that many primary teachers lack content knowledge in mathematics and are less confident in teaching these concepts (Hembree, 1990). Moreover, teachers who are anxious about their own mathematical abilities can transmit uncertainty to their students (Gresham, 2008). Teachers need to be sufficiently skilled to recognise and respond to the needs of students who have mathematical difficulties. Teachers also need to have the skills to build on improvements for students who undertake an intervention and return to regular classroom teaching. At present, both in Australia and internationally, the entry requirements for primary teachers typically do not require success at high-level mathematics courses. Options to require higher mathematics prerequisites of prospective teachers or to include more mathematics content in teacher training courses have been regarded as unrealistic (Stanley, 2008). Given these conditions, ongoing high quality professional learning is the primary avenue for enhancing the mathematical knowledge of the teaching profession.

Until recently however, there has been little focus on what teachers must know in order to be effective teachers of mathematics. The work of Shulman (1986, 1987) was pivotal in characterising teacher professional knowledge and extending the conceptualisation to include content knowledge, curricular knowledge and pedagogical content knowledge. Yet, as Ball and colleagues (Ball, Lubienski, & Mewborn, 2001; Ball, Thames, & Phelps, 2008; Hill, Rowan, & Ball, 2005; Hill, Schilling, & Ball, 2004) have contended, efforts to link improved student achievement to specific aspects of teacher content knowledge are often lacking. Hill et al. (2005) established a link between teacher's mathematical knowledge for teaching and the achievement gains of American students in Year 1 and Year 3. Findings of this nature affirm

what is commonly assumed, that high quality, sustained professional learning has a role to play in improving teacher confidence in teaching numeracy, developing their knowledge about how children acquire numeracy and developing their range of instructional approaches to teaching numeracy.

When considering implementation of numeracy interventions by teachers in schools, a further consideration is the role of professional learning in ensuring consistent implementation of interventions. The fidelity of implementation of interventions in school contexts is often given little consideration in describing the impact of different interventions. Academic researchers often conduct numeracy interventions described in published studies, with interventions and assessments often undertaken by project staff rather than by classroom teachers (e.g. Codding, Chan-Iannetta, George, Ferreira, & Volpe, 2011). By constraining those delivering the intervention to a small number of trained researchers, the consistency of intervention implementation, as measured through observation and rating of consistency of delivered instruction, can be maintained at a high level (e.g. Bryant, Bryant, Gersten, Scammacca, & Chavez, 2008; Bryant et al., 2008; Bryant et al., 2011; Jordan et al., 2011).

There is good evidence that professional learning in numeracy for teachers has the potential to have a significant impact upon their students' learning (Bailey, 2010). Children's mathematical development is complex and patterns of understanding of mathematical concepts are likely to vary substantially across children (Dowker, 2005a). Professional learning has the capacity to build teacher knowledge in the area of early numeracy, and provide teachers with the skills to appropriately diagnose mathematical difficulties and implement interventions. The evidence is strong that successful interventions rely on highly skilled teachers who have access professional learning which is of a high quality and which equips them to successfully intervene where children experience numeracy difficulties (Williams, 2008). Teacher access to professional learning in numeracy can be relatively ad hoc. Thus, strategies to monitor teacher access to professional learning in numeracy (such as through the NSW Department professional learning management system MyPL@DET), provides one avenue to tracking professional learning and targeting professional learning needs. Isolated instances of professional learning are also unlikely to encourage sustained growth in teachers' capacity as effective teachers of mathematics (Stanley, 2008). Instead, whole-school initiatives, with ongoing support for teachers as they trial teaching strategies in the classroom, and which are of sufficient duration to enable practice to change are recognised characteristics of high quality professional learning (Groves, Mousley, & Forgasz, 2006; Stanley, 2008).

Assessment Approaches

Planning an approach to providing effective intervention for children with difficulty learning numeracy must necessarily consider the importance of assessment in identifying children in need of intervention, and in developing an intervention plan to address the needs of individual children. Ann Dowker (2004, 2009) has undertaken two reviews of the central components of effective numeracy intervention. In her 2004 review, she identified the critical nature of assessment in profiling particular patterns of strengths and weaknesses in mathematics. Dowker is a strong advocate of pronounced individual differences in arithmetic, based on substantial research demonstrating significant variation in the development of children's mathematical

understanding (see for instance Canobi, 2005; Dowker, 1998, 2003, 2005b; Dowker & Sigley, 2010; Gervasoni, 2011; Gilmore & Papadatou-Pastou, 2009). Such findings suggest that a one size fits all to intervention is unlikely to be effective. Instead, interventions that target specific difficulties experienced by individual children are more likely to be successful.

Baker, Gersten and Lee (2002) synthesised the evidence from 15 mathematics intervention studies between 1971 and 1999. Several findings from these studies were considered relatively strong evidence for the crucial components of effective numeracy intervention. Among these the authors identify the crucial nature of assessment to provide feedback to teachers and students about their specific difficulties as a means to enhance mathematics achievement. The UK review of mathematics teaching in the early years and primary schools also affirms the role of appropriate assessment in identifying those children most in need of intervention (Williams, 2008). Universal assessment of students at the Tier 1 level is also asserted to have moderately strong evidence of effectiveness and is included as a best practice recommendation in *Assisting Students Struggling with Mathematics: Response to Intervention (RtI) for Elementary and Middle School Students* (Gersten et al., 2009a) (see Table 3.3).

Two key issues emerge from the findings presented above. First, these recommendations encourage consideration of the forms and purpose of assessments used to profile children's mathematical understanding. Second, these recommendations focus attention on the need for sensitive assessments that are able to capture variation in individual children's strengths and weaknesses in numeracy. In Australia, structured clinical assessment interviews are widely used through research and subsequent implementation in projects such as *CMIT* in NSW and the *ENRP* in Victoria. Interest in these approaches arose more broadly from a desire to develop detailed accounts of children's mathematical competencies through a process of observation and exploration of children's thinking (Hunting, 1997). In doing so, the clinical interview returned to experimental methods first used by Piaget and Vygotsky to explore children's thinking (Ginsburg, 2009; Hunting, 1997). These approaches are formative in that they are conducted for the purpose of developing an instructional strategy based on individual children's needs. Although they are necessarily more time-consuming and expensive to resource, individualised assessment approaches have significant benefits in describing in detail what children know and can do: teachers value this information and instructional approaches can be targeted to individual difficulties (Gervasoni, 2011).

Although individualised assessment in conjunction with targeted instructional approaches has good support (see for instance *Numeracy Recovery*, Dowker & Sigley, 2010), the evidence that numeracy intervention must be delivered individually for greatest effect is less clear (Gifford & Rockliffe, 2012). Based on her work developing *Numeracy Recovery*, Dowker favours individualised interventions, but suggests that the amount of individual intervention may not need to be large in order to enable the child to gain much more from regular classroom instruction. Williams (2008) concluded that evidence was equivocal in relation to the advantages of individual and small group interventions at Tier 3; however, the review does recommend individual interventions with the option of exploring small group work. Baker et al.'s (2002) synthesis provides an alternate viewpoint, suggesting that learning with peers has a moderately strong effect on the achievement of students with numeracy difficulties. Across a number of more recent research studies, there is moderately strong evidence of the efficacy of several

small-group Tier 2 interventions to improve numeracy achievement (e.g. Bryant et al., 2011; Jordan et al., 2011; Rolfhus et al., 2012). Slavin and Lake's (2008) synthesis of nine studies also concluded that there was a strong effect for numeracy interventions which incorporated cooperative learning. When considered against the significantly increased resource investment of individual interventions, research evidence of this kind suggests that initially exploring small group (2–3 students) options for structuring interventions may be warranted (even at the Tier 3 level).

A conceptual framework for children's mathematical development

A strong feature of a number of numeracy interventions described in this review is the use of a research framework to describe learning in different mathematics domains. Such a framework provides a structure for the professional learning, underlies diagnostic assessment and guides instructional approaches. For instance, *CMIT*, *LIEN*, *Numeracy Matters*, *SINE*, *TEN*, *EMU*, *Mathematics Intervention*, *Mathematics Recovery*, all appear to incorporate elements of a research-based framework for learning in mathematics. In the *ENRP* the concept of growth points described a research-based progression of mathematical understanding in nine domains (Gervasoni, 2011). The growth points reflect significant transitions in mathematical understanding which teachers can use to describe the knowledge of individual students and of their entire class, which can assist them to identify patterns of vulnerability in particular domains, and which can be used to target instruction (Gervasoni, Hadden, & Turkenburg, 2007). Several numeracy interventions utilise the *ENRP* framework which focuses on assigning children to growth points (e.g. *EMU*, *SINE*). Another strong research-based framework is the *LFIN* used in *CMIT* and *Mathematics Recovery*. The developmental principles embodied in these frameworks provide structure to the interventions, guiding teacher professional learning, providing a basis for assessment and an instructional focus.

3.3 In Conclusion

In the context of an increasing interest in identifying and remediating children's mathematical difficulties, the current review provides some guidance on the level of evidence for the efficacy of numeracy intervention programs currently implemented (or which could be implemented) in NSW. This chapter outlined two approaches to reviewing, analysing and describing evidence for the efficacy of numeracy interventions. First, the analysis provided a review of selected Australian and international numeracy interventions that suggested that the strength of evidence for the efficacy for individual programs was generally low. Second, the chapter briefly described the findings of a relatively modest evidence base of research literature to provide commentary on some general principles of numeracy intervention. In reviewing the evidence for specific Australian and international numeracy intervention programs, substantial commonalities in the design of individual programs were evident. The review briefly highlighted these commonalities in the historical overview of the origins of selected programs. The overview of the academic literature was useful in further establishing the credibility from a wider evidence base of some of the key components of many numeracy interventions. In Chapter 4, the review provides some concluding statements that emerge from the discussions of evidence for the efficacy of specific numeracy interventions and of general principles of numeracy intervention.

4. CONCLUSIONS AND RECOMMENDATIONS

The current literature review has analysed the research evidence for the efficacy and effectiveness of a range of literacy and numeracy interventions in the early years of schooling (K–3). Most of the interventions originated in Australia and the majority have been implemented, at least to some extent, in NSW schools. To supplement the analysis of evidence on specific interventions, the review also examined the evidence for general principles in the design and delivery of effective literacy and numeracy interventions in the early years.

Efficacy was considered in relation to the impact of interventions on both short and long-term improvement in students' literacy and numeracy learning. *Effectiveness* was considered in terms of the relationship between the measurable inputs (total resource investment in implementing the intervention) and outputs (long and short term). Almost all of the research identified for the review focused on the efficacy dimension. There were only a few studies that explicitly addressed resourcing questions, especially in terms of a comprehensive approach to assessing cost-effectiveness, as outlined in Chapter 1 of the review.

The lack of evidence on the cost-effectiveness of literacy interventions for Aboriginal students has been noted by the NSW Auditor-General (2012, p. 21). The lack of such information makes it difficult to determine whether programs are achieving the best outcomes for Aboriginal students from the funds available, or what funding may be required to provide a specified improvement in literacy. The current review has found that this concern also applies to interventions in literacy and numeracy more broadly.

A set of criteria was developed for the review that guided the evaluation of the quality and outcomes of included research. These criteria drew on significant common aspects between the protocols of the *WWC* for beginning reading and elementary mathematics interventions, Ritchie, Chudler and Della Sala's (2012) protocol for assessing research evidence, and the Standards of Evidence used to determine the inclusion of literacy and numeracy strategies and research on the *Teach, Learn and Share* national database. The criteria, which are documented in Chapter 1 of the review, were used to judge whether specific evidence should be subjected to detailed analysis.

In a number of sections in Chapter 2 (literacy interventions) and Chapter 3 (numeracy interventions) the review has emphasised the lack of research evidence for specific interventions, or drawn attention to significant inadequacies in existing research. Firm conclusions about the efficacy or effectiveness of an intervention are difficult in the absence of high quality research evidence. As noted in the discussions of individual interventions, many of them have received strong support from sectors, schools and teachers, and such endorsements are clearly an important consideration. It should also be noted that a lack of evidence does not necessarily mean that an intervention is ineffective. A general lack of independent research evidence identifies a clear need for more rigorous research and evaluation to inform evidence-based intervention. This issue is taken up in section 4.2 below.

4.1 Main Conclusions

4.1.1 Conclusions about specific interventions

In general, independent, valid and reliable evidence for the efficacy and effectiveness of specific literacy and numeracy interventions currently implemented (or which could be implemented) in the early years is relatively scarce, particularly for interventions focused on numeracy.

In addition to the lack of quality evidence for the efficacy of specific programs, there is often wide variation in the rigour of research and evaluation designs which sometimes limits conclusions about intervention efficacy. In general, there are often difficulties in linking any identified effects on student achievement to the results of a specific literacy or numeracy intervention. Often only descriptive data are reported, and only rarely is achievement for students targeted for inclusion in the intervention compared with students of similar age and ability who did not participate in the intervention. This applies to individual students as well as groups of students, such as Aboriginal and Torres Strait Islander students, ESL learners and students from low SES backgrounds. Although such a comparison would improve the rigour of the design of literacy and numeracy interventions, it does not preclude the possibility that additional time in literacy and numeracy learning situations (irrespective of how that time is spent) is the explanation behind any observed achievement differences over and above typical growth. A conclusion that additional, intensive instruction in literacy and numeracy is helpful for some children is important, but must be balanced against the potential impact of loss of classroom time in other areas.

Literacy interventions

Based on the criteria used for the review, among the literacy interventions reviewed there is no research evidence or very limited evidence available for the efficacy of: *Accelerated Literacy*; *Best Start*; *First Steps*; *Language, Learning and Literacy; Literacy on Track*, *Literacy Lessons*; *Focus on Reading, Off to a Good Start: Learning to Read K–2 (OTAGS); Principals as Literacy Leaders (PALL)*; *Reading Matters; or Reading to Learn*.

Some evidence is available for the positive impact of: *Successful Language Learners; MiniLit; and QuickSmart Literacy.*

Only in a small number of cases is there a reasonably strong base of research evidence which assesses the efficacy of literacy interventions*; Reading Recovery*; and *MultiLit.*

Most of the literacy interventions with at least some research evidence of efficacy are Tier 2 interventions. The Tier 2 interventions focus on small group or individual instruction for students at risk of not achieving expected literacy or numeracy levels.

In general, it is not possible to draw conclusions about the *effectiveness* of the interventions reviewed because little detailed information is available on resource use and costs, and there are almost no systematic cost-effectiveness studies available. The notable exception is for *Reading Recovery*, about which findings are somewhat mixed, and the studies concerned were conducted

in the UK and the USA, and not in Australia. The overseas studies show that the costs per participating student in *Reading Recovery* do seem to be relatively high, but so are the effect sizes.

The limited cost-effectiveness studies that are available on literacy interventions in the early years of schooling underline the importance of the time frame used in evaluating effectiveness. Programs that appear relatively costly when implemented–but which produce substantial learning gains in the early years, especially for students who are struggling–may prove more cost-effective over the longer term than low-cost interventions. The longer the time frame that can be used when evaluating early interventions, the greater the scope to consider potential cost savings in other aspects of schooling (e.g. less placement in special education and less grade repetition); such savings need to be taken into account for a thorough assessment.

Numeracy interventions

Based on the criteria used for the review, among the numeracy interventions reviewed there is no research evidence or very limited evidence available for the efficacy of: *Getting Ready in Numeracy (GRIN)*; *First Steps*; *Learning in Early Numeracy* (*LIEN)*; *Mathematics in Indigenous Contexts; Numeracy Intervention Research Project (NIRP); Numeracy Matters*; *Mathematics Intervention*; *Train a Maths Tutor*; *Count Me in Too Indigenous* (*CMITI)*; *Success in Numeracy Education* (*SINE)*; *Targeted Early Numeracy* (*TEN)*; *Mathematics Recovery*; *Numeracy Intervention Project* (*NIP)*; *Taking Off With Numeracy* (*TOWN); Building Blocks*; *Everyday Maths*; or *Numeracy Recovery*.

Some reliable evidence is available for the positive impact of: *Count Me In Too (CMIT)*; *Extending Mathematical Understanding (EMU)*; *Number Rockets*; and *QuickSmart Numeracy*.

Most of the numeracy interventions with at least some research evidence of efficacy are Tier 2 interventions (with the exception of the Tier 1 intervention *CMIT).*

It is not possible to draw conclusions about the *effectiveness* of the numeracy interventions because for most, there were no systematic cost-effectiveness studies available. Where cost data are provided, these tend to be limited by uncertainties about whether all the resources required by schools for the intervention have been costed.

4.1.2 Conclusions regarding general principles underpinning effective interventions in literacy and numeracy interventions in the early years

A number of findings about general principles underlying effective intervention in literacy and numeracy in the early years of schooling emerge from the detailed review of the specific interventions in conjunction with a broader review of the literature on learning and teaching and effective intervention. Chapter 2 discussed the general principles that underpin effective literacy interventions. Chapter 3 discussed general principles in regard to numeracy interventions. This section outlines general principles that appear common to effective interventions in both fields–literacy and numeracy.

Embedding interventions in a whole school approach to enhance learning

- Effective literacy and numeracy interventions are embedded in whole-school approaches to improving literacy and numeracy for all students. Appropriately skilled teachers are required to capitalise on any effects of interventions within the classroom context, in the immediate and longer term. Support for intervention and for improving literacy and numeracy teaching and learning more broadly suggests a focus on the learning culture of schools is warranted.

- Of major significance to the likely success of interventions is high quality extended professional learning in literacy and numeracy learning for principals, school leaders and teachers.

- Literacy and numeracy interventions in the first four years of schooling are multi-dimensional, often incorporating a professional learning component (of different durations, focus and purpose), variation in content, an assessment approach (most often clinical interviews in the early years), specific teaching strategies, variation in teacher skill and confidence in implementing the intervention, in delivery (small group or individual) and the duration of the intervention. There is scope to further investigate how variation in these features of interventions relates to achievement. For instance, it may be that individuals who are already highly skilled teachers of numeracy may need only minimal professional learning to deliver an intervention, whereas the efficacy of intervention may be compromised if less skilled teachers receive minimal professional learning and thus do not have sufficient depth of knowledge and skill to implement the intervention.

- Many primary school teachers lack knowledge in mathematics content and pedagogical approaches and these difficulties can impact on the attitudes and learning progress of their students. High quality, sustained professional learning thus plays a significant role in enhancing the quality of classroom teaching, in implementing interventions consistently and in increasing the likelihood that interventions are effective for students who need to improve their numeracy skills.

Early diagnosis and intervention for literacy and numeracy difficulties

- Early diagnosis and intervention is vital for students at risk of not progressing in literacy and numeracy learning. Effective interventions require appropriate assessment to identify students' learning needs. There needs to be a strong focus on monitoring progress for all students from school entry onwards, and on building teacher capacity in observation and diagnostic assessment and use of data to tailor interventions. Classroom teachers need to be aware of children's progress in interventions, in order to adjust expectations in line with progress.

Effective diagnostic assessment

- Universal screening of all children at school entry for literacy and numeracy difficulties is an effective approach to identifying those children who may benefit from Tier 2 interventions. Any assessment must be sufficiently sensitive to develop profiles of children's literacy and numeracy skills and understanding on which instructional approaches may be based. Nonetheless, the utility of such assessments is heavily reliant on a skilled practitioner, appropriate assessment materials and sufficient opportunity for training and practice.

- The use of the one-to-one clinical interview as a means of assessing children's mathematical difficulties is widely used in Australian interventions, is well supported by research and is typically underpinned by a strong conceptual framework of typical growth in mathematics. Nonetheless, the utility of such an assessment is heavily reliant on a skilled practitioner and sufficient opportunity for training and practice must support the implementation of this component of interventions.

Individualised approach to intervention

- An individualised approach to interventions is warranted given the wide variation in children's literacy and numeracy difficulties and the evidence that instructional approaches that are targeted to particular patterns of difficulty are more likely to be effective. Although some research favours individually delivered interventions, the overall evidence is not compelling for the efficacy of individual as compared with small-group interventions.

Incorporate evidence-based principles of effective teaching in literacy and numeracy interventions

- Interventions are likely to be more effective if they incorporate principles known to be associated with effective teaching. At present, available descriptions of the professional learning components of interventions and the teaching strategies specific interventions employ are limited. There is, however, evidence for research-based principles for effective teaching (e.g. explicit and systematic instruction and assessment in the context of intervention) that may be used to assess the rigour of proposed interventions. At the same time, it should be recognised that instructional approaches that work well for some children may be ineffective or lead to further difficulties for others.

Focus of literacy and numeracy interventions

- Literacy learning involves all language modes (reading, writing, speaking and listening) and interventions need to be designed to attend to the interconnections between the modes. For example, the knowledge and skills involved in learning to read and write are closely connected. Literacy learning involves a number of critical aspects (concepts about print, alphabetic knowledge, phonics, phonemic awareness, fluent oral reading,

vocabulary knowledge, comprehension, and writing). All aspects must be attended to in a student's program; however, all aspects may not need "intervention".

- There is compelling evidence for wide variation in children's number sense abilities when they commence school and of a relationship between basic deficiencies in children's number sense (such as quantity discrimination and applying counting to solve number problems) and difficulties acquiring more complex mathematical ideas. The broad focus of many numeracy interventions on promoting the development of different aspects of number sense has good research support. It is less clear whether interventions with a narrower focus (e.g. a focus on improving automaticity for basic facts) results in a more general improvement in numeracy skills, although there is evidence that practising fluent basic fact retrieval as a component of broader interventions is justifiable.

4.2 Recommendations: Policy and Research on Interventions

The review has indicated that there is a lack of strong evidence on the efficacy and effectiveness of literacy and numeracy interventions in the early years of schooling. Yet, there is evidence that many of these interventions incorporate evidence-based general principles of effective intervention derived from research in early literacy and numeracy. A number of the interventions embed principles derived from the wider research literature, although the effectiveness of specific components of these interventions is often assumed, rather than subject to independent monitoring and evaluation.

Only a small number of the specific interventions reviewed have a reasonably strong evidence base about their *efficacy*, that is, their positive impact on student learning. While that information is clearly important, such studies provide only part of the picture that school leaders, systems and sectors need when making decisions on which interventions best meet the needs of individual students as well as groups of students. This is in addition to the need to consider resource and budgetary issues associated with the choice of interventions. Conclusions about the *effectiveness* of most interventions are difficult to draw because little detailed information is available on the resources they require and their costs, and there are almost no systematic cost-effectiveness studies available.

Although a lack of research evidence does not necessarily mean a particular intervention is ineffective, education authorities and schools require solid evidence to inform their decision-making. Education authorities need to know which interventions should be endorsed and supported in schools. The systems also need to know where new interventions may need to be developed because existing approaches are not having the hoped-for impact or are not sustainable in a resource sense. Schools need reliable information to help them to meet the needs of their students in their particular context–will a particular intervention meet curriculum requirements and improve learning outcomes for the school's students, and what resources will it require to be implemented?

In this context it is important that education authorities take the lead and initiate steps to: improve the evidence base about literacy and numeracy interventions; tighten the criteria by which interventions are assessed as worthy of support, with consideration being given to the criteria used in this review (see Chapter 1); and ensure that decision makers, particularly at school level, have the information they need.

Recommendation 1: ***Criteria for supporting an intervention***

Literacy and numeracy interventions should only be supported for implementation in schools when the interventions:

a. address the current syllabus requirements and learning objectives of the curriculum;
b. are based on independent and credible findings on their efficacy and effectiveness; and
c. include a full costing of the resources required by schools for implementation.

Recommendation 2: ***Documenting the current use and impact of interventions***

a. Education authorities should document the literacy and numeracy interventions are currently being used in the early years of NSW schools in terms of: (i) the number of schools using the interventions concerned; (ii) the number, type and year level(s) of the students involved; and (iii) evidence on the efficacy and effectiveness, including costs of the interventions.
b. The mapping of interventions being used should be updated every 3 years.

Recommendation 3: ***School literacy and numeracy improvement plans***

a. Education authorities should require all schools to have a literacy and numeracy improvement plan. Such plans need to be developed and monitored on an ongoing basis and form part of schools' accountability requirements.
b. Education authorities need to ensure that they have the capacity and expertise to guide and support schools as they develop and implement their literacy and numeracy improvement plans.
c. Each school literacy and numeracy improvement plan should be externally reviewed every 3 years.

Recommendation 4: ***Evaluation plan for new or expanded interventions***

Education authorities should ensure that the introduction of any new literacy or numeracy intervention in the early years of schooling, or the expansion of an existing intervention, is accompanied by a research and evaluation plan to provide an independent assessment of the efficacy and effectiveness of the new or expanded intervention after 3 years. The research and evaluation process should commence before the intervention is introduced or expanded and include a dissemination strategy.

Recommendation 5: ***Consistent and comprehensive costing data***

Education authorities should ensure that resources and costs involved in implementing an intervention in schools are documented and reported in a comprehensive and consistent manner. The resource mapping and costing should:

a. identify the costs incurred at system and school levels;
b. itemise all the capital and recurrent personnel and other costs involved;
c. provide the present-value cost of the resources required over the expected duration of the intervention; and
d. relate the costs to evidence on impact within a cost-effectiveness framework.

Recommendation 6: ***Strengthening the knowledge base***

Education authorities should strengthen the knowledge base about the efficiency and effectiveness of literacy and numeracy interventions by:

a. supporting research on how well interventions work for different groups of students, including Aboriginal and Torres Strait Islander students, students learning English as a second language, and students from low socioeconomic background communities, the factors that shape whether interventions are successfully implemented at school and classroom levels, and the resources involved;
b. supporting longitudinal and time series studies that follow students from school entry through their schooling so that a richer picture of their development over time, and the key factors involved, can be established;
c. linking students' performance data on NAPLAN assessments in Years 3, 5, 7 and 9 with other system and school data so as to obtain greater diagnostic and analytical value from information that is already collected;
d. producing regular updates every 3 years of the research on literacy and numeracy interventions, and the principles underpinning effective literacy and numeracy teaching in the early years, and disseminating the updates widely to teachers and schools; and
e. strengthening the capacity of school leaders and teachers in using evidence to improve practice in literacy and numeracy.

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