Spatial Reasoning and Geometry in Early Childhood: Educator Observations, Assessment, and Curriculum Planning

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Thesis Summary

Mathematics in early childhood education and care is receiving increased attention as research continues to bring to light young children's inherent mathematics capabilities (Cohrssen, de Quadros-Wander, Page, & Klarin, 2017; Davis & the Spatial Reasoning Study Group, 2015; Moss, Hawes, Naqvi, & Caswell, 2015). This raises questions about how best to prioritise the inclusion of mathematics curricula in early childhood play-based programs. This thesis outlines the importance of mathematics in early childhood curriculum, looking at how educator beliefs influence mathematics teaching practice. Historically, educators have been drawn to the early childhood profession with the mistaken understanding that the teaching of mathematics is not a requirement (Lake & Kelly, 2014). Further, some early childhood educators perceive the teaching of mathematics to be at odds with play-based learning philosophies (Warren, Thomas, & DeVries, 2011). Educator beliefs about their own mathematics ability, their ability to teach mathematics, and the place of mathematics in early childhood all have implications for the inclusion of mathematics in early childhood play-based programs (Beilock & Maloney, 2015; Clements & Sarama, 2014; Hachey, 2013a; Lee & Ginsburg, 2009; Maloney & Beilock, 2012). This is significant, as growing evidence suggests that children are mathematical and explore mathematical concepts in their everyday environments, during routines and through play (Bobis, 2008; Cohrssen et al., 2017; Clements & Sarama, 2014; MacDonald & Lowrie, 2011). However, knowing how to identify and assess children's existing mathematics knowledge within a play-based context and further, knowing what and how to plan to support children's learning can be challenging for educators when faced with a broad curriculum area such as mathematics.

In the state of Victoria, both the Victorian and Australian early years curricula for mathematics (Foundation, Level 1 and Level 2) includes the proficiencies of understanding, fluency, problem-solving, and reasoning, which are applied across the

three strands of number and algebra, measurement and geometry, and statistics and probability (Australian Curriculum, Assessment and Reporting Authority, [ACARA], n.d.-a; Victorian Curriculum and Assessment Authority [VCAA], 2017). The Victorian Curriculum F–10: Mathematics (VCAA, 2017) and the Australian Curriculum: Mathematics (ACARA, n.d.-a) provide a learning continuum for children throughout their primary school education and achievement standards for assessment. Prior to commencing primary school, the early learning frameworks provide educators with a guide to support children's mathematics learning. Numeracy is embedded in Learning Outcomes 3, 4, and 5 of the Early Years Learning Framework (Department of Education, Employment and Workplace Relations [DEEWR], 2009) and referenced in the Victorian Early Years Learning and Development Framework (Department of Education and Training, [DET], 2016); however, broad references to children's mathematics learning outcomes can make assessment and planning for children's ongoing learning challenging.

At the time of conceptualising this project, new research was emerging to suggest that spatial reasoning is a key concept underpinning all mathematics learning (Davis & Spatial Reasoning Study Group [SRSG], 2015; Moss et al., 2015). This was significant, because a growing body of research supported the thinking that the explicit teaching strategies, which support the learning and development of children's spatial reasoning skills, could establish foundations for children's future mathematics learning (Cohrssen et al., 2017; Uttal et al., 2013; Uttal & Sheehan, 2014; Watts, Duncan, Siegler, & Davis-Kean, 2014; Watts et al., 2013). This body of research also highlighted that the teaching of spatial reasoning in early childhood education remains a neglected priority, meaning that a key area of mathematics, which supports children's future mathematics learning, is not occurring in practice (Clements & Sarama, 2014; Duncan & Rafter, 2005). Spatial reasoning is an area of mathematics that is often neglected when teaching young children because spatial reasoning is associated with internal thought and perceived as being difficult to see, difficult to assess, and difficult to teach. However, when combined with geometry, spatial reasoning suits the tenets of a play-based curriculum (Davis & SRSG, 2015).

By narrowing the focus on mathematics to include the key mathematical concepts of spatial reasoning and geometry relevant to a play-based curriculum, it was hypothesised that this would support educators in knowing what to look and listen for when assessing children's mathematics knowledge. In this way, spatial reasoning, when combined with geometry, forms a key focus for the assessment of and planning for children's mathematics learning.

The critical theoretical argument underpinning this study is that children, from a young age, benefit from explicit teaching specifically targeted at supporting the learning of spatial reasoning and geometry skills. This study evaluated the impact of the educators' implementation of a suite of assessment activities with 3- to 5-year-old children in early childhood play-based settings, focusing on teaching practice, observations, assessment, and planning for curriculum. The study also evaluated the impact of the implementation on educators' beliefs regarding their own mathematics abilities and beliefs about mathematics education in early childhood programs.

It was hypothesised that the implementation of the assessment activities would support educators in knowing what to look and listen for as evidence of children's demonstrated spatial reasoning and geometric knowledge. The assessment activities and resources also provided examples of support and/or extensions for planning, therefore providing guidelines for educators in knowing how to enact the assessment outcomes in practice. It was further hypothesised that the implementation would have a positive effect on educator beliefs about their ability to teach mathematics and their beliefs about the place of mathematics in early childhood education. It was therefore important for the research methods to take educators' current knowledge and beliefs into consideration, to adopt a strengths-based approach toward the enactment of the activities, and further support the uptake of the implementation in practice.

The research project included qualitative and quantitative methods, which, when combined, added depth and meaning to the data analysis and outcomes. Quantitative and qualitative methods included surveys, implementation assessment records, workshops with participants, and semistructured interviews. The outcomes of each phase of the research project were used to inform the next. For example, during Phase 1, the first survey provided information about educators' existing mathematics teaching practices, beliefs about their own mathematics abilities, and mathematics in early childhood education. The workshop and assessment activities were designed in response to the survey outcomes and adopted a strengths-based approach to build on educators' existing mathematics practices and beliefs. Thematic analysis was used to analyse the qualitative data, which included assessment and planning outcomes, written survey responses, semistructured interviews, and educator reflections. Statistical analysis was applied to the scaled survey outcomes and assessment records, which, when combined with the thematic analysis, informed the overall results of the implementation.

Results demonstrated that a focus on spatial reasoning, geometry, and assessment, when supported by ongoing professional learning and contingent coaching, can impact teaching practice and beliefs about mathematics. Ongoing professional learning and mentoring provided a bridge between educators simply observing children's geometry and spatial reasoning processes during play and intentionally including evidence-based planning in curricula and, furthermore, enacting the assessment concepts in teaching practice. This highlighted the significance of ongoing professional learning and mentoring for educators when enacting change in daily practice, as the outcomes demonstrated that observations became more purposeful and specifically linked to assessment and planning when educators enacted the implementation with the support of a mentor. Shifts in educator beliefs about mathematics began to emerge and were influenced by the recognisable impact their teaching practice had on children's learning outcomes.

Educators demonstrated a shift in beliefs about their own mathematics abilities and the place of mathematics in early childhood education when children's learning outcomes reflected gains in spatial reasoning and geometry abilities and further, children demonstrated understandings about the links between mathematics and their everyday environments. Through the enactment of the implementation, educator efficacy, and links between observations, assessment and planning increased. Results demonstrated multidirectional influences between the educators' implementation of the assessment activities, teaching practice, and their beliefs about mathematics.

The findings indicate implications for research, policy, and practice. Implications for further research include a focus on how educator beliefs about mathematics inform practice and program planning and how specific play-based assessment tools and resources can reframe the enactment of play-based mathematics in curriculum. Further research is necessary into the role of spatial reasoning and geometry in contributing toward children's future mathematics learning and its potential to form the foundations of an early childhood mathematics curriculum. Further research into the implementation model is also necessary to determine how the model can support a practical professional learning and mentoring framework and further support the enactment of research in practice. Implications for policymaking include the provision of sustained professional learning and mentorship to bridge the gap between mathematics, play-based learning, and the requirements of the National Quality Standard (Australian Children's Education & Care Quality Authority [ACECQA], n.d.-b). Implications for policy also need to address access to and equity of the provision of mathematics education for every child. Finally, implications for practice include the development of a play-based mathematics curriculum to focus educator attention on how to identify and assess children's demonstrated mathematics knowledge in the context of play, therefore informing what is important to include in practice and program planning.

ABSTRACT

Children are innately mathematical and explore mathematical concepts through play. Recent research has suggested that spatial reasoning is a key concept that forms the foundations of all mathematics learning. The theoretical argument underpinning this research project is that children, from a young age, benefit from explicit teaching specifically focused on supporting the learning of spatial reasoning skills. This research project investigated the implementation of a suite of assessment activities on educator beliefs about mathematics in early childhood education, by analysing teaching practices that included observations, assessments, and evidence-based planning of mathematics curricula. The study found reciprocal influences between the three key areas of the research project, which included the implementation of the assessment activities, educator beliefs about mathematics in early childhood education, and mathematics teaching practice. The findings have implications for further research, policymaking, and practice, which include the need for play-based mathematics assessment strategies, research methodologies that can contribute to professional learning enacted in practice, and the contribution of a focus on spatial reasoning to early childhood mathematics curricula.

DECLARATION

I certify that this thesis

i. comprises my original work toward the Doctor of Philosophy;

ii. is fewer than the maximum word limit in length, exclusive of tables, bibliographies and appendices;

iii. was funded by an Australian Postgraduate Award;

iv. has not been previously submitted for a degree or diploma at any other higher education institution;

v. to the best of my knowledge contains no material previously published or written by another person except where due reference is made.

Signature:

Date: 16 November 2018

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LIST OF ABBREVIATIONS

EAL	English as an additional language
ECEC	early childhood education and care
EYLF	Early Years Learning Framework
ICT	information communication technology
STEM	science, technology, engineering and mathematics
VEYLDF	Victorian Early Years Learning and Development Framework
ZPD	zone of proximal development

CHAPTER 1: INTRODUCTION

1.1 Introduction to Early Childhood Mathematics Education

Mathematics in early childhood education and care (ECEC) is a topic under increased investigation as research continues to bring to light children's inherent mathematics abilities and how best to support children's mathematics learning in early childhood play-based programs (Clements, Copple, & Hyson, 2002; Clements & Sarama, 2017; Cohrssen, Church, & Tayler, 2016; Davis & SRSG, 2015; Lee & Ginsburg, 2009; Moss et al., 2015; Uttal & Sheehan, 2014). Research has indicated that children think mathematically and explore mathematical concepts innately during play (Clements & Sarama, 2014). Research has also indicated that educators' beliefs about the place of mathematics in early childhood and beliefs about their ability to teach mathematics can significantly impact the identification of children's demonstrated mathematics knowledge in play-based programs (Bobis, Higgins, Cavanagh, & Roche, 2012; Rosenfeld, 2010). Therefore, educators' beliefs can have a significant impact on the inclusion of mathematics in early childhood curricula. How to support educators in identifying, assessing, and planning for children's mathematics learning established the context for this research project, informing the design of the research questions.

1.2 Research Context

Within Australian play-based settings, the necessity of assessing and teaching mathematics in early childhood education is often debated (Barblett, 2010; Fleer, 2011a; Saffigna, Franklin, Church, & Tayler, 2011). Historically, there has been a reluctance for educators to adopt intentional pedagogies within play-based philosophies of teaching and learning, creating barriers to the implementation of emerging ideas about teaching mathematics in early childhood education (Kilderry, 2015). The foundations of curriculum planning, in ECEC, are largely founded on children's emerging interests (Page & Tayler, 2016; Stonehouse, 2015), and the teaching of mathematics is often perceived as clashing with play-based approaches to learning. This is because mathematics may be perceived as requiring explicit teaching strategies, which are often considered unsuitable for and in conflict with early childhood play-based philosophies of learning (Aubrey, 2013; Kilderry, 2015). Further, mathematics is considered a

discrete subject, which historically has been taught as a "lesson" rather than integrated with play-based teaching and learning strategies (Australian Curriculum, Assessment and Reporting Authority, [ACARA], 2012).

Historically, research has influenced the age at which children are introduced to mathematical concepts, based on beliefs about child development and what children are ready to learn. For example, Piaget (1952) believed that, building on four stages of development, children's capacity to reason mathematically reaches maturity at around age 7. Piaget's research continues to impact curriculum planning and pedagogy in early childhood today. The tension between beliefs and understandings of intentional pedagogies and play-based approaches to learning has had a lasting impact on the inclusion of mathematics curricula in early childhood education (Clements, Fuson, & Sarama, 2017; Clements & Sarama, 2014; Hachey, 2013a).

Mathematics teaching and learning in early childhood programs can present many challenges for early childhood educators, particularly if preservice training has not adequately addressed how to plan for and enact an early childhood mathematics curriculum in practice (Kennedy & Stonehouse, 2012). Children often explore complex mathematical ideas across many curriculum areas (Clements & Sarama, 2014; Davis & SRSG, 2015; Uttal & Sheehan, 2014), and their demonstrated mathematics knowledge can be expressed in many varied and unique ways (Carruthers & Worthington, 2011; Pollitt, Cohrssen, Church, & Wright, 2015). Children's mathematics knowledge is not always expressed as an isolated mathematical idea or associated with "doing" one mathematics task at a time; therefore, identifying children's mathematical thinking during play can be challenging. Ideas about play-based mathematics can conflict with traditional perceptions about what constitutes mathematics in early childhood as mathematics is often perceived as being number centric, with a key focus on identifying and naming numbers, rote counting, and identifying and naming shapes (Clements & Sarama, 2014; Moss et al., 2015). In contrast, research has suggested that children's demonstrated understandings of mathematics take many forms that are often interrelated, enacted during everyday activities, routines, and play, and may encompass multiple areas of mathematical thinking across many curriculum areas. In short, children do not necessarily explore mathematics ideas separately or in isolation (Carruthers & Worthington, 2011; Clements & Sarama, 2014; MacDonald, 2013).

Knowing how to support children's mathematics learning, knowing what constitutes an early childhood mathematics curriculum, and knowing how to teach it can be challenging (Uttal & Sheehan, 2014). Therefore, recognising the mathematics inherent in children's daily activities, routines, and play—beyond the traditional expectations of counting, number, and shape—can be challenging. Further challenges arise when educators are unsure of what to look and listen for as evidence and assessment of children's demonstrated mathematics knowledge (Geist, 2010; Oppermann, Anders, & Hachfeld, 2016). This is significant as the development of children's mathematics skills requires explicit teaching strategies.

In Victoria, Australia, educators are required to use assessment to inform evidence-based planning and curriculum decisions based on the Early Years Planning Cycle (Department of Education, Employment and Workplace Relations [DEEWR], 2015). This requires educators to identify the mathematics occurring during play, gather observational evidence of children's mathematics knowledge, and analyse and interpret assessment outcomes to inform the next steps when planning for mathematics learning. This cycle of planning becomes interrupted when children's demonstrated mathematical understandings are not recognised and opportunities for teaching mathematics are missed (Oppermann et al., 2016).

The teaching of early childhood mathematics requires specific content knowledge (Holm & Kajander, 2012), developmentally appropriate explicit teaching strategies, and effective evidence-based planning. For children to make connections between mathematical concepts, and to further develop their mathematical ideas during play, children need the intentional support of a more knowledgeable other (Lee & Ginsburg, 2009; van Oers, 2010). Opportunities to identify and plan for children's mathematics learning can be missed when there are gaps in initial teacher training, impacting educators' mathematics content knowledge and teaching proficiencies (Ryan, Whitebook, & Cassidy, 2014). These gaps can also be informed by educator beliefs about mathematics and their beliefs toward mathematics in early childhood education. To explain further, if educators are not confident about their training and ability to teach mathematics, they may be drawn to a profession where they believe the teaching of mathematics is not required. Many educators are mistakenly drawn to the early

childhood profession with the misguided belief that they will not be required to teach mathematics (Lake & Kelly, 2014).

Traditionally, assessment in early childhood is based on understandings of developmentally appropriate practice (Copple & Bredekamp, 2009) and educators' beliefs about young children's interests in and readiness to learn mathematics (Clements & Sarama, 2017). The implementation of this study was designed to influence approaches toward assessment and play-based practices in early childhood programs and support educators in recognising areas of children's interests and play as "mathematical".

The research methodologies supported play-based approaches to mathematics assessment and investigated how mathematics assessment currently forms part of the Early Years Planning Cycle (DEEWR, 2015) within early childhood play-based programs. It was clear that the role of the educator was important to consider throughout the research, as the educator was critical in supporting the changes trying to be enacted throughout this implementation. As Rosenfeld (2010) wrote, "Teachers are crucial change agents in education reform, and teachers' beliefs about themselves and about the content they are teaching are precursors to change" (p. 31). Therefore, gaining insights into educators' beliefs about mathematics in early childhood and beliefs about their abilities to enact mathematics in practice (Brown & Inglis, 2013) was important information for the design of the instruments and knowing how to support the uptake of the instruments in practice.

Understanding the mathematics currently occurring in early childhood programs informed the design of the materials for the implementation. Linking educators' current understandings and teaching practice with the assessment activities, strategies, and mathematical theory was integral to the uptake of the implementation and research plan. The overall research methodologies underpinning the project were designed with the understanding that educators were agents of change, and their beliefs about themselves and the content they teach can promote changes in practice and inform the development of new theory (Rosenfeld, 2010).

1.2.1 Early Years Learning Frameworks

Belonging, Being and Becoming—The Early Years Learning Framework [EYLF] (DEEWR, 2009) forms a key component of the National Quality Framework for ECEC in Australia. The framework is implemented nationally throughout Australian early childhood services, and its vision for children's learning states, "All children experience learning that is engaging and builds success for life" (DEEWR, 2009, p. 7). The EYLF (DEEWR, 2009) was designed with a view to supporting early childhood professionals when developing strategies to achieve the principles, practices, and learning outcomes for children from birth to age 5 years, including their transition to school. The EYLF "forms the foundation for ensuring that children in all ECEC settings experience quality teaching and learning" (DEEWR, 2009, p. 5).

Similarly, the Victorian Early Years Learning and Development Framework (VEYLDF) (DET, 2016) is a guide for all early childhood professionals in the state of Victoria, Australia, which includes principles and practices, and learning and development outcomes for children. The VEYLDF promotes children's learning from birth to age 8 years in the belief that continuity is an important consideration for children's learning and development as children transition between the home, early childhood settings, and formal schooling environments during the early years (DET, 2016). The vision and purpose of the VEYLDF includes a comprehensive approach to children's learning and development that highlights the significance of children's health and wellbeing, relationships among early childhood professionals, family, and community, and positions the child at its core as a capable learner (DET, 2016).

Both the EYLF (DEEWR, 2009) and VEYLDF (DET, 2016) are used widely throughout Victorian early childhood settings to guide assessment, teaching, and planning (ACECQA, n.d.). Unlike a formal school curriculum, the frameworks are designed to provide a guideline for the inclusion of numeracy when planning to support children's mathematics knowledge within the five learning outcomes. As defined by the EYLF (DEEWR, 2009), numeracy requires educators to have a "rich mathematical vocabulary to accurately describe and explain children's mathematical ideas and to support numeracy development" (p. 38).

Examples of how to support mathematics development are embedded within three of the five learning outcomes in the EYLF (DEEWR, 2009). However, suggestions for educators to promote mathematics learning are broad and impact educators' ability to recognise and build on children's specific mathematics learning. For example, educators promote mathematics learning when they "recognise mathematical understandings that children bring to learning and build on these in ways that are relevant to each child" (DEEWR, 2009, p. 35). This learning outcome suggests that educators are aware of the many and varied ways in which children demonstrate and communicate their mathematical understandings and have the relevant skills, content knowledge, and teaching strategies to support ongoing learning. However, research evidence suggests that, in practice, awareness of children's mathematics knowledge does not occur (Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006; Lehrl, Kluczniok, & Rossbach, 2016), having further implications for evidence-based planning.

1.2.2 Early Years Planning Cycle

The Early Years Planning Cycle (DEEWR, 2015) is designed to guide early childhood professionals when observing, assessing, and responding to evidence of children's learning. Early childhood professionals collect information by recording observations of children as they are engaged in activities that demonstrate their learning, analyse this evidence with a view to understanding what children may be ready to learn next, plan to extend children's learning, enact the learning experience, and evaluate the learning outcomes. The planning cycle is ongoing, and learning outcomes inform the purpose and direction of subsequent observations so that learning is a continuum and is evidence based. Observing the mathematics occurring during children's play is a necessary first step.

Educators are required to "observe purposefully" (ACECQA, n.d.), using the Early Years Planning Cycle (DEEWR, 2015) and the framework to support assessment for learning "which is designed to discover what children know and understand, based on what they make, write, draw, say and do" (DET, 2016, p. 13). The Early Years Planning Cycle is used to support links between assessment and planning for learning. It is important to note that evidence-based planning is a requirement of the National Regulations and the National Quality Standard (ACECQA, n.d.; DEEWR, 2009), and how educators link children's mathematical ideas and knowledge to the learning

outcomes has significant implications for children's learning. How assessment and evidence-based planning inform children's achievement of these learning outcomes is also of considerable significance (Klibanoff et al., 2006). Understanding precisely how educators are currently assessing and planning for children's mathematics learning in early childhood formed an important aspect of this study.

1.2.3 Australian Curriculum: Mathematics

The Australian Curriculum: Mathematics (ACARA, n.d.-a) is used widely across Australian primary and secondary schools. The curriculum is based on proficiencies (understanding, fluency, problem-solving, and reasoning), which are integral to the three mathematics strands (number and algebra, measurement and geometry, and statistics and probability). Together, the proficiencies and strands provide the basis and the language to develop mathematics learning. For example, at the Foundation year level (the first year of formal school),

> **understanding** includes connecting names, numerals and quantities
>
> **fluency** includes readily counting numbers in sequences, continuing patterns and comparing the lengths of objects
>
> **problem-solving** includes using materials to model authentic problems, sorting objects, using familiar counting sequences to solve unfamiliar problems and discussing the reasonableness of the answer
>
> **reasoning** includes explaining comparisons of quantities, creating patterns and explaining processes for indirect comparison of length. (ACARA, n.d.-a) emphasis in original)

Similarly, the Victorian Curriculum F–10: Mathematics (VCAA, 2017) is used widely in Victorian primary and secondary schools, and is based on the proficiencies and mathematics strands. The first three levels of the Australian Curriculum: Mathematics (ACARA, n.d.-a) and theVictorian Curriculum F–10: Mathematics (VCAA, 2017) (Foundation, Level 1 and Level 2), recognises children's learning continuum across the early years, with a view to providing a learning continuum for children throughout their primary school education and achievement standards for assessment.

Together, the early years frameworks (DEEWR, 2009; DET, 2016), the Australian Curriculum: Mathematics (ACARA, n.d.-a) and Victorian Curriulum F–10: Mathematics (VCAA, 2017) can provide an overview of children's learning and development outcomes from birth through to age 8 years. Referring to the first three levels of the curricula can help early childhood educators to "see" the direction of the learning continua, which has the potential to inform planning. The curricula can be useful when guiding educators' understandings of what to plan next as it provides specific content descriptions for each mathematics strand and demonstrates the expected learning outcomes. In this way, the evidence-based continuum of early years mathematics learning is clear. Given early childhood educators play a key role in supporting children's learning and transition into a primary mathematics curriculum (ACARA, n.d.-a), it is necessary to understand where children are heading.

However, research has indicated that children have more mathematics experience and knowledge prior to commencing school than previously understood (Clements & Sarama, 2014; Ginsburg & Ertle, 2008), and although useful in providing guidelines and the language necessary to describe children's mathematics learning, the frameworks and curricula underestimate what children already know and understand mathematically long before commencing school (Lipton & Spelke, 2003, 2004). Therefore, knowing how to identify and observe children's demonstrated mathematics knowledge during play is important.

To highlight how to identify the mathematics inherent in children's play (Clements & Sarama, 2017), it was necessary to examine the key concepts underpinning children's mathematics learning. The rationale was to provide educators with specific mathematical concepts relevant to a play-based early learning context and provide clarity and support for educators when facing negative beliefs toward teaching mathematics. It was necessary to clearly align mathematics and assessment with play-based approaches to learning. A focus on play-based spatial reasoning and geometry assessment activities provided a solution.

1.2.4 Spatial Reasoning and Early Childhood Education

Recent research has demonstrated that spatial reasoning underpins children's ability to grasp mathematical concepts (Cheng & Mix, 2014; Davis & SRSG, 2015;

Uttal & Sheehan, 2014). However, little is known about young children's spatial reasoning skills, how to assess them (Diezmann & Watters, 2000; Ramani, Zippert, Schweitzer, & Pan, 2014; Verdine, Golinkoff, Hirsh-Pasek, & Newcombe, 2014), and how the outcomes of these assessments inform planning for mathematics learning in early childhood. Therefore, this study focused on educators' identification of and planning for the inclusion of spatial reasoning in play-based curricula to understand how the mathematics assessment activities informed planning for learning. Spatial reasoning was linked with geometry, made visible to educators, and connected to familiar aspects of teaching practice within their early childhood play-based programs. Educators were supported to identify, assess, and align planning and curriculum with the spatial reasoning and geometry already occurring in their programs, establishing a platform for further development in this area.

1.3 Research Aims

The aims of the research were to evaluate the impact of the educators' implementation of the assessment activities with 3- to 5-year-old children in early childhood settings on their teaching practice, including their observations, assessment, and planning for mathematics curricula. In addition, the impact of the assessment activities on educator beliefs regarding mathematics education in early childhood programs was of interest. The research questions address the gaps that have emerged in the review of the literature as most studies to date have focussed on classroom teaching, rather than preferencing assessment for learning within the context of an informal play-based curriculum. The conceptual framework for the research questions is discussed further in Chapter 3. The research questions were as follows:

1. How did the implementation of a suite of play-based mathematics assessment activities impact early childhood teaching practices, including observations, assessment, and curriculum planning?
2. How did the implementation affect educator beliefs regarding mathematics education in their early childhood programs?

1.4 Thesis Structure

Chapter 1 introduces the context for the research, the research aims, and questions. This chapter establishes spatial reasoning as a foundation for children's

mathematics learning. It is hypothesised that supporting educators in the identification and assessment of children's existing spatial thinking will support evidence-based planning in early childhood mathematics curricula. Further, providing clear insights into what constitutes play-based mathematics assessment will have a positive influence on educator beliefs about mathematics in early childhood education. The implementation study was designed to support assessment and play-based practices in early childhood education and the identification of children's demonstrated "mathematical" interests during play.

Chapter 2 presents the literature review and reveals gaps in the extant research relating to the assessment of mathematics and teaching practice in early childhood education. This includes how educators are observing, documenting, analysing, and planning for children's mathematics learning. The literature review highlights how educator beliefs have a significant impact on the teaching and inclusion of mathematics in early childhood curricula. Spatial reasoning and links to geometry are explained, highlighting the importance of making mathematics visible in play-based programs and therefore identifiable and assessable in early childhood. The significance of this implementation study is discussed with a view to addressing the gaps in the research literature.

Chapter 3 explains the theoretical rationale underpinning the conceptual plan and research questions. This chapter explains implementation research, the significance of the methodological approaches informing the research plan, and why these approaches were chosen to collect data and evaluate the impacts of the implementation. The rationale informing the choice of instruments is addressed, including the surveys, play-based mathematics assessment activities, workshops, and semistructured interviews. It is hypothesised for early childhood educators that the very act of participating in the intervention will lead to meaningful change.

Chapter 4 presents the methods and describes the key instruments used for data collection: the surveys, mathematics assessment records, and the semistructured interviews. Phase 1 and 2 of the study design and implementation timeline are discussed. How data are collected and the qualitative and quantitative methods used for data analysis—thematic analysis, content analysis, and statistical analysis—are

presented. This includes discussion about methods of data triangulation employed to clarify findings.

Chapter 5 describes the six assessment activities designed for the implementation study. Discussion includes the rationale for the assessment activities based on the mathematical concepts inherent in spatial reasoning and geometry, which align with play-based learning contexts: perspective taking, mental rotation, and spatial visualisation. The key benefits of the play-based assessment activities are discussed.

Chapter 6 outlines the key findings from Phase 1 of the study. This includes the pilot survey and trial of the assessment activities, assessment records, and guidelines for the implementation. Modifications to the data collection tools for the implementation are explained.

Chapter 7 presents the results from Phase 2 of the research project, pre- and post-implementation. Data demonstrate that frequency of dosage across the four-month implementation stage informed changes in teaching practice and beliefs about mathematics in early childhood education. Change was led by increased educator efficacy and further supported by the observable differences in children's learning outcomes. The results demonstrate that when enacted, the assessment activities were useful in supporting the identification and assessment of mathematics in play-based settings, further supporting the inclusion of mathematics in early childhood curriculum.

Chapter 8 discusses the impacts of the enactment of the implementation of the assessment activities on teaching practice, including observations, assessment, and planning and educator beliefs about mathematics in early childhood education. This chapter discusses the significance of mentorship and coaching when effecting change in practice, disrupting cycles of negative beliefs through enactment, and the potential contribution of a suite of play-based assessment activities—based on spatial reasoning and geometry—toward teaching practice and early childhood mathematics curriculum.

Chapter 9 draws together the conclusions from each chapter, including implications for further research, policy, and practice. This chapter discusses the enactment of the implementation, the practical implications, and contribution toward play-based mathematics assessment in early childhood contexts. The implementation provides a significant opportunity to address educators' perceptions about their own

mathematics abilities, the place of mathematics in early childhood programs, and the importance of assessment and planning in this area. This chapter highlights the need for an early childhood mathematics curriculum to support early childhood educators when identifying, assessing, and planning for mathematics in play-based contexts.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In Australia, there is an increasing number of children attending early childcare settings (DET, 2016). Given the significant links between the early years and later academic achievement, high-quality pedagogical practices are important and should include evidence-based planning for learning across all curriculum areas (DEEWR, 2009). However, not all curriculum areas in early childhood education receive equal attention. Recent research has called attention to early childhood mathematics pedagogy and how educators are teaching and assessing children's individual understandings, as current practices in early childhood mathematics reflect a gap in the cycle of planning for learning in this curriculum area (Anders & Rossbach, 2015; Anthony, McLachlan, & Lim, 2015; Chiatovich & Stipek, 2016).

Research includes insights into why these gaps in assessment and planning for children's mathematics learning exist, highlighting the need for adequate initial teacher education that includes appropriate early childhood mathematics content knowledge (Lake & Kelly, 2014). Furthermore, educators require ongoing professional learning and mentorship to support the enactment of new knowledge in practice. Gaps in knowledge about how and what to teach in early childhood mathematics curricula impact the ability to assess children's mathematics competencies and to teach the subject (McCray, 2008; McCray & Chen, 2012; Oppermann et al., 2016). The disparity between teaching mathematics and the ability to identify and assess children's mathematics knowledge means there is a disconnect between what children know and what they are being taught. This impacts educators' abilities to foster children's emergent mathematics skills (Bruns, Eichen, & Gasteiger, 2017). These gaps have a significant impact on the quantity and quality of mathematics being taught in early childhood education (Bobis et al., 2005; da Ponte & Chapman, 2005).

The reasons for these gaps are varied and complex. However, research points to the lack of adequate initial training for educators in early childhood mathematics curriculum and pedagogy. Indeed, the prioritising of mathematics in initial teacher training is a relatively recent development (Chen & de Groot Kim, 2014; Lake & Kelly, 2014). This lack of adequate initial teacher training has led to gaps in mathematics

content knowledge and contributed toward educators' lack of confidence about their own mathematics abilities (Hine, 2015). This lack of training has further reinforced negative beliefs about the inclusion of mathematics in early childhood curricula as misunderstandings about the role of mathematics in early childhood education persist (Aydın & Coştu, 2016).

The provision of training for educators in knowing how to assess children's mathematics knowledge, knowing which assessment strategies to use in play-based contexts and how to implement them is lacking in most initial teacher education and training. Therefore, over time, misunderstandings about the place and purpose of mathematics assessment in early childhood have been based on beliefs that no longer hold true. Gaps in assessment become evident when informed by negative beliefs and bias about mathematics (Dockett, 2011). It is important to consider what is being assessed as evidence of children's mathematics learning, as children's demonstrated mathematics knowledge is often interrelated and evident across all developmental stages and curriculum domains.

Educators' negative beliefs about mathematics in early childhood education, and negative beliefs about their ability to teach the subject, impact the prioritising and inclusion of mathematics in daily teaching practice and curriculum planning. Therefore, educators' negative beliefs can widen the gap in children's mathematics learning (Lee & Ginsburg, 2009). Children enter primary school with highly variable understandings and yet are required to meet the ongoing expectations of a mathematics curriculum (Arbaugh et al., 2010). Research has demonstrated that if gaps in children's knowledge are not recognised, they widen over time, significantly impacting children's confidence and later, mathematics abilities (Lehrl et al., 2016; National Council of Teachers of Mathematics [NCTM], 2000b). Educators' negative beliefs are therefore important to consider as further research evidence has suggested that many early childhood educators are fearful of mathematics and, furthermore, believe the teaching of the subject to be incompatible with play-based programs (Warren et al., 2011).

Historically, early childhood educators who want to avoid teaching mathematics have been drawn to play-based learning environments, where they believe it is unlikely they will encounter "traditional" mathematics curricula (Lake & Kelly, 2014). Educator

beliefs about their own mathematics abilities are often based on the product of their own mathematics education (O'Neill & Stephenson, 2012), training, and skills and are often associated with recollections of negative experiences of mathematics learning at school. This suggests there is a fundamental mismatch between what the place of mathematics should be in early childhood education, as indicated by multiple guiding documents such as the VEYLDF (DET, 2016), the EYLF (DEEWR, 2009), the National Quality Standard (ACECQA, n.d.), and the Early Years Planning Cycle (DEEWR, 2015) and educator beliefs about their own mathematics abilities and the teaching of mathematics in play-based curriculum.

This mismatch highlights the fundamental tensions that persist about the role of mathematics within play-based philosophies of learning (Hachey, 2009; Stipek, 2013). These misunderstandings are compounded further by steadfast beliefs about developmentally appropriate practice and what children are ready and able to learn based on their age and relevant developmental milestones (Ginsburg & Golbeck, 2004; Lee & Ginsburg, 2009; Piaget, 1952; Starkey, Klein, & Wakeley, 2004). Some early childhood educators were taught that purposefully teaching mathematics to young children prior to commencing primary school was inappropriate, unnecessary, and could be harmful to children's development (Elkind, 1981, 1998). Mathematics is a subject perceived to be overly teacher directed, reliant on didactic materials and instructional formats that are seemingly at odds with "free play" and play-based learning philosophies (Lee & Ginsburg, 2009). These outdated beliefs have had a lasting impact on the inclusion of mathematics in early childhood curriculum, and have informed this research into how play and the explicit teaching of mathematics can coexist in early childhood programs.

Outdated beliefs are an ongoing concern as they persist and continue to influence children's learning (Hirsh-Pasek, Golinkoff, Berk, & Singer 2009; Maloney & Beilock, 2012; Zhang & Wong, 2015). These beliefs can form barriers to the uptake of new research findings in practice. This is problematic when thinking about the evolving nature of early childhood education, as it is through the enactment of new research findings in practice that change can occur and pedagogy and practice evolve. With the rapid emergence of new research into early childhood education (Chen & de Groot Kim, 2014), and specifically research into early childhood mathematics education

(Cohrssen et al., 2016; Davis & SRSG, 2015; Moss et al., 2015), ongoing professional learning is necessary to support educators in keeping up to date with recent research, particularly when knowing how to enact new research findings about early childhood mathematics in practice.

To summarise, historically, there has been little emphasis on preparing early childhood educators to teach mathematics in early childhood education, contributing to a lack of knowledge and lack of confidence about mathematics teaching and learning (Copley, 2004; Lake & Kelly, 2014; Piasta, Logan, Pelatti, Capps, & Petrill, 2015). Research has suggested that this is through the lack of provision of specific training and preparation aimed at identifying the mathematics in young children's everyday activities in informal settings (Ginsburg, Hyson, & Woods, 2014; Isenberg & Quisenberry, 2000; Ryan & Lobman, 2010). This highlights the need for further investigation into how educators identify, assess, and plan for the development of children's mathematics competencies in early learning environments. With a view to investigating these issues further, it is necessary to review play-based learning and intentional teaching to further understand the context for this study.

2.2 Learning Through Play

Children's learning is gradual and socially mediated (Wood, 2013). In Australian early learning contexts, the key focus is on learning through play (DET, 2016; Ebbeck, & Waniganayake, 2016). Play is relational: Children learn through interactions with their environment and others (Bronfenbrenner & Morris, 1998; Gauvain, 2001; Lester & Russell, 2008; Vygotsky, 1978). Play is a way of referencing the child's interests within their social and cultural contexts, highlighting how play supports a sociocultural context for the construction of knowledge (Siraj-Blatchford, 2010a).

In the home environment, early dependency and mediations with parents provide social cues on what to pay attention to, what is important to learn, and how to construct processes of thinking (Melhuish et al., 2008; Wood, 2010). In early childhood settings, educators build on children's existing knowledge, the foundations of which have been established in the home learning environment (ACECQA, n.d.; Niklas, Cohrssen, & Tayler, 2015). This highlights the importance of creating continuity between the home learning environment and early childhood settings, and providing an organisational

framework that supports conceptual learning and cognitive development (Bruner, 1990; Gauvain, 2001; Rogoff, 1998). Therefore, when educators identify and assess the existing knowledge and learning dispositions that children bring with them from their home learning environments into the early childhood setting, educators take an important step toward establishing links between children's existing knowledge and their ongoing learning (DET, 2016). This applies to children's knowledge of and interest in mathematics. However, if educators do not recognise the mathematics inherent in children's existing knowledge, opportunities to support children's learning may remain undetected.

Within the early childhood education setting, educators provide the organisational structures for children's ongoing learning, which inform the "social practices through which knowledge is used" (Gauvain, 2001, p. 53). In this way, learning within the early childhood setting is strongly informed by the educator's beliefs, knowledge, learning dispositions, and skills (Chiatovich & Stipek, 2016). Ideally, the educator creates a focus on and draws attention to the way knowledge is considered by children to support meaning making and learning (Fleer, 2013). However, if children's demonstrated knowledge and interests in mathematics are not recognised by the educator, opportunities for learning are missed. Given that learning is relational, and children learn socially and through joint attention with more experienced others (Siraj-Blatchford, 2007), it is important to understand how educator beliefs, knowledge, and skills inform curriculum choices and pedagogical approaches to learning mathematics in early childhood settings (McDermott, Leigh, & Perry, 2002; Pramling Samuelsson & Johansson, 2006).

While it has been theorised that play supports the social and emotional development necessary to lead cognition, these developmental domains are in fact complex, interrelated, and closely linked (Leong & Bodrova, 2012; Gauvain, 2001; Williams, 2007; Williams, Sheridan, & Sandberg, 2014). Development in one domain can influence and be influenced by learning in another (Stonehouse, 2011). Sustained periods of engagement in play are known to support cognitive development, particularly when more experienced peers and adults are engaged (Bodrova & Leong, 2007; Chiatovich & Stipek, 2016). This further highlights the role of the educator in facilitating the mathematics learning inherent in children's daily explorations and play

(Clements & Sarama, 2014; Cohrssen, Church, Ishimine, & Tayler, 2013; Cohrssen et al., 2014; Hachey, 2013b) and making intentional links between explicit teaching strategies and play-based learning. This is not always straightforward as understandings about what constitutes play and learning in early childhood education varies widely. This is discussed in further detail in the following section.

2.2.1 Play-Based Approaches to Learning and Early Childhood Education

An important context for this study is provided by insights into play and play-based approaches to learning. What constitutes play in early childhood environments is complex and challenging to define as understandings of "play" and "learning" vary widely across the early childhood profession (Arthur, Beecher, Death, Docket, Farmer, 2012; Barblett, 2010; Bruce, 2015; Cutter-Mackenzie, Edwards, & Fleer, 2009; Fleer, 2011a; Grieshaber & McArdle, 2010; Marfo & Beirsteker, 2011; O'Gorman & Ailwood, 2012; Rogers, 2011; Whitebread, Coltman, Jameson, & Lander, 2009; Wu & Rao, 2011). How play is constructed and informs educational practices within early childhood environments is contentious and widely debated (Hachey, 2009; O'Gorman & Ailwood, 2012; Rogoff, 1998; Sandberg & Pramling Samuelsson, 2003; Smith, 2006). The term "play" does not have one specific definition; therefore, discussion, research, and evolving theoretical understandings of "play" and "learning" and what this looks like in the early childhood context are reliant on individual interpretation.

This raises questions about the focus on play, learning, and developmentally appropriate practices in early childhood education and the relevance and inclusion of intentional teaching practices, curriculum planning, and academic learning outcomes (Copple & Bredekamp, 2009; Smith, 1990). Discussions offer differing opinions about how to interpret play and manifest in variability in practice and planning in early childhood settings. These debates are not new. Historically, opinions have ranged from children's rights to free unstructured play, which is child centred and child initiated, to educator-initiated play, which includes explicit teaching strategies and specific learning objectives (Barblett, 2010; Elkind, 1998; Hachey, 2013b; Manning & Sharp, 1977; Sumsion, Grieshaber, McArdle, & Shield, 2014). These diverse understandings of play are not unusual given that educator beliefs about play are themselves socially and culturally mediated.

Given the varying opinions surrounding play-based approaches to learning and definitions of play, it is useful to refer to the Australian Early Years Learning Framework (DEEWR, 2009) as this is a guiding document mandated for use in Australian early childhood settings. The EYLF describes play-based learning as "a context for learning through which children organise and make sense of their social worlds, as they engage actively with people, objects and representations" (DEEWR, 2009, p. 46). This requires children to be provided with a context for learning in which there are opportunities to engage socially with "people, objects and representations" to make meaning, assimilate new ideas, understand, integrate, and apply new knowledge in everyday contexts (Barblett, 2010; Fleer, 2011b; Fleer & Peers, 2012; Stonehouse, 2015). This further suggests that social and emotional development goes hand in hand with cognitive development. To support learning during play, it is suggested that a balance between the child's interests, self-initiated play, explicit instructional formats, and intentional teaching should be met (Ashiabi, 2007, Bodrova & Leong, 2007; Vartuli, 1999). Therefore, a balance between child-led and teacher-directed learning further supports links between children's interests and academic concepts during explorations of their everyday worlds (Halpenny & Pettersen, 2013). This is important to consider when addressing how children learn in play-based environments and the role of the educator in identifying how best to support children's learning.

Informal, early childhood curricula can provide a vehicle for identifying what to teach children (DEEWR, 2009; DET, 2016). This vehicle provides further opportunities for the teaching and learning of mathematics, which links to the diverse ways in which children demonstrate their interests and knowledge during play. The educator plays a key role in enacting the Early Years Planning Cycle in practice (DEEWR, 2015). This requires skill and specific training. It is of growing importance to understand which aspects of early years programs are supporting children's conceptual development and how "play"—as the context and vehicle learning of mathematics—forms an important aspect of this development. As a vehicle for learning, play provides the necessary links between the child's interests and the mathematical concepts being explored. Bodrova and Leong (2007) stated, "Pre-academic activities can be beneficial in the early childhood classroom, but only if they emerge out of children's interests and only if they occur in a social context appropriate for young children" (p. 138).

Children express their mathematics knowledge through play in diverse ways. It stands to reason that interpretations of children's demonstrated knowledge during play are broad (Sandberg & Pramling Samuelsson, 2003). Interpretations of mathematics identified during play differ depending on educators' skills, teaching proficiency, and beliefs. To implement the EYLF (DEEWR, 2009) and the VEYLDF (DET, 2016) and address the five learning outcomes in practice, educators need to know how play supports mathematics learning, how play provides links between children's interests and their learning outcomes and how to assess children's existing knowledge. Educators also need to know appropriate teaching strategies to use when supporting learning across curriculum domains, how to implement a play-based program, and furthermore, how to use play as a vehicle for learning (Barblett, 2010). Anthony and colleagues (2015) wrote, "Given that most of the learning experiences in kindergarten involve well-planned, free-choice play, it is critical that teachers are able to utilise free-choice play to support mathematics learning" (p. 411). In contrast, understandings of "free play" include play that is typically undirected, with minimal intentional interactions between educators and children. For children to acquire content-specific learning, free play can be limiting as a free-choice play environment alone has been identified as the least successful when supporting children's specific learning needs (Kennedy & Stonehouse, 2012).

It is well established that play provides opportunities for children to communicate their unique mathematics knowledge in diverse ways (Cohrssen et al., 2013; Piasta, Pelatti, & Miller, 2014; Pollitt et al., 2015; Wright, 2010). Mathematics, when integrated with a play-based curriculum, can support creative and flexible approaches to learning, engage children's interests, and influence future learning outcomes (Duncan et al., 2007; Lester & Russell, 2008; Mulligan & Vergnaud, 2006).

However, links between mathematics learning and play are not always easily understood. The term "play" is commonly used in early childhood education; however, understandings of the role of play and how it supports children's learning are often assumed or remain unchallenged (Stonehouse, 2015). At times, the role of play and how it informs pedagogy and curriculum are overlooked as a vehicle for learning (Cohrssen et al., 2013; Klibanoff et al., 2006; Thomas, Warren, & DeVries, 2011). As research rapidly builds new insights into how children learn (Organisation for Economic Co-

operation and Development [OECD], 2015) and the role of play in learning, so, too, must early childhood pedagogy and curriculum evolve. This is particularly relevant in the teaching of mathematics, often perceived as incompatible with play. Early childhood professionals have the capacity to provide rich learning opportunities and experiences that are structured and designed to meet the learning needs of each child and therefore begin to establish the foundations necessary for lifelong learning (DEEWR, 2009; Knutsdotter-Olofsson, 1996; Lillard et al., 2012; Pramling Samuelsson & Sheridan, 2004; Rogoff, Goodman Turkanis, & Bartlett, 2001; Siraj-Blatchford, 2010a).

2.2.2 Explicit Teaching and Play-Based Mathematics Learning

The National Quality Framework is governed by Australian National Law and Regulations that aim to raise the quality of educational programs and promote continuous improvement and continuity in ECEC within Australian early childhood settings (ACECQA, n.d.). The National Quality Standard (ACECQA, n.d.) forms a key component of the National Quality Framework, and meeting the standards is a legal requirement in Australian early childhood settings. Evidence-based planning is outlined in Standard 1.1, which states that the educational program plan is child centred, supports each child's learning and development, and that "each child's current knowledge, strengths, ideas, culture, abilities and interests are the foundation of the program" (ACECQA, n.d., p. 1). The standards are linked to the approved early years learning frameworks (DEEWR, 2009; DET, 2016), and curriculum planning is defined in the EYLF as the "interactions, experiences, activities, routines and events, planned and unplanned, that occur in an environment designed to foster children's learning and development" (DEEWR, 2009, p. 9). The point being made is that planning that responds to evidence and analysis of what children know, with a view to intentionally supporting learning and development, is a legal requirement of the National Quality Framework in Australia.

Intentional teaching is defined by the EYLF as "educators being deliberate, purposeful and thoughtful in their decisions and actions" (DEEWR, 2009, p. 15) and is the opposite of teaching by rote, or continuing with traditional and outdated approaches to teaching and learning. Epstein (2007) similarly suggested that being purposeful, with a specific goal and a careful, well-thought-out plan for achieving it, is to be "intentional": "An "intentional" teacher aims at clearly defined learning objectives for

children, employs instructional strategies likely to help children achieve the objectives, and continually assesses progress and adjusts the strategies based on that assessment" (p. 4).

Epstein (2007) further highlighted that intentional teaching is reliant on assessment that not only informs learning objectives, but also influences the teaching strategies needed to achieve these goals. This suggests that intentional teaching relies on accurate and ongoing assessment to inform decisions about curriculum planning and the teaching strategies employed to support children's learning (McLean Davies et al., 2015). As Kennedy and Stonehouse wrote, "When professionals are intentional, they have well-thought-out learning and development outcomes in mind and are able to explain both what they are doing and why" (2012, p. 5). This suggests that teaching is both intentional and explicit.

Building educator competencies in identifying and assessing the mathematics inherent in children's interests, daily routines, and play is important because children's existing mathematics skills cannot be built on without the support of a more knowledgeable other—children's learning outcomes depend on the educator's mathematics competencies (Bruns et al., 2017; Klibanoff et al., 2006; Moss, Bruce, Caswell, Flynn, & Hawes, 2016). To reiterate, assessment is recognised as complex and informed by the interactions of many components (Woodcock, 2002). In early childhood, a further challenge is knowing how to assess children's mathematical understandings while children are engaged in play (Copple & Bredekamp, 2009; Vig & Sanders, 2007) and employ the explicit teaching strategies necessary to support childrens mathematics learning.

2.2.3 Value of Explicit Teaching, Play, and Mathematics Learning

Play-based approaches to learning require high-quality, purposeful, and intentional teaching practices (Barblett, 2010; Bodrova, 2008; Bransford, Darling-Hammond, & LePage, 2007; Cohrssen et al., 2013; Dockett, 2011; Gasteiger, 2012; Jung & Conderman, 2013; Sammons et al., 2004; Siraj-Blatchford, 2010a). Research has indicated the important role of the educator when using explicit teaching strategies to support children's learning within a play-based curriculum: knowing how to identify what children know, knowing how and what to plan to support children's learning, and

knowing how to implement and teach a play-based curriculum (Bennett, Wood, & Rogers, 1997; Blair, Ursache, Greenberg, & Vernon-Feagans, 2015; Dockett, 2011; Dockett & Fleer, 1999).

When educators are actively and intentionally involved in play (Perry, 2013), it is easier to gain necessary understandings of the child's zone of proximal development (ZPD) (Vygotsky, 1978), providing evidence of what children have already mastered and are ready to learn next. The child's ZPD is where connections to prior knowledge and new learning can be made (Vygotsky, 1978). However, understanding when a child is in their ZPD requires an ability to assess the upper levels of children's existing knowledge. Play-based assessment strategies, which reveal children's knowledge and existing skills, are necessary to support educators when assessing and planning for learning in this area. This is particularly important when planning to support the next steps in children's mathematics learning (Clements & Sarama, 2014), as high-quality interactions between the educator and the child can determine the difference in learning outcomes (Bakken, Brown, & Downing, 2017; Duncan & Sojourner, 2013; Tayler, Ishimine, Cloney, Cleveland, & Thorpe, 2013; Wang, Shen, & Byrnes, 2013).

Research has further suggested that successful learning environments provide a range of stimulating resources and have a balance between child-initiated, adult-guided, and adult-/child-led learning, highlighting the importance of explicit, integrated approaches to teaching and learning within play-based environments (Page & Tayler, 2016; Williams et al., 2014). For example, Edwards and colleagues (2017) addressed the difficulty educators' often encounter when balancing open-ended play with intentional teaching. Their research investigated three play-types: open-ended play, modelled play and purposefully framed play. The research was conducted with 119 children and 16 educators, who developed learning experiences based on the three play-types. Although it was anticipated that purposefully framed play would be preferable, the outcomes demonstrated that the three play-types were equally valued by both children and educators, using a balance of open-ended play and intentional teaching strategies. Furthermore, the VEYDLF's (DET, 2016, p. 12) integrated teaching and learning approaches demonstrate how guided play and learning, adult-led and child-directed learning and play interweave to facilitate learning and development. The argument is that play can be open, exploratory, *and* intentionally focused on learning

objectives and outcomes (Chiatovich & Stipek, 2016). Further, explicit teaching strategies are needed to develop specific mathematics skills, as young children rely on the knowledge of others to identify the mathematical concepts being considered during play, and at times, explicit teaching is necessary to support children's ongoing learning. It is known that educators' intentional involvement with children during play increases and extends opportunities for assessment and explicit teaching, and further, it increases the value of learning through play (Kennedy & Stonehouse, 2012).

2.3 Mathematics, Spatial Reasoning, and Play-Based Curricula

In this section, our focus narrows from mathematics to spatial reasoning as the importance of supporting spatial reasoning in play-based curricula becomes increasingly apparent. A substantial body of research has investigated the foundations of mathematics learning, identifying which aspects of the subject are important to support young children's acquisition of mathematics skills (Davis & SRSG, 2015; Moss et al., 2016; Moss et al., 2015; Uttal et al., 2013; Uttal & Sheehan, 2014; Weckbacher & Okamoto, 2015). Common to this body of work is spatial reasoning, as it is a key concept at the heart of all mathematical understandings. It is often believed that knowledge of and proficiency in number and counting is an important foundation for and basis of mathematics learning. However, research conducted by Gunderson and colleagues (2012) suggests that spatial skills can also promote numerical skills by helping students to develop a linear spatial representation of numbers. These findings are supported by further research which suggests mathematics relies strongly on visual and spatial representations. For example, to determine if the development of spatial skills supported mathematics learning, Cheng and Mix (2014) randomly assigned children to one of two groups: the first, a spatial skills group which included mental rotations; the other, a group which focused on crossword puzzles. The children completed pre- and post-tests focussing on mathematics and spatial reasoning. The spatial skills group demonstrated significant improvement in their calculation skills, outperforming children who completed crossword puzzles. Furthermore, early opportunities for spatial learning have been found to foster children's skills and improve symbolic representations of numbers and future mathematics learning (Gunderson, Ramirez, Beilock & Levine, 2012). This is supported by research that suggests that

spatial reasoning actually underpins our ability to learn mathematics (Davis & SRSG, 2015; Weckbacher & Okamoto, 2015).

Explicitly teaching young children spatial reasoning skills may improve mathematics learning; however, research has suggested that spatial reasoning is not often taught in early childhood settings (Verdine, Lucca, Golinkoff, Hirsh-Pasek, & Newcombe, 2015). This is partly because spatial reasoning relies on internal thought processes that are not always visible (Uttal & Sheehan, 2014), making it challenging for educators to observe and assess children's demonstrated understandings of spatial reasoning concepts during play. This means that specific assessment strategies and appropriate assessment resources, which reveal children's spatial reasoning knowledge, are necessary to support educators when identifying and planning for children's spatial reasoning learning. The critical theoretical argument underpinning this study is that children, from a very young age, benefit from explicit teaching specifically targeted to support the learning of spatial reasoning skills (Miller, Rittle-Johnson, Loehr, & Fyfe, 2016; Verdine et al., 2015).

Play-based curricula may not always include an explicit focus on mathematics and rarely include opportunities to focus purposefully on spatial reasoning (Moss et al., 2016). Before discussing this further, it is important to provide an overview of spatial reasoning in early childhood education: what it is, why it is important, and how it supports mathematics learning.

2.3.1 Spatial Reasoning in Early Childhood Education

Spatial reasoning is a set of cognitive functions, processes, and skills that enable us to understand and describe representations and spatial relationships between objects, ourselves, and our environment—it is a life skill. Spatial reasoning is an "essential human ability that contributes to mathematical ability" (Clements & Sarama, 2009, p. 107) and is often described as a collection of cognitive processes and skills (Moss et al., 2016). It is the ability to communicate the relationships between objects, ourselves, and space. There are three key areas of spatial reasoning associated with mathematics ability: perspective taking, mental rotation, and spatial visualisation. Spatial reasoning is at the core of mathematical thinking. It is closely associated with working memory (Baddeley, 2000), which itself is particularly important for learning mathematics in

early childhood (Davis & SRSG, 2015; Miller et al., 2016). Research has suggested that children are more likely to find mathematics easier when they are able to remember and mentally manipulate visual–spatial information (Boaler, Chen, Williams, & Cordero, 2016; Davis & SRSG, 2015; Kyttala & Lehto, 2008; Thompson, Nuerk, Moeller, & Kadosh, 2013).

In early childhood, children's mathematical thinking incorporates many mathematics strands, proficiencies, and domains (ACARA, n.d.-a), across multiple curriculum areas and in a short space of time. Teasing the strands apart and identifying which concepts children are exploring requires specific knowledge and skill. Spatial reasoning is not often taught in early childhood (Clements & Sarama, 2014), perhaps because it is difficult to define, difficult to identify and difficult to teach. Spatial reasoning can have multiple meanings, particularly when applied across different disciplines (Moss et al., 2015; National Research Council, 2006).

Little is known about how spatial reasoning specifically supports children's mathematics learning in early childhood education (Diezmann & Watters, 2000). It is known that spatial reasoning is an important skill that underpins mathematical understanding and is closely related to outcomes in early mathematics performance (Cheng & Mix, 2014). Clements and Sarama (2011) elaborated further that through mathematics, we "communicate ideas that are essentially spatial. From number lines to arrays, even quantitative, numerical, and arithmetical ideas reason on a geometry base" (p. 134), highlighting the importance of understanding how spatial reasoning skills support mathematics learning. With the growing awareness and shifting focus on fields of education relating to science, technology, engineering, and mathematics (STEM) (Levine, Ratcliff, Huttenlocher, & Cannon, 2012; NCTM, 2010b), the development of spatial reasoning skills plays a significant role in children's education and needs to be supported by explicit teaching and assessment strategies.

Spatial reasoning and the capacity to visualise and hold images in the mind's eye is an important skill that supports mathematical reasoning (Davis & SRSG, 2015; Moss et al., 2015; Uttal & Sheehan, 2014). Further, teaching spatial reasoning is closely aligned with cognitive development (Shumway, 2013). Children are more likely to find mathematics easier when they can remember and mentally manipulate visual–spatial

information to solve problems, communicate their reasoning, and transfer concepts to other contexts (Baroody, 2017; Davis & SRSG, 2015; Kyttala & Lehto, 2008; Thompson et al., 2013). Children build new knowledge on the foundations of existing knowledge (Watts et al., 2017), and explicit teaching strategies (Baroody, 2017) are necessary to support children's spatial reasoning skills. This research project points to the fundamental importance of spatial reasoning and assessment in early childhood, highlighting that spatial reasoning is congruent with play-based approaches to learning, and furthermore, how a focus on spatial reasoning can inform evidence-based planning for children's ongoing mathematics learning.

2.3.2 Explicit Teaching and Spatial Reasoning

Research has continued to debate whether spatial reasoning skills are innate or can be learnt (Hyde et al., 2011). This results from traditional beliefs that individuals either do or do not possess spatial reasoning skills. However, further research has suggested that spatial reasoning is both innate *and* malleable, which is to say that spatial reasoning skills can be taught and developed (Hyde et al., 2011; Ramani et al., 2014; Uttal et al., 2013). For example, children who were explicitly taught to recognise spatial concepts during play demonstrated improved spatial reasoning skills (Cohrssen et al., 2017; Farmer et al., 2013; Pruden, Levine, & Huttenlocher, 2011; Ramani et al., 2014; Uttal & Sheehan, 2014). Furthermore, research has demonstrated that children who are intentionally taught spatial concepts are better able to perform spatial tasks (Hawes, Tepylo, & Moss, 2015). This is a key predicator of children's future mathematics performance (Uttal et al., 2013; Verdine et al., 2015) as "many mathematics tasks use inherently spatial representations" (Hawes et al., 2015, p. 35). Therefore, supporting the development of children's spatial reasoning skills can help to improve the spatial concepts and skills that in turn support the foundations of mathematics learning now and in the future.

2.3.3 Play-Based Learning, Spatial Reasoning and Working Memory

Play-based approaches to early childhood education promote the engagement of children's interests in learning (Bodrova, 2008). This motivates curiosity, self-regulation, and sustained attention (DEEWR, 2009). The following sections (2.3.3.1 and 2.3.3.2) highlight examples from meta-analysis, case studies and research that demonstrate how explicitly teaching spatial reasoning, working memory and spatial

language can contribute to young children's mathematics learning in play-based contexts. These examples provide evidence to suggest that a focus on spatial reasoning, can promote children's engagement in mathematics tasks and therefore, engagement in mathematics learning. Motivation to learn and sustain interest in mathematics affects children's ongoing task engagement (McGrew, 2005). This points to a fundamental issue about how mathematics is taught in early childhood education. As discussed in Section 2.2.2, mathematics in early childhood education is typically perceived as an academic subject unrelated to play-based approaches to learning. However, as demonstrated in sections 2.3.3.1 and 2.3.3.2, the explicit teaching of spatial reasoning, working memory and spatial language can support play-based approaches to mathematics learning, that motivate children's curiosity and promote the engagement of children's interests. This demonstrates that play-based approaches to mathematics learning are possible.

2.3.3.1 Spatial reasoning and working memory

Spatial reasoning is one way to support the development of working memory capabilities, therefore supporting the foundations for mathematics learning (Uttal & Sheehan 2014). Spatial reasoning aligns with play-based approaches to mathematics learning, as very young children begin to develop the ability to hold images, symbols, and directions in their "mental workspace" (McGrew, 2014) while solving increasingly complex problems. In a meta-analysis of 217 studies conducted by Uttal and colleagues (2013), it was apparent how quickly spatial reasoning skills could be learnt. For example, one of the studies revealed that 2-year-old children could find an object hidden in a room by looking at a model of the room first and watching where the educator placed the object inside the model. The children could find the object in the room when they were involved in hiding the object in the model; however, they were unable to read the map on its own as a projection of a future action (Uttal et al., 2013). Children were unable to hold the image and concept in their mental workspace unless they physically experienced hiding the object first. However, children of 2.5 years could find the object by using the model and/or map and orienting themselves, their position, and direction within the room. This highlights that when provided with opportunities to explore and develop their spatial skills, very young children have the capacity to hold information in their mental workspace, and that the development of spatial reasoning

skills is possible and can be rapid. The outcomes of Uttal and colleagues (2013) research indicate that it is possible to assess young children's spatial reasoning and working memory capabilities and furthermore, suggests the importance of frequent and formative assessment strategies that are playful and engaging for children.

2.3.3.2 Acquisition of spatial and directional language

Young children benefit from explicit teaching in spatial relations language when developing spatial reasoning skills (Cohrssen et al., 2017; DEEWR, 2009; Farmer et al., 2013; Hyde et al., 2011; Pruden et al., 2011). Children who are exposed to, and intentionally taught, spatial language are better able to perform spatial tasks than children who are not (Hawes et al., 2015; Moss et al., 2016). Spatial language, gestures, and activities designed for improving spatial reasoning play an important role in children's learning as they are predictive of future mathematical performance (Davis & SRSG, 2015; Nguyen et al., 2016; Uttal & Sheehan 2014; Verdine et al., 2015). These findings have significant implications for policy and education in the early childhood profession, as this growing body of research points toward the fact that a specific focus on the teaching of spatial language and spatial reasoning skills to young children in play-based contexts, supports future mathematics learning and academic outcomes. The findings also informed the rationale for the study at hand.

2.3.4 Making Spatial Reasoning Visible During Play

Pramling Samuelsson and Pramling (2013) described education as making the invisible visible to the child, highlighting the educator's role in making children's learning visible during play, as play is not the same as learning. Hattie and Yates (2014) also discussed making learning "visible", whereby learning objectives and goals are explicit and provide children with clear insights into the learning processes they need to undertake to achieve learning outcomes. To achieve visibility and clarity of the mathematical ideas children explore during play, the ideas need to be made visible; the ideas need to be identified and discussed within a mathematics context to be assessed and to scaffold children's learning (Anthony et al., 2015; Hurst, 2015; Pollitt, Seah, & Cohrssen, 2017).

A clear understanding of children's mathematical ideas and representations requires assessment strategies and techniques that identify children's mathematical

thinking and make it visible to both the educator and the child (Siemon, Bleckly, & Neal, 2012). One way to make spatial reasoning concepts more visible is to link spatial reasoning with geometry. The following section discusses the value of spatial reasoning and geometry in early childhood education.

2.3.5 Spatial Reasoning, Geometry, and Mathematics Abilities

There is a natural association between spatial reasoning concepts and geometry, as geometry, broadly speaking, is the study of spatial relationships, shapes, sizes, and positions (Moss et al., 2016). There are three key areas of spatial reasoning associated with mathematics ability: perspective taking, mental rotation, and spatial visualisation. As stated, spatial reasoning is often associated with internal thought, which is private and therefore difficult to externalise and identify (Rosenfeld, 2010; Whiteley & Mamolo, 2014). Geometry provides a way to externalise the spatial thinking and to make the assessment and the learning visible (Moss et al., 2015). Geometry provides a strategy for revealing what educators are looking for when assessing children's spatial reasoning skills.

Children also benefit from engaging in hands-on activities that encourage geometric composition and conceptual understandings of mathematics (Cohrssen et al., 2016; Davis & SRSG, 2015; Moss et al., 2015). This is an important skill that further supports the development of children's geometric understandings and links among conceptual understandings of shape, for example, with everyday shapes in their environment (NCTM, 2000a). Mathematics can explain the world we live in and can help us to communicate our ideas. Providing opportunities for children to make *geometric* sense of their world connects spatial reasoning concepts with the everyday, making spatial reasoning visible and further, giving mathematics relevance and purpose (Mulligan, 2015; Ramani et al., 2014).

The United States' NCTM (2000a) standards for the early grades provides a useful overview of what geometry and spatial reasoning is in the early years, identifying the key aspects of geometry and spatial reasoning as

- analysing characteristics and properties of two and three dimensional geometric shapes and their relationships;

- specifying locations and describing spatial relationships using coordinate geometry and other representational systems;

- applying transformations by recognising and applying slides, flips, and turns as well as recognising and creating shapes containing symmetry;

- using visualisations to create mental images of geometric shapes using spatial memory; to recognise and represent shapes from different perspectives; and to recognise geometric shapes and structures in the environment and specify their location. (p. 97)

Young children actively engage with mathematics and explore their understandings of mathematics through play and informal activities using concrete objects, using both language and gesture to explain the objects' characteristics and location. Children have multiple opportunities during play to manipulate objects, transform them and observe them from multiple perspectives (Cheng & Mix, 2014; Moss et al., 2015; Sinclair & Bruce, 2014, Sinclair & Moss, 2012). Geometry thus provides a way to focus on spatial reasoning in *action*, during children's play.

2.4 Importance of Assessing Mathematics in Early Childhood

It is well established that learning and development in early childhood occurs simultaneously across all developmental domains, is informed by sociocultural contexts, and is unique to each child (DET, 2016; Perry, Dockett, & Harley, 2012). It therefore follows that accurate assessment is necessary to identify and inform children's specific and ongoing learning needs (DEEWR, 2009). The exact nature of what constitutes assessment of children's mathematics learning in early childhood settings is often unclear, and the notion of assessing learning at all may be at odds with educator beliefs about the role of assessment in early childhood. In general, assessment in the context of informal curricula is often perceived as being overly academic, a form of "testing" and belonging to isolated "classroom" activities not often associated with play (Leong & Bodrova, 2012). Perceptions about mathematics and assessment in early childhood education are explored in more detail in sections 2.4.1, 2.4.2 and 2.4.3.

2.4.1 Mathematics, "Testing", and Assessment

In Australia, there exists a gap between assessment and play-based approaches to learning (Stonehouse, 2015). This is problematic when the National Quality Standard requires evidence to inform curriculum planning (ACECQA, n.d.; DEEWR, 2009). Gaps between assessment and planning for learning are most evident in the assessment of mathematics in play, as mathematics assessment is perceived as being incongruent with early childhood theories of learning and development (Bredekamp & Copple, 1997). Assessment of mathematics is traditionally perceived as "academic" and developmentally inappropriate for early childhood play-based programs (Elkind, 1981; Piaget, 1952). Mathematics "testing" has historically included timed testing, which, when used inappropriately, can further influence mathematics anxiety and impact mathematics achievement (Boaler, 2013).

Nevertheless, assessment of children's mathematics learning is a critical step in knowing what and how to plan for children's ongoing learning. Learning takes place when children are scaffolded to extend their knowledge over and above what they already know (Baumert, Lüdtke, Trautwein, & Brunner, 2009). This takes skill and planning. Ongoing assessment forms an essential part of planning, taking children's learning "beyond what they already know, can do and understand" (Kennedy & Stonehouse, 2012, p. 6). Without contingent planning, evidence of children's learning remains a record of what children know now and not what they are ready to learn next. Learning occurs when children experience a challenge just beyond their present level of mastery (Ashiabi, 2007; Grieshaber & McArdle, 2010), highlighting the importance of assessment in identifying how to extend learning beyond what the child already knows.

Assessing children's learning is complex, as evidence of learning is not always immediate and outcomes may surface over time. In early childhood programs, it is necessary to use a variety of assessment strategies across time, that are conducted in the child's early learning context, and repeated frequently by an early childhood professional who has knowledge of the child, their learning dispositions, and skills. Across time, "an accurate, comprehensive representation of the child may emerge" (Bordingnon & Lam, 2004, p. 742). In this way, educators develop knowledge of the children they teach, are invested in learning outcomes, and are intentionally and collaboratively involved in the learning with the child (Williams et al., 2014).

Assessment includes evidence of children's abilities to transfer learning into new contexts and to address new problems by applying processes of learning to problem-solving (Baumert et al., 2009; Siraj-Blatchford, 2010a).

Assessment can have a significant impact on establishing solid foundations for learning, particularly in mathematics, preventing gaps and misunderstandings in foundational mathematics knowledge from occurring (Clements & Sarama, 2014). Reversing misunderstandings of mathematical concepts that have been incorrectly taught is difficult and requires intentional support from educators (Goss, Hunter, Romanes, & Parsonage, 2015). When children carry misguided beliefs and knowledge about mathematical concepts into formal schooling, the impact on their capacity to link new mathematics knowledge with existing understandings can widen significantly (Cannon, Eisenband, Ginsburg, & Pappas, 2008). This, therefore, highlights the significance of frequent and ongoing mathematics assessment to understand whether gaps in children's knowledge exist and to determine how best to address these gaps in children's knowledge (Goss et al., 2015). Assessment provides evidence of what children know and are ready to learn next, and in this way, can prevent gaps in children's foundational mathematics knowledge from widening.

2.4.2 Argument for Play-Based Assessment of Mathematics

There exists a theory–practice deficit (Nolan & Raban, 2015), and although the gap is closing, the necessary link between what is observed, documented, and analysed as evidence of children's learning does not always align with theories of assessment in practice (DET, 2016). The deficit would appear to exist in the gap between documenting *and* analysing children's learning, a critical step in the Early Years Planning Cycle (DEEWR, 2015) necessary to inform assessment and evidence-based planning. A further gap exists between documentation and relevant theories of analysis to assess, understand, and plan for children's learning (Hattie & Yates, 2014; Tayler, Cloney, & Niklas, 2015) in play-based contexts. Stonehouse (2015) suggested that educators tend to document children's behaviours and developmental milestones as they are easier to recognise in play-based contexts, as identifying and analysing the learning occurring during play can be challenging. What is missing from early childhood teaching practice is the analysis and interpretation of children's learning, informing assessment and evidence-based planning. The focus of this study is to explore the

operationalisation of assessment and evidence-based planning for learning. It was therefore important to consider assessment of children's mathematical thinking, in the context of play, and the ways in which this supports formative assessment in the enactment of the Early Years Planning Cycle (DEEWR, 2015).

Assessing documentation and observations of children's learning requires a broad range of theoretical and developmental knowledge and understandings of early childhood assessment strategies (Griffin, 2007, 2014; Gronlund & James, 2005; MacNaughton & Williams, 2009; Sharma, Cockerill, Okawa, & Sheridan, 2014; Shulman, 2013). It is also important to consider assessment strategies that are playful, developmentally appropriate, use resources that are engaging and align with the child's interests, and are conducted by educators who have existing knowledge of the child. Bordingnon and Lam (2004) wrote, "An assessment process that could foster the energy, creativity, and enthusiasm that children initially bring to the school, should be the goal of all personnel designing, administering, and employing such instruments" (p. 746), suggesting that early years assessment strategies should reflect play-based philosophies of teaching and learning, as promoted in early childhood education.

Educators require a fluent understanding of early childhood developmental theory and theoretical knowledge specifically related to learning and assessment in early childhood (Tayler et al., 2016). It is beneficial for the child when assessment can be conducted in a setting familiar to them (Ford, Kozey, & Negreiros, 2012), and for assessment to reflect best outcomes for the child. Successful assessment strategies provide multiple opportunities for children to demonstrate their understandings, and furthermore, provide children with opportunities to demonstrate the extent of their knowledge and how they come to know it (Pollitt et al., 2015). In this way, planning is based on the authentic assessment of children's knowledge, necessary to support children's learning. Addressing these threshold conditions requires specific and ongoing mentorship to support educators when refining their existing understandings, and developing new knowledge and skills in practice.

In early childhood environments, assessment typically consists of observational data gathered over time (DET, 2016). Assessment quality is reliant on many variables: the skills of the educator in determining the purpose and focus for the observations, the

ability to document relevant observational data, the quality of the data analysis, the quality of the program and setting, and the interpretation and implementation of the pedagogical theories that inform these elements (Kaufman, Reynolds, Liu, Kaufman, & McGrew, 2012). Observations of learning in early childhood are typically analysed using developmental theories that endeavour to assess children's general developmental abilities in accordance with developmental domains and milestones (Stonehouse, 2015). Historically, assessing what children are learning in play has been challenging and dependent on the educator's qualifications, experience, and skill (Ford et al., 2012; Leont'ev, 1994; OECD, 2015), meaning assessment outcomes can be variable.

The context for assessment is important to ensure an authentic indication of the child's capabilities (Bagnato, 2007; Zumwalt & Craig, 2005). Historically, assessment of children's mathematics abilities has relied on standardised cognitive tests, conducted by someone unknown to the child, usually outside of the child's context, and with assessment tools that do not always align with children's interests or early childhood play-based programs (McGrew, 2014). When assessment takes place in a familiar setting during play, with a familiar educator who has existing knowledge of the child, the assessment is more likely to be accurate and therefore appropriate to inform ongoing planning. Assessment strategies that can be repeated over time are more likely to contribute to ongoing assessment outcomes (Muskin, 2017), providing a record of children's learning and development over time. Therefore, assessment strategies that are appropriate to an early childhood context and can be enacted by educators in their programs is important to consider.

Multiple studies (Bobis et al., 2005; Sarama & Clements, 2002; Doig, 2003) may appear to be investigating mathematics curricula in early years education, however studies tend to focus on moreso on the teaching mathematics – rather than formative assessment – in the early years of primary school contexts. For example, Bobis and colleagues (2005) reviewed three large scale mathematics studies, namely the *New Zealand Numeracy Development Project*, the *Count Me In Too* program in New South Wales and the *Victorian Early Numeracy Research Project,* to identify which topics are included in mathematics curricula in the early years of primary school, and how mathematics is taught to young children. Addressing Foundation to Year 6, the review included individual task-based interviews for children and teachers to draw conclusions

about the success of whole school professional development programs and effective classroom practices. The outcomes demonstrated that the use of practical resources and strategies for supporting children's mathematical thinking improved teacher confidence, and their ability toward and enthusiasm for teaching mathematics. In the USA, Sarama and Clements (2002) developed Building Blocks for Young Children's Mathematical Development, which is a Pre-K to Grade 2 software-based mathematics curriculum for children aged from five to eight years of age. The program supports the recognition and development of mathematics in children's daily activities and supports understandings of how mathematics applies to children's everyday contexts. The program is used in a primary school context, with 'on screen' manipulatives (Sarama & Clements, 2002, p. 100) and content is chosen in response to children's emerging capabilities, based on a primary school curriculum approach.

Big Math for Little Kids Early Childhood Mathematic Program (Balfanz, Ginsburg & Greenes, 2003), is also a mathematics curriculum, however the focus is on children aged from four to five years. Based on educational and psychological research (Copley, 1999; Ginsburg, 1999), this curriculum aims to create a developmentally appropriate, research based, early childhood mathematics program which focuses on number, shapes, pattern and logic, measurement, operations on numbers and spatial relations. The program aims to integrate purposeful learning in play-based environments. The fundamental principles underlying the program suggest "all children are capable of learning mathematics at a young age" (Balfanz, Ginsburg & Greenes, 2003, p. 265), and children explore mathematical concepts during everyday play and interactions with one and another. Their program aligns with research suggesting that children need explicit teaching and guidance to understand mathematical language and concepts, and free play to explore these concepts in different contexts (Bowman, Donovan & Bruns, 2001). Early findings indicated that initial expectations were not set high enough, and when given the opportunity to engage in rich mathematical learning environments, children demonstrated that they were capable of complex mathematical thinking and problem solving (Balfanz, Ginsburg & Greenes, 2003, p. 268).

The current study differs from the programs described above as it seeks to determine how the implementation of a suite of play-based assessment activities impact early childhood teaching practices. This includes determining how the implementation

affected educator beliefs regarding mathematics in their early childhood programs and whether educator beliefs informed the prioritising of mathematics in early learning environments.

Furthermore, these studies tend to focus on teaching, whereas the current study focuses on how educators' are identifying and assessing children's understandings of mathematics. The need to support educators' ability to assess children's mathematics thinking in order to plan effectively for children's play-based mathematics learning is the gap in the research literature that this study addresses.

Making assessment meaningful for children involves using strategies that are appropriate to the child's context and used within play-based programs (Copple & Bredekamp, 2009). Assessment that provides playful opportunities for educators to observe and assess children's learning, while the child is engaged in play, is necessary to align assessment with play-based contexts for learning (DEEWR, 2009; DET, 2016). Therefore, assessment that is engaging for children and based on their interests can provide an accurate and authentic overview of children's existing knowledge and determine if and how learning objectives are being met. However, the role of the early childhood professional in identifying and assessing children's mathematics capabilities during play is not always straightforward.

2.4.3 Role of the Early Childhood Professional in Assessment

Identifying children's mathematics abilities during play can be challenging (Copple & Bredekamp, 2009), as every child has an individual way of demonstrating their mathematical understandings (Pollitt et al., 2015). Assessment investigates, analyses, and measures children's understandings to inform teaching practices, planning, and pedagogies in response to a range of integrated formative and summative assessment outcomes (Ford et al., 2012; Vig & Sanders, 2007). Children's ability to verbally express, explain, or demonstrate their thinking and reasoning skills emerges over time, and assessment of children's capabilities are informed by the interactions of many components (Woodcock, 2002). The role of the early childhood professional in identifying and assessing children's understandings is important, as predominantly, it is the educator who identifies and assesses children's demonstrated mathematical understandings during play and can articulate and plan for children's learning. The

educator provides the necessary link between play and assessment, as children's demonstrated mathematics knowledge can be complex (Vig & Sanders, 2007) and influenced by many factors, impacting on children's ways of knowing and learning.

Bronfenbrenner's (1979, 1986, 1998) ecological systems theory takes into account the whole child and relationships between systems of family, community, society, and culture that influence a child's life and their ways of knowing and learning. He suggested that between these systems, the *action* within the interactions is important, and the child's joint activity with a significant other leads to further development and learning (Bronfenbrenner, 1998; Bruner, 1990, 1996; Rogoff, 1998). This suggests that assessment is dynamic and active and not a static test or situation that exists separately from the child's social and cultural understandings of and interactions with their world. In this light, it is beneficial for children's learning outcomes when educators are actively engaged in assessment tasks and take part in the dynamic process (Davis & SRSG, 2015). The following section (2.5) focuses our attention on educators' beliefs about mathematics in early childhood education and how beliefs about mathematics can influence assessment, teaching, curriculum planning and young children's beliefs about their own mathematics abilities.

2.5 Educator Beliefs About Mathematics in ECEC

Educator beliefs may be described as the views and understandings of their world that are thought to be true. Philipp (2007) wrote, "Beliefs might be thought of as lenses that could affect one's view of some aspect of the world or as dispositions toward action" (p. 259). From a broad perspective, educator beliefs about their teaching abilities and beliefs about what is appropriate to teach in early childhood education can impact what is included in daily practice in the early childhood setting. Educator beliefs about the appropriateness of teaching mathematical concepts and language in early childhood programs and further, beliefs about their ability to teach mathematics have had an impact on the inclusion of mathematics in early childhood curricula (Ginsburg & Golbeck, 2004; Hachey, 2013a; Lake & Kelly, 2014; Lee & Ginsburg, 2007, 2009). Planning for children's mathematics learning has been limited by beliefs that mathematics in early childhood should focus on number knowledge, rote counting, pattern, and shape (Clements & Sarama, 2014). This influences what early childhood

educators observe and assess as evidence of children's mathematics knowledge. Traditional beliefs about what constitutes mathematics curricula in early childhood education have contributed toward limited understandings of children's demonstrated mathematics learning.

However, recent research has demonstrated a much broader understanding of how young children learn mathematics (Davis & SRSG, 2015; Miller et al., 2016; Moss et al., 2015; Uttal & Sheehan, 2014; Verdine et al., 2014, 2016; Weckbacher & Okamoto, 2015). This makes it necessary to develop strategies to recognise the many varied ways in which children demonstrate their mathematics knowledge during play (Anthony et al., 2015; Piasta et al., 2015; Pollitt et al., 2015; Ramani et al., 2014) and thus to broaden early childhood educators' recognition of the breadth of mathematics learning in early childhood education. This, however, does not address educators' beliefs about the appropriateness of explicitly teaching (and assessing) children's mathematical thinking in play-based curricula.

Educators' beliefs about mathematics are important to consider, as these beliefs can inadvertently lead to "task-avoidant" (Pakarinen et al., 2011, p. 377) behaviours, which in turn may influence the beliefs of the children they teach (Connor & Neal, 2014). Educators' task-avoidant behaviours can reinforce negative beliefs about their ability to teach mathematics, by avoiding opportunities to include mathematics in program planning, educators miss the opportunity to build on their mathematics teaching practice and skills. Educators' task-avoidant behaviours can also impact the quality and quantity of mathematics content knowledge included in practice and curriculum planning (Maloney & Beilock, 2012). The following sections (2.5.1, 2.5.2 and 2.5.3) discuss the influence of educators' beliefs about mathematics on early childhood education in detail.

2.5.1 Beliefs About Mathematics Education, Training, and Skills

It has been established that educators' personal beliefs about their own mathematics education and abilities impact the inclusion of mathematics in early childhood curricula (Elkind, 1998; Lee & Ginsburg, 2009). Indeed, Lake and Kelly (2014) argued that educators' preconceived beliefs about mathematics, rather than their content knowledge, are likely to frame how educators behave toward mathematics tasks.

Similarly, Maloney and Beilock (2012) believed that training in mathematics alone will not address the link between anxiety about the subject and low performance, suggesting it is necessary to reduce the anxiety first to support improved performance outcomes. These outcomes are congruent with a body of research that supports the argument that it is necessary to address the anxiety affecting educators' behaviour toward the teaching of the subject, as well as focus on training and the acquisition of mathematics content knowledge (Ashcraft, 2002; Beilock, 2010; Beilock & Carr, 2005; Beilock & Maloney, 2015; DeStefano & LeFevre, 2004; Maloney & Beilock, 2012; Ramirez, Gunderson, Levine, & Beilock, 2013).

Research has indicated there are many ways to support a positive approach to the inclusion and teaching of mathematics (Ashcraft, 2002; Bursal & Paznokas, 2006; Mattarella-Micke, Mateo, Kozak, Foster, & Beilock, 2011). These include supporting educators to recognise, name, and understand the mathematics they are already achieving in daily practice. In early childhood education, it is therefore necessary to provide educators with support when identifying and addressing their beliefs about mathematics (Geist, 2010). It appears that addressing mathematics anxiety has the capacity, therefore, to shift educator beliefs about their ability to teach mathematics; investigating this was one of the aims of this study.

2.5.2 How Beliefs About Mathematics Influence Teaching Practice

Educator beliefs about mathematics influence levels of anxiety (Hachey, 2013a). Anxiety has a direct impact on the cognitive functions necessary to perform mathematics tasks (Ashcraft, 2002; Beilock, 2010; Mattarella-Micke et al., 2011; Ramirez et al., 2013). Anxiety can affect cognitive functions closely related to working memory, which is important when processing information relevant to the task at hand and particularly important for the completion of mathematicss tasks (Beilock & Maloney, 2015; Maloney & Beilock, 2012; Yu, 2015). Research further supports links between the processing of negative emotions and numerical computations in areas of the brain known to support working memory and mathematical processing (Young, Wu, & Menon, 2012). This is significant as educators' negative beliefs about their own mathematics competencies can lead to feelings of anxiety, and the physiological responses that occur because of this anxiety can determine learning outcomes (Mattarella-Micke et al., 2011). Therefore, educators' beliefs about mathematics alone

may impact the cognitive functions necessary to reason mathematically, impacting further on the educator's ability to teach mathematics (Anders & Rossbach, 2015; McCray & Chen, 2012). Research has suggested that a solution to reduce the impacts of anxiety on working memory is to use a combination of concrete materials to support conceptual understandings, which together reduce the effect of negative beliefs on an individual's capacity to reason mathematically by reducing strain on the working memory (Bursal & Paznokas, 2006; Lyons & Beilock, 2012a; Vinson, 2001). Addressing the effects of anxiety and negative beliefs about mathematics is important, as beliefs about our capacity to reason mathematically are formed in childhood, and once formed, these beliefs are not easily changed (Anders & Rossbach, 2015).

2.5.3 Influences on Children's Beliefs About Mathematics

Personal beliefs about mathematics are established at a young age and often associated with recollections of negative experiences at school (Dickerson & Kemeny, 2004; Jackson & Leffingwell, 1999; Lyons & Beilock, 2012b). In 1996, Richardson described three major factors impacting teacher beliefs about mathematics, which are still applicable today, namely, personal experience, experience of mathematics at school, and experience of the teachers' didactic methods of teaching formal knowledge. As adults, beliefs and attitudes are set because of prior experiences (Geist, 2010; Mayers, 1994), and negative beliefs about mathematics can be steadfast and difficult to change (Anders & Rossbach, 2015).

In fact, research has suggested that negative beliefs about mathematics can emerge at a very young age, even prior to entering primary school (Arnold, Fisher, Doctoroff, & Dobbs, 2002). The behaviours educators inadvertently display toward teaching mathematics can influence children's emerging beliefs about their own capabilities (Anders & Rossbach, 2015). Educators' negative beliefs about their own mathematics abilities can also lead to anxiety developing in the children they teach. There is a direct link between educators' anxiety about teaching mathematics and children's mathematics achievement (Lake & Kelly, 2014). This is significant because educators' beliefs about mathematics and their attitudes toward teaching the subject can impact children's beliefs about their own mathematics ability from a young age (Geist, 2010; Hadley & Dorward, 2011), perpetuating a negative cycle of beliefs, which for

very young children are founded *not* on mathematics, but on the beliefs about mathematics demonstrated by the adults around them.

Research now indicates that there are persistent links between the development of children's early mathematics skills and later mathematics achievement (Campbell, Ramey, Pungello, Sparling, & Miller-Johnson, 2010; Duncan et al., 2007; Maloney, Risko, Ansari, & Fugelsang, 2010; Maloney, Ansari, & Fugelsang, 2011; Tyler et al., 2016). This is important as the implications suggest that addressing educators' negative beliefs about the subject can have a positive influence on children's emergent beliefs about their own mathematics skills and competencies (Beilock, 2010; Scarpello, 2007). Therefore, shifting educator beliefs can support children's positive experiences of and approach toward the learning of mathematics. As spatial reasoning and geometry are not typically associated with traditional perceptions of mathematics, a focus on professional learning in this area provides a way to indirectly address educators' negative beliefs about mathematics. Professional learning and mentoring for early childhood educators in the field is necessary to address negative beliefs about mathematics in early childhood education, and a focus on spatial reasoning and geometry provides a way forward. The contribution of professional learning based on spatial reasoning and geometry toward educator training is discussed further in section 2.6.

2.6 Professional Learning

The need for a focus on spatial reasoning as a core component of early childhood mathematics methods classes in initial teacher education has been addressed. For practitioners already in the field, there is a need for professional learning to address this gap. Moss and colleagues (2016) referred to geometry and spatial reasoning as "a neglected priority in early-years mathematics" (p. 378), highlighting a lack of educator preparation and content knowledge as significant contributing factors to why this subject area continues to be neglected today. Approaches to early childhood mathematics also highlight a lack of educator training in the areas of spatial reasoning and geometry (Cannon et al., 2008; Ginsburg, Cannon, Eisenband, & Pappas, 2006). This may lead to a lack of educator confidence and uncertainty in teaching mathematics in early childhood programs, which can lead to mathematics being assigned a lower priority in planning early childhood curricula (Ginsburg et al., 2014). Often,

mathematics content can be too broad or perceived as being too academic to inform everyday teaching practices (Siemon et al., 2012). This means that if educators are unsure of how to teach mathematics, and further, unsure of what mathematics to teach, children may not receive ongoing support for learning and development in this area (Ramirez et al., 2013).

Many early childhood programs are specifically designed to predominantly follow the interests of the child. This may create gaps in children's mathematics learning (Ginsburg, Lee, & Boyd, 2008; Klibanoff et al., 2006; National Association for the Education of Young Children [NAEYC], 2010). Educators are trained to follow children's interests and link these interests to their ongoing learning needs. However, research has suggested that educators are not receiving appropriate training to identify the mathematics occurring in children's play (Engel, Claessens, & Finch, 2013; Engel, Claessens, Watts, & Farkas, 2016; Martinez, 2017; Sarama, 2002; Vendlinski, Hemberg, Mundy, & Phelan, 2009). If children's interest in mathematics remains undetected, gaps in their learning are likely to result. This becomes increasingly evident in primary school where these gaps—if unaddressed—widen (Epstein, 2007; Jordan, Glutting, & Ramineni, 2010). There is a need for contingent strengths-based professional learning, which is based on evidence of what educators know about mathematics in early childhood and are ready to learn next. This can prove problematic, as educators who have negative beliefs and are not confident about their mathematics abilities are likely to avoid professional learning in this area. Interestingly, spatial reasoning and geometry is not typically associated with perceptions of mathematics teaching and learning (Moss et al., 2016); therefore, professional learning for educators which focuses on spatial reasoning and geometry may, in fact, support shifts in negative beliefs about their mathematics capabilities without necessarily 'doing mathematics'. Negative beliefs about mathematics might arise from a narrow conception of what the discipline is. This includes ideas or misconceptions that mathematics predominantly focuses on counting and calculations (Verdine, Golinkoff, Hirsh-Pasek & Newcombe, 2013). For example, even in geometry, young children might be expected to 'count' the number of sides of triangles and rectangles. A higher profile of spatial reasoning and geometry, one which encourages children to focus on the attributes of shapes, might

broaden educators' conceptions of the nature of mathematics, and lead to the development of positive beliefs about the subject (Boaler, 2016).

2.7 Summary

It has been established that there is a need for further research into spatial reasoning and geometry, and teaching practices that align with play-based philosophies of mathematics learning in early childhood education. Professional learning is necessary to provide support for educators when observing, assessing, and planning for spatial reasoning and geometry in early childhood education. Professional learning and mentoring are also necessary to support educators in bridging the gap between negative beliefs about mathematics and the potential for mathematics to form part of everyday teaching practice in play-based programs. The literature also indicates that educator beliefs about mathematics have a significant impact on the quantity and quality of mathematics included in early childhood curriculum. Extant research had indicated that a focus on the assessment of spatial reasoning and geometry could support children's future mathematics learning, by focusing educator attention on what to assess and how to assess these concepts in play-based settings. Assessing children's competencies in this area is important because spatial reasoning and geometry are fundamental to all mathematics learning and children's future learning outcomes (Arbaugh et al., 2010; Clements & Sarama, 2017; Davis & SRSG, 2015; Farmer et al., 2013; Moss et al., 2016; Ramani et al., 2014).

Despite evidence that spatial reasoning underpins children's ability to grasp mathematical concepts (Davis & SRSG, 2015; Moss et al., 2016; Uttal & Sheehan, 2014), little is known about children's spatial reasoning skills, how formative assessment of these skills informs teaching practice, and how assessment outcomes can inform planning for learning in early childhood (Diezmann & Watters, 2000; Ramani et al., 2014; Verdine, Golinkoff, Hirsh-Pasek, & Newcombe, 2016). Existing gaps in the research literature highlight the need to address spatial reasoning and geometry assessment strategies that align with play-based programs. As children naturally explore these concepts during play and everyday activities, this area of mathematics can be readily investigated in early childhood programs.

This study thus addressed the gaps in the literature by investigating the impacts of the implementation of a suite of play-based mathematics assessment activities on teaching practice and educator beliefs about mathematics in early childhood education. The implementation was designed to reveal the spatial reasoning and geometric thinking embedded in children's play, providing educators with an important starting point for the identification and assessment of and planning for these mathematical concepts in practice. This study was designed with a view to addressing the gaps identified in the literature. In Chapter 3, the conceptual framework and methodological approaches informing each phase of the research design are explained in detail.

CHAPTER 3: RESEARCH DESIGN

3.1 Introduction

This chapter explains the conceptual design for the research plan. Included in this chapter is a discussion about the significance of the methodological approaches informing the research and why these approaches were chosen.

First, a discussion and summary of the key constructs of the research questions are necessary to understand the significance of the conceptual design. After reviewing the research questions, the theoretical rationale and methodologies employed are discussed.

3.2 Research Questions and Research Plan

This implementation study examined the effects of the targeted enactment of a suite of play-based spatial reasoning and geometry assessment activities on teaching practice, curriculum planning, and beliefs about mathematics in early childhood programs in Melbourne. Two research questions were investigated:

1. How did the implementation of a suite of assessment activities impact early childhood teaching practices, including observations, assessment, and curriculum planning?
2. How did the implementation affect educator beliefs regarding mathematics education in their early childhood programs?

To answer the research questions, the study was conducted in two phases. Phase 1 included the pilot survey, the trial of the assessment activities, the administration of the study survey, and outcomes. The outcomes of Phase 1 informed the design of Phase 2 of the research plan (see Table 1). This consisted of Workshop 1, the implementation phase, a repeat of the study survey, the semistructured interviews, and Workshop 2. Phase 1 participants for the pilot survey, study survey, and trial were different and were recruited separately. Phase 2 participants were from the initial recruitment for the study survey and implementation.

Table 1

Phase 1 Outcomes Informed Phase 2 of the Research Plan

Research Plan					
Phase 1	Pilot survey *n* = 38	Study survey 1 *n* = 34	Trial *n* = 3		
Phase 2	Workshop *n* = 27	Implementation *n* = 27	Study survey 2 *n* = 16	Interviews *n* = 13	Workshop *n* = 13

3.3 Theoretical Perspectives

The theoretical underpinning of this research closely aligns with a social constructivist approach (Vygotsky, 1978; Wood, 1998). A social constructivist approach examines how individuals create knowledge, or come to understand knowledge, through social interactions and experiences of the world around them (Schwandt, 2003; Taber, 2011; Young & Collin, 2004). The underlying assumption is that individuals construct knowledge in relation to their experiences, interactions with others, and understandings of the world. These understandings of the world are socially mediated, influence, and can be influenced by multiple belief systems. This assumption aligns with the theory that realities are socially constructed (Merriam, 2009) and further, that realities are informed by "lived experiences" (Guba & Lincoln, 2005, p. 196), meaning that our knowledge and beliefs are malleable and shaped through our experiences and interactions with others. Therefore, in the context of this research, constructivism adopted an epistemological perspective as it focused on how knowledge is constructed and understood. This perspective also recognises multiple ways to interpret a reality, question, or issue, as individuals are made up of complex knowledge systems based on truths, beliefs, and justifications that are closely linked to their experiences and history (Creswell, 2012).

Integral to the study were the social situations and cultural contexts in which the implementation took place, as the collective beliefs and "culture" of mathematics within early childhood settings have the potential to influence individual approaches toward the implementation and subsequent outcomes. This is perhaps better explained in reference to Bronfenbrenner's (1979) ecological systems theory, which demonstrates

how society, culture, and beliefs can influence the choices individuals make, consciously or otherwise (in this instance), about mathematics in early childhood, and how these perspectives have the potential to inform the enactment of the implementation in their setting.

A constructivist approach was important to consider, as this research project would examine the impact of an implementation of spatial reasoning and geometry assessment activities on teaching practice and beliefs about mathematics in early childhood education. The assessment activities were specifically designed as small-group experiences, supporting opportunities for peer scaffolding and assessment for learning, whereby the educator could contribute to processes of meaning making with children. Constructivism was useful when examining how the enactment of the implementation would impact educators' dispositions toward mathematics in early childhood, based on the meaning and beliefs participants attributed toward mathematics in their practice and programs.

Through the enactment and "lived experience" (Durlak, 2010, p. 12) of the intervention, it was believed that the links between theory and practice would be of potential benefit to educators, having a positive impact on educator beliefs about mathematics assessment, practice, and pedagogy in play-based curriculums (Clements & Sarama, 2011). In short, it was hypothesised that the very act of participating in the implementation would lead to meaningful change for the educators involved in the study. The following section now turns to focus on the methodologies and rationale underpinning the study.

3.4 Methodological Approaches and Rationale

This section discusses the research methodologies, why they were adopted, and the important role these methodologies played in facilitating the research outcomes. This implementation research adopted a mixed methods approach to collect data, which was analysed using thematic and statistical analysis.

3.4.1 Mixed Methods Research

Mixed methods research is widely used in education research as it is a useful way to gather a broad range of perspectives on a topic. It combines qualitative and quantitative methods to facilitate the study of the complexities of human behaviour,

while gaining breadth and depth of understanding in the research (Burke-Johnson, Onwuegbuzie, & Turner, 2007). Qualitative research can be described as investigating the meaning groups or individuals attribute to social or human problems (Creswell, 2009; Kincheloe, & McLaren, 2018). Quantitative research can be described as gathering numerical data for systematic empirical investigation across groups of people to test and replicate a hypothesis (Blaikie, 2010). The challenge lies in determining which methods are most appropriate for the research, how best to collect the data, the status afforded the qualitative and quantitative data, how the data is combined, and if equal attention is given to both data sources (Almalki, 2016). When combined, quantitative and qualitative data can contribute depth to the analysis by providing further insights into participant views and, therefore, a holistic view of the research outcomes (Creswell, 2012; Goodwin & Goodwin, 1996).

A mixed method approach was appropriate in this study as cross-sectional data were generated from multiple sources over time. Quantitative data from the surveys and assessment records and qualitative data from the surveys, assessment records, and semistructured interviews were collected. In this study, most data were qualitative; however, both datasets were given equal attention. When points of intersection between the qualitative and quantitative datasets were identified, the outcomes played a significant role in responding to the research questions (see Section 4.4). This helped to capture the complexity, breadth, and depth of participant responses and played a significant role when cross-referencing self-reported outcomes (Cohen, Manion, & Morrison, 2013; Creswell, 2012; Hatch, 2002; Miles, Huberman, & Saldana, 2014; Stake, 2010).

3.4.2 Implementation Research

Implementation research is "the study of methods to promote the uptake of research findings into routine practice" (Bhattacharyya, Reeves, & Zwarenstein, 2009, p. 491). Implementation research suited the purpose of this study as the interventions were specifically designed to support the uptake and enactment of recent research findings about early childhood mathematics and assessment into routine practice (Derzon, Sale, Springer, & Brounstein, 2005; Durlak & Dupre, 2008). Examples of how implementation research has been applied demonstrate the benefits of enacting research in practice (Clarke, Clarke, & Roche, 2011; Cohrssen, Tayler, & Cloney, 2015). The

purpose of this study was to assess the effects of a targeted intervention—the workshop followed by the enactment of the mathematics assessment activities—on teaching practice and educator beliefs and to determine the extent to which these effects informed routine teaching practices and planning for children's ongoing mathematics learning.

It was first necessary to determine educators' existing knowledge about early childhood mathematics and how this knowledge was being embedded in practice. It was also necessary to understand if educator beliefs about mathematics in early childhood were impacting the inclusion of mathematics in their curricula. To understand educators' knowledge and beliefs about mathematics, a survey was conducted to gather information and gain insights into these areas of inquiry. Surveys are recommended as a research tool to elicit information from individuals that can provide a valuable combination of qualitative and quantitative data (Dillman, 2006; MacNaughton, Siraj-Blatchford, & Rolfe, 2010). The outcomes from the pre-implementation study survey provided evidence of participant knowledge and beliefs about mathematics and how these determined the enactment of mathematics in practice. This evidence informed the design of the intervention to promote the uptake of the assessment activities in practice. The surveys and contribution of survey data to the design of the implementation study is discussed further in Section 3.4.5.1.

Sustaining participant engagement in implementation research is not without its challenges. The implementation variability may range from rigorous to no actual implementation at all, affecting the validity of the study if left unmonitored (Durlak, 2010; Odom et al., 2010). Many factors may influence the implementation process from educator beliefs through to changes in life circumstances (Kelly & Perkins, 2012). It was therefore necessary to have strategies to monitor how these factors influenced the implementation process to support consistency and fidelity across participants over time (Dunst, Trivette, & Raab, 2013; Dusenbury, Brannigan, Hansen, Walsh, & Falco, 2005; Smith, Daunic, & Taylor, 2007).

Six characteristics of effective implementation were monitored during this study, namely, fidelity, dosage, quality, participant responsiveness (engagement or involvement and reported impacts on each), program reach, and adaptations (Durlak,

2010). These characteristics provided an effective way to monitor the implementation phase, compare data outcomes across the implementation continuum, and ensure the outcomes were robust. By monitoring the implementation of the assessment activities *as they were implemented,* feedback to participants regarding the fidelity of their implementation could be provided. It became apparent that while monitoring the fidelity of the implementation, this feedback became a form of coaching and the monitoring and coaching process supported implementation rigor (see Section 8.7.3). The implementation process, therefore, was as important as the outcomes (Dunst et al., 2013).

3.4.3 Self-Reported Data

A common methodology in education research is the use of self-reported instruments to gather data (Cohen et al., 2013). Self-reported data are based on the opinions and beliefs of participants and can capture important information about the research as it is enacted. Self-reported data are an important source of implementation information; however, the information can be variable (Creswell, 2013). This highlights the importance of incorporating methods within the research design to validate the reliability of the outcomes (Chan, 2008). One such method is triangulating the data by cross-referencing a range of data sources to validate outcomes (Almalki, 2016; Creswell, 2013). Outcomes are verified by comparing findings across data sets, a method that can increase reliability and confidence in the research outcomes (Cohen et al., 2013) (see Section 4.3.7). In this study, self-reported data included participants' opinions and beliefs about teaching and assessing mathematics in early childhood education (McCray & Chen, 2012).

3.4.4 Thematic Analysis

Thematic analysis is commonly used in mixed methods research and has been described as a flexible research method as it focuses on the data and is not bound to a methodology, epistemology, or specific theoretical perspective (Braun & Clarke, 2012, 2013). Thematic analysis is a systematic research approach for identifying and interpreting "themes" in qualitative and quantitative data to further understand the meanings inherent in the data (Terry, Hayfield, Clarke, & Braun, 2017). This deductive research process provides a way to compare qualitative and quantitative outcomes, and

analyse and interpret meaning from a range of data within the same study (Terry et al., 2017).

Thematic analysis highlighted the intersection of qualitative and quantitative data and supported the identification of related themes within each data set (Braun, Clarke, & Terry, 2014). To ensure data were relevant to the study (Schreier, 2014), it was necessary to align the themes with the four key areas of inquiry: (1) assessment, (2) planning, (3) teaching practice, and (4) educator beliefs (see Appendix 17, "Thematic Analysis"). These outcomes were compared across data sets and informed the identification of themes relating to Research Questions 1 and 2 (Greene, Caracelli, & Graham, 1989; Hatch, 1995).

3.4.5 Systematic Observation of Intervention

The research plan incorporated a range of instruments designed to monitor the implementation of the play-based assessment activities. These included assessment records, surveys, and semistructured interviews. The outcomes of each instrument were analysed and informed the design of the next. Each instrument is discussed below, in Sections 3.4.5.1, 3.4.5.2, and 3.4.5.3, focusing on the theoretical perspectives and rationale for its inclusion in the study.

3.4.5.1 Surveys

Surveys elicit information about the beliefs, characteristics, and opinions of a population and can capture the complexities of human behaviour (Cohen et al., 2013). The survey developed for this project was based on items drawn from the Teachers' Sense of Efficacy Scale (Tschannen-Moran & Hoy, 2001), the Teacher Beliefs Scale (Rosenfeld, 2010), and the Mathematical Development Beliefs Survey (Platas, 2014). These instruments were developed with educators and have been regularly accepted for research purposes as reliability and validity meet the recommended social science standards (Tschannen-Moran & Hoy, 2001). Items relevant to an early childhood context were chosen to gain insights into educator beliefs about mathematics and their ability to teach it in the context of an informal early childhood curriculum.

The study survey was informed by the pilot survey outcomes and included a combination of closed and open questions, generating quantitative and qualitative data (Nolan, McFarlane, & Cartmel, 2013; Nueman, 2007). The study survey was cross-

sectional by design, collecting data from each participant at fixed points to capture a snapshot of their beliefs and practices (Ruspini, 2002). The pre-implementation study survey informed the design of the assessment activities and workshops. In addition, the survey outcomes provided a measure of change between the pre- and post-implementation research phases (Cohen et al., 2013; Creswell, 2013).

3.4.5.2 Play-based mathematics assessment activities and records

Central to the research methodology was the implementation of six play-based mathematics assessment activities with a core focus on spatial reasoning and geometry. Each play-based activity included an assessment record that also served as a participation record. Drawing on the theoretical perspectives underpinning the spatial reasoning and geometry activities designed by Moss and colleagues (2016), the assessment activities were modified to reflect an early childhood play-based assessment context (see Appendix 1, "Guideline to the Assessment Activities").

As outlined in Figure 1, the activities adapted for this study included the three key areas of spatial reasoning and geometry identified by research as forming the foundations of young children's later mathematical understandings (Uttal et al., 2013). These were shape, spatial orientation, and spatial visualisation or imagery (Clements & Sarama, 2014; Davis & SRSG, 2015; Moss et al., 2016; Uttal & Sheehan, 2014). Implementing six mathematics assessment activities across a four-month period was intended to provide educators with a focus on fewer, yet more specific, mathematical concepts to explore in depth and further support understandings of these key mathematical concepts and assessment strategies. In addition, the intention was to increase educator confidence and the uptake of new skills in practice (Common Core State Standards Initiative, n.d.).

The key areas of spatial reasoning and geometry informing the content of the play-based assessment activities were 2D and 3D shape composition and decomposition, symmetry, pattern, positional and directional language, mapping, coding, spatial awareness, and working memory.

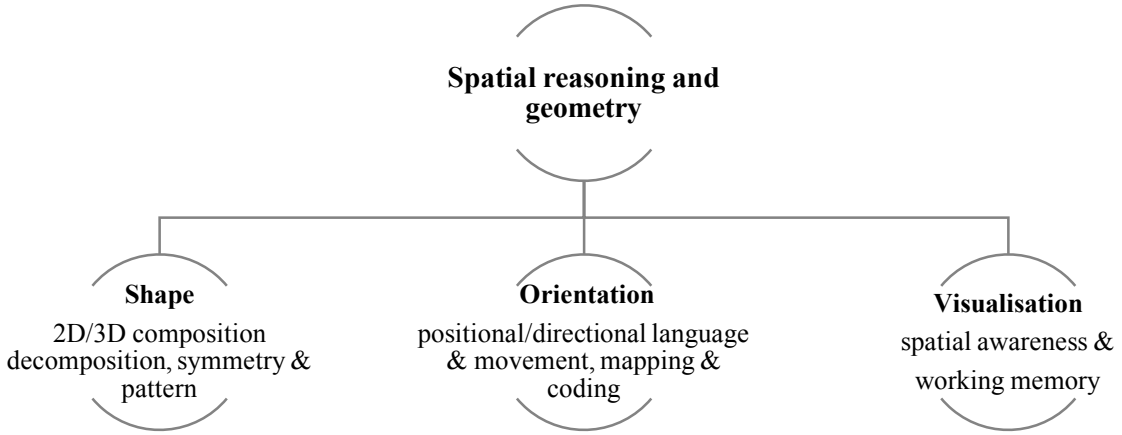


Figure 1. Three key areas of spatial reasoning and geometry.

The assessment activities were designed to reveal the spatial reasoning and geometric thinking embedded in children's play to support educators in identifying, assessing, and planning for children's ongoing mathematics learning (Clements & Sarama, 2017; Moss et al., 2016; Perry et al., 2012).

The assessment activities, guidelines, and records were aligned with the familiar stages of the Early Years Planning Cycle (DEEWR, 2015) to provide educators with practical links between the research materials and their observations, analysis, and planning for children's learning (see Chapter 5). The play-based assessment activities were designed to make children's mathematical thinking visible, identifiable, and therefore assessable in daily practice (Hattie & Yates, 2014; Moss et al., 2016; Rosenfeld, 2010; Whiteley & Mamolo, 2014).

The assessment activities, guidelines, and records were informed by co-constructivist theories of learning (Vygotsky, 1978) to engage educators, children, and their peers in small-group assessment contexts. This was with a view to supporting joint problem-solving skills and peer discussion to achieve a common goal (Ramani et al., 2014). The activities, therefore, encouraged a "hands-on" approach to assessment in the play-based context for both educator and child. The formative assessment strategies were both play based and open ended, designed to assess the upper levels of children's existing mathematics knowledge and provide educators with evidence for planning, scaffolding, and extending learning. Traditionally, mathematics assessment is perceived as occurring in "test" situations as a standalone, summative task (Fleer & Quiñones,

2013). Therefore, it was important for the assessment activities to be repeatable, formative, and part of children's play, as development in early childhood is typically rapid and requires ongoing assessment (DEEWR, 2009). The assessment records listed specific mathematical concepts for educators to look and listen for, name, discuss, and document during the assessment process to support contingent planning for learning. The assessment records also served as a participant record, tracking educators' use of the activities, outcomes, and planning.

3.4.5.3 Semistructured interviews

Interviews provide an opportunity to meet with participants, discuss questions on a one-to-one basis, and take into consideration verbal and nonverbal communication (Nolan et al., 2013). This adds meaning to self-reported data, by obtaining the participant's personal views and voice (Creswell, 2012). Interviews are often used in qualitative research to obtain additional information and clarify content in the data by providing further opportunities to investigate and discover information that is otherwise unknown (Creswell, 2013; Wellington, 2000). The semistructured interview questions were formulated toward the end of the study and addressed gaps in the data set relating to educator beliefs and their subsequent impact on the implementation. The conversational nature of the semistructured interviews provided an opportunity for participants to discuss their experiences of the research project and their beliefs about mathematics, spatial reasoning, and geometry in early childhood education. The interviews also provided opportunities for participants to expand on their contributions to the research project and clarify meaning.

3.4.6 Workshops and Enacting New Knowledge in Practice

Workshops in education provide a way to introduce new ideas to practitioners and are an opportunity to provide guidance for professionals when learning how to enact new knowledge and skills in practice (Bobis et al., 2012; Bobis, Papic, & Mulligan, 2009; Brown & Inglis, 2013; Bruns et al., 2017; Ginsburg et al., 2014; Piasta et al., 2015; Sarama, 2002; Vendlinski et al., 2009).

The workshop for this study provided a way to scaffold and extend participants' existing knowledge in a supportive environment among peers. The design of the workshop responded to the survey outcomes, which indicated that a large percentage of

educators held negative beliefs about their own mathematics ability and the teaching of mathematics in early childhood education. The survey outcomes also indicated a gap between assessment and evidence-based planning for children's mathematics learning in teaching practice (Appendix 2, "Trial and Survey Outcomes Inform Workshop Design"). Survey outcomes indicated further that at times, participants were unaware of the mathematics they were already enacting in practice. Research has demonstrated that increasing educator awareness of the mathematics they are already enacting in practice can make a difference to educator confidence and the inclusion of mathematics in teaching practice (Brown, 2005; Brown & Inglis, 2013; Ketelaar, Koopman, Brok, Beijaard, & Boshuizen, 2014). Starting with existing knowledge supported participants' sense of comfort and thus encouraged participation and the uptake of new ideas in practice (Bailey et al., 2016).

Research suggests that the provision of opportunities to support children's mathematics learning impacts long-term learning outcomes and further, that the provision of these opportunities relies on educators' specific understandings of mathematics content knowledge (Bailey et al., 2016; Brown & Inglis, 2013; Piasta et al., 2015). Research also indicates that both teacher beliefs and existing mathematics content knowledge need to be considered when addressing change in this area (Zhang & Wong, 2015). Therefore, the workshop design was sensitive toward participant beliefs about mathematics in early childhood education and existing content knowledge, both of which were considered in the workshop content and structure. The workshop introduction was based on spatial reasoning and geometry concepts identified in the survey outcomes as familiar to participants and currently being enacted in practice, for example, shape composition and decomposition, symmetry and pattern. The workshop gradually progressed toward lesser known mathematics content knowledge, such as visualisation, spatial language, and coding. Participants were also provided with a guidelines booklet (see Appendix 1, "Guideline to the Assessment Activities") to support the enactment of the activities in practice.

Purposefully incorporating a focus on observations, assessment, and strategies to enact the implementation of the assessment activities informed the design of the workshop and was critical to support the uptake of the activities in practice. It is well documented that when educators experience difficulties in practice, existing beliefs and

a strong will can help to overcome challenges and strengthen their practice (Chen, McCray, Adams, & Leow, 2014; Wen & Leu, 2004); therefore, it was important for the workshops to draw educators' attention to the benefits of the assessment activities in contributing to participants' capacity to observe, assess, and plan for children's mathematics learning, and by implication, support children's mathematics learning outcomes.

The workshop format also provided an opportunity for participants to enact and rehearse the materials in a supportive learning environment (see Appendix 3, "Workshop Presentation"). This was with the intention of providing resources and support for participants when implementing new ideas in practice. In addition, the workshop ensured the activities were familiar to participants, related to play-based practices, and could be integrated into their existing programs. In summary, the workshops were designed to build on participants' agency and confidence as well as their current content knowledge and understandings about mathematics assessment in early childhood (Bailey et al., 2016).

3.5 Summary

Chapter 3 discussed the research design, theoretical rationale, and methodologies informing this study. Monitoring of the implementation of the study through systematic observation was discussed, and it was noted that feedback from the researcher became a form of coaching which supported the implementation rigour. The theoretical rationale underpinning the instruments for data collection was explained. The outcomes of one instrument were analysed and used to inform the design of the next, thus ensuring the research design was responsive to participant beliefs about mathematics in early childhood and their mathematics teaching capabilities. The workshop was designed to provide participants with opportunities to rehearse and discuss the enactment of the assessment activities among peers, prior to enacting the implementation in their early childhood programs. This was with the view to building on participants' existing mathematics content knowledge, agency, and efficacy when assessing children's mathematics knowledge in play-based programs. Our focus now turns to Chapter 4, which describes the study participants and the instruments used for data collection and analysis.

CHAPTER 4: METHOD

4.1 Introduction

This chapter includes a description of the participant selection process and the key instruments used for data collection: the surveys, assessment records, and the semistructured interviews. University ethics approval was obtained prior to the commencement of the study (see Appendix 22 for the Ethics approval letter, Appendices 8 & 10 for the plain language statements and Appendices 9 & 11 for the consent forms). The instruments used for data collection align with the theoretical underpinning of the research to examine how individuals create knowledge, based on their experiences and interactions with others, their understandings of the world and how these understandings can be influenced by multiple belief systems (Creswell, 2012).

There were two main phases of data collection. Phase 1 of the data collection included a pilot survey to test face validity of items. A trial of the mathematics assessment activities (and associated assessment records) was conducted to determine if the instruments worked in a play-based context and generated data relevant to answering the research questions. Phase 1 included the pilot survey, trial of the assessment activities, and administration of the study survey. Phase 1 data analysis and outcomes informed the design of Phase 2 of the research.

Phase 2 of the study took place during Term 3 and Term 4 of the Victorian school year, spanning a total of four months. Participants completed a survey (trialled in Phase 1 and subsequently refined) before attending a workshop specifically designed to introduce the assessment activities and to demonstrate how play can be the vehicle for mathematics teaching and learning. Thereafter, the implementation of six assessment activities took place over the course of four months. At the end of the four-month implementation phase, participants were required to repeat the survey to provide evidence of change in knowledge and beliefs over time. Finally, semistructured interviews took place prior to a group workshop at which participants were afforded an opportunity to provide further feedback and to share their experience in using the assessment activities—challenges and successes—with their peers. Figure 2 outlines the study design and timeline for each phase of the research.

Study design and timeline 2016											
	Month	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Phase 1	Recruitment										
	Pilot survey										
	Trial activities										
Phase 2	Study survey										
	Workshop										
	Implementation										
	Survey repeat										
	Interview										
	Workshop										

Figure 2. Study design and timeline.

4.2 Phase 1

The University of Melbourne has six "networks" of ECEC settings located within a 24-kilometre radius of the city centre (see Figure 3: Geographic context of the University of Melbourne Teaching "networks"). These networks comprise 342 ECEC settings that meet the National Quality Standard (ACECQA, n.d.). Each centre in each network was emailed an invitation to participate in a pilot study that would trial an educator survey focusing on teacher beliefs and mathematics teaching practice. The purpose of trialling the survey was to refine the items and test the face validity of the questions asked. Seventy-five responses were received from six centres.

Following the receipt of email responses, follow-up visits to centres were made to distribute surveys and "post boxes" for the anonymous submission of survey responses.

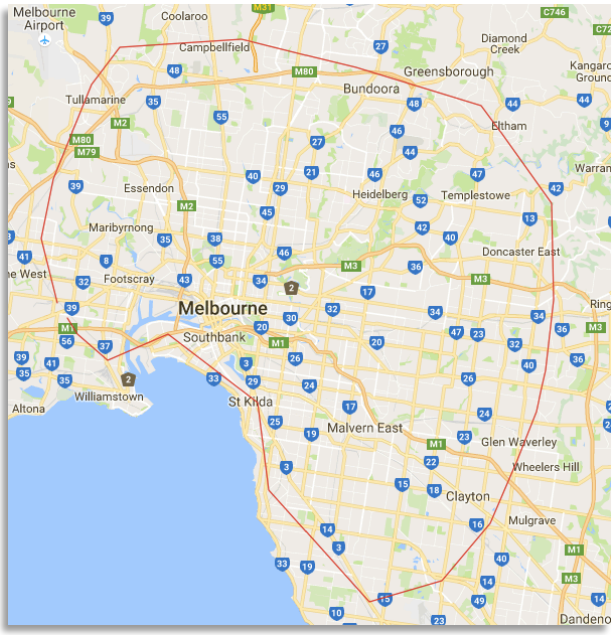


Figure 3. Geographic context of the University of Melbourne teaching "networks".

4.2.1 Participant Selection Criteria

During Phase 1 of the study, the pilot survey and the assessment activities (and the associated assessment records) were trialled to refine the instruments prior to their application in Phase 2—the main implementation phase—of this study.

Selection criteria to participate in Phase 1 of the study differed for the two instruments that were trialled. Phase 1 of the study is described below.

4.2.2 Pilot Survey

Emails explaining the pilot study were sent to all 342 centres in the University of Melbourne networks. Six centres responded and in each instance expressed willingness to participate in the pilot study. By chance, each centre was situated within each of the University networks, thus providing a geographic spread across the greater Melbourne area.

Blank hard copies of the pilot survey were distributed to the six ECEC settings. The surveys were placed in staffrooms, along with a poster describing the purpose of the survey (see Appendix 15, "Poster for Pilot Survey") and a sealed box for posting completed surveys to protect anonymity.

Thirty-eight completed surveys were collected after 14 days. The number of participants who took part in the pilot survey and the range of participant qualifications are shown in Table 2. For further information regarding participant years of experience, see Appendix 7, "Participant Qualifications and Experience".

Table 2

Participant Qualifications

Qualification	Participants
Bachelor of Education, Primary	10
Bachelor of Education, Early Childhood	11
Certificate III, Early Childhood	6
Diploma, Early Childhood	5
Graduate Diploma, Early Childhood	1
Registered educators	1
Master's student, Early Childhood	2
Diploma student, Early Childhood	2
Total	38

4.2.3 Pilot Survey Items

The pilot survey was based on four key domains identified as important in determining if mathematics was explicitly taught in early childhood programs and why (Tschannen-Moran & Hoy, 2001). The survey domains were as follows:

1. Perceived age appropriateness of children to receive mathematics instruction;
2. Educator confidence and comfort in mathematics instruction;
3. Educator and/or child responsibility for the construction of mathematical knowledge to determine the role of the educator in play-based approaches to learning mathematics and how these roles are perceived;
4. Social and emotional development and/or mathematical development as a primary goal of early childhood.

These domains were adapted to incorporate statements relating to mathematics, geometry, and spatial reasoning assessment in early childhood, with a view to collecting data about current mathematics practices in early childhood programs. Included beneath

each domain was a subset of sample statements forming the pilot survey: "A survey study of early childhood educators' beliefs and confidence about observing, assessing and teaching maths" (see Appendix 13, "Pilot Survey").

The pilot survey served several functions. It provided an opportunity to test the survey items under trial conditions to measure the consistency of participant responses and understand the practicability of the survey in collecting the necessary data to address the research questions (Babbie, 2010; Cohen et al., 2013). The pilot investigated if the survey was a valid instrument, providing measurable outcomes that aligned with the study concepts (Hair, Black, Babin, & Anderson, 2010). Therefore, testing the efficacy of the pilot supported the reliability of the questionnaire and reduced errors in the measuring process (Platas, 2014). The pilot was valuable in highlighting how to optimise data collection to ensure the final survey would provide measurable outcomes relevant to the research questions and that the data generated from the survey were robust and clear (see Appendix 19, "Study Survey").

4.2.4 Assessment Activities

As the survey was being administered, the draft iteration of the play-based mathematics assessment activities was trialled for one week in three settings: two early learning centres and one kindergarten offering long day care. Centres approached were purposively selected due to an ongoing professional relationship with the centre directors in each setting. The selected centre directors were experienced early childhood professionals who had expressed interest in this research project, and a willingness to trial the assessment activities and provide constructive feedback on the extent to which the assessment activities aligned authentically with a play-based philosophy of teaching and learning.

Each participant was requested to trial each of the six assessment activities in any order over a one-week period. To provide structured feedback, participants in the trial enacted the assessment activities, completed the assessment records, and provided feedback during a semistructured interview. The trial of the assessment activities determined if data generated from the assessment records would adequately address the research questions.

Evidence of connections between the enactment of the assessment activities and subsequent planning were sought to determine whether the assessment activities provided participants with appropriate observation data to inform planning for learning. Frequency of implementation to assess child capabilities was calculated for each activity. In addition, feedback on the ease of enactment and the alignment of the activities with the business-as-usual programs in the rooms was sought. In response to this feedback, modifications were made to the draft activities and assessment records as follows:

- Additional space was provided in the assessment records to allow more space to write.
- Multiple copies of blank assessment records were needed as educators reported that they frequently had multiple activities running concurrently in the room.
- The small-group nature of the assessment activities was emphasised as it emerged that one educator was using the activities on a one-to-one basis, setting up a didactic approach. This was contrary to the design of the assessment activities, which were to be enacted with a small-group focus in line with a constructivist approach, which would also afford opportunities for children to observe and learn from each other.
- Examples of mathematical language, open-ended questions, and suggestions for discussions with children during the assessment process were included in the guidelines.

The trial was necessary to test the activities and concepts in everyday programs, to gain insights into the applicability of the activities in daily practice, and to determine if the activities could be enacted in daily programs during the implementation phase.

Brown and Inglis (2013) identified key attributes that influence teachers' enactment of mathematics teaching. Drawing on this research, it was thus important to seek the following information in the feedback from the trial:

1. Did participants understand the spatial reasoning concepts embedded in the assessment activities?

2. Were the activities useful for assessment and planning?

3. Did participants understand how to use play as a vehicle for learning mathematical concepts?

4. Were participants willing to transfer these ideas into practice?

The following section describes Phase 2 of the study design, and includes participant selection, the study survey, the workshops, the implementation of the assessment activities and the semistructured interviews.

4.3 Phase 2

Participants who had taken part in Phase 1 of the study were excluded from participating in Phase 2 of the study. Excluding the six centres that had already participated in Phase 1, each centre in each network was emailed an invitation to participate in the study, a total of 336 centres. Table 3 outlines the timeline for Phase 2 of the study:

Table 3

Phase 2 Study Design and Timeline 2016

Phase 2 Study Design & Timeline 2016		
June	Pre-implementation survey	*n* = 38
July	Workshop	*n* = 27
Aug–Nov	Implementation data collection (x 8)	*n* = 27
Nov	Post-implementation survey	*n* = 16
Nov	Semistructured interviews	*n* = 13
Nov	Workshop	*n* = 13

4.3.1 Participant Selection Criteria

To be eligible to participate in Phase 2 of this study, particular selection criteria were met. These included the following:

1. Teacher held a minimum qualification of a diploma in early childhood education;

2. Lead teacher in the room;

3. Used the frameworks to underpin their practice—specifically, enacting the Early Years Planning Cycle (DEEWR, 2015);
4. Completion of the pre-implementation survey;
5. Willingness to make a yearlong commitment to the project;
6. Willingness to implement the intervention (assessment activities, assessment records, submission of planning documentation);
7. Willingness to attend professional development workshops;
8. Willingness to participate in an interview.

The 336 ECEC settings that fell within the University of Melbourne's early childhood networks were sent a second email, introducing the main study (as opposed to the pilot study) and attached to the email were the plain-language statements and consent documents for centre directors and educators (see Appendix 8, "Plain Language Statement for Centre Director"; Appendix 9, "Consent Form for Centre Director"; Appendix 10, "Plain Language Statement for Educator" and Appendix 11, "Consent Form for Educator"). A week after the email, follow-up phone calls were made to centre directors to discuss the study and clarify the selection criteria. An indication of interest in taking part in the study was sought from centre directors during this discussion. Centre directors were also reminded to ask early childhood educators interested in participating in the study to call or email the researcher to clarify any questions they may have had and were prompted to return any signed consent forms via email by the end of the following week.

Thirty-four signed consent forms were received from 25 centres. The consent forms were checked to ensure each educator had met the participant criteria. Once consented, participants were emailed to thank them for participating in the study. The email included a letter of welcome, an introduction to the study outlining the key stages, and a link to the online survey, administered via SurveyMonkey (see Appendix 20, "Study Survey"). Dates for the workshops, the start and end dates of the implementation phase, and the timing of semistructured interviews and workshops were confirmed with participants and centre directors. Of the 34 participants who completed the survey, 27 participants from 15 centres continued to participate in the study.

4.3.2 Participant Qualifications and Experience

Participants included six early childhood educators, two centre directors, and 19 lead teachers. A wide range of teaching qualifications and experience—ranging from six months to 35 years—was represented in the study (see Appendix 7, "Participant Qualifications and Experience" for detailed information.)

Seventeen of the participants had 10 or more years of teaching experience, suggesting the data would be a standard representative of these qualifications and experience. Of the 27 consented participants, one withdrew during the first week, another in August, and a third in September, leaving 24 participants in total at the end of the implementation.

4.3.3 Pre-Implementation Survey

Thirty-four participants (from 25 settings) completed the pre-implementation study survey and were invited to take part in the research project. This provided for possible participant attrition (Tyler et al., 2016) as a minimum of 10 participants were required to conduct the study. Attrition during the implementation phase of the study resulted in 16 participants taking part in the post-implementation survey.

While 34 participants completed the pre-implementation survey, 27 educators from 15 centres continued to take part in the study. Consequently, the survey data obtained from the seven participants who declined to proceed further in the study were excluded from further data analysis.

Data were entered into SurveyMonkey, an online data gathering and analysis platform. The quantitative and qualitative item responses were analysed using a combination of statistical and thematic analysis. The scaled responses were statistically analysed using a method adopted directly from SurveyMonkey. An example of a sample survey statement and average rating scale are shown in Table 4.

Table 4

Average Rating Scale

Sample Statement	Strongly Disagree (1)	Disagree (2)	Neither Agree/ Disagree (3)	Agree (4)	Strongly Agree (5)	Total	Average Rating
It is better to wait until primary school for maths activities.	20.45% 9	27.27% 12	20.45% 9	11.36% 5	20.45% 9	44	2.84

Note. The weight assigned to the statement is the number beside it ( ).

Survey data analysis for the scaled items was automatically calculated as follows:

w = weight of answer choice
x = response count for answer choice

$$\frac{x1w1 + x2w2 + x3w3 \ldots xnwn}{\text{Total}}$$

The following is a sample of the survey data analysis and calculations. The average rating is calculated as follows:

$$\frac{(9*1) + (12*2) + (9*3) + (5*4) + (9*5)}{44} \text{ therefore } 125/44 = 2.84$$

Note. Adapted from SurveyMonkey: http://help.surveymonkey.com/articles/en_US/kb/What-is-the-Rating-Average-and-how-is-it-calculated.

Qualitative items were analysed using thematic analysis to understand the relationship between each data set. This involved manually coding data to identify patterns and themes, which were aligned with the areas of inquiry in the research questions. The survey included open questions to balance the combination of qualitative and quantitative data and add meaning to the quantitative outcomes, further highlighting the value of a mixed methods approach.

The study survey was administered twice via SurveyMonkey, once prior to the implementation of the play-based assessment activities and again at the conclusion of the implementation phase. At both times, the survey remained open for two weeks and elicited responses to open questions and Likert-scaled statements. Responses to open

questions elaborated upon the scaled responses. The survey outcomes directly informed the design of the workshop and the delivery of the assessment activities.

4.3.4 Professional Learning Workshops

The intervention in this study had multiple components: two workshops (pre- and post-implementation), the implementation of the assessment activities and the associated assessment records (effectively, implementation logs), and the provision of mentoring in response to the submission of planning documentation throughout the implementation phase.

Participants were requested to attend two workshops: one prior to the implementation of the assessment activities and one following the conclusion of the implementation phase. The outcomes of the survey completed immediately prior to Workshop 1 informed its content and the delivery format (see Appendix 3, "Workshop Presentation").

Workshop 1 focused on the implementation of the activities and use of the assessment records in the participants' current early childhood programs.

Workshop 2 included discussion about the impacts of the implementation on practice, planning, and beliefs. During both workshops, observations and anecdotal notes were taken with a view to contributing data to pre- and post-implementation outcomes. Section 4.3.5 outlines the enactment of the play-based assessment activities and what this involved for participants during the implementation.

4.3.5 Play-Based Assessment Activities

The assessment activities and assessment records were a key intervention component.

The participants were provided with six spatial reasoning and geometry assessment activities and resources for use in their programs. The enactment of the play-based assessment activities involved

- implementing six play-based mathematics assessment activities in their settings (August to November);
- submitting assessment records (data) via email each fortnight—eight data collection points in total (August to November);
- documenting practice and planning.

Section 4.3.6 explains how the assessment records and contingent mentoring supported implementation fidelity.

4.3.6 Assessment Records and Contingent Mentoring

Participants submitted assessment records fortnightly during Terms 3 and 4 of the Victorian school year (August to November 2016). Figure 4 is an example of the types of assessment record used for data collection. Participants' data submissions were acknowledged via return email, and the implementation was monitored. The assessment records were analysed as they became available. Statistical analysis was used to determine the overall implementation rate, the individual participant implementation rate, and the rate at which each activity was implemented. Thematic analysis was applied to the written responses with a view to determining links between assessment and planning, impacts on mathematics teaching practice, and beliefs about mathematics.

Implementation and Assessment Record Tangram: What Makes a Square?																	
Date & Child's Initial								Composes/ decomposes shape			Identifies shape and attributes				Makes square uses trial and error	
	flip	slide	turn	rotate	half turn 180° whole turn 360°	around	matching	triangle	square	parallelogram	angle	corner	side	face	part (half)	whole
Comments: Please note any impacts on planning:																	

Figure 4. Example of assessment record for data collection.

Participant questions were answered via email and telephone conversations, and mentoring and coaching were provided to support the enactment of the implementation in practice. Section 4.3.7 outlines how the semistructured interviews were useful when

addressing identified gaps in data collection, and discusses the important contribution the interview data made when addressing the research questions.

4.3.7 Semistructured Interviews

Semistructured interviews were conducted at the end of the implementation (n = 13), prior to Workshop 2. Due to the ongoing data analysis, gaps had been identified in the data relating to educator beliefs. This enabled these gaps to be addressed in the design of the interview questions to elicit further information. Eleven interviews were conducted at the participants' settings, and two were conducted by telephone.

Participants were provided with a copy of the interview questions one week prior to the interview (see Appendix 20, "Semistructured Interview Questions"). The interviews were audio recorded using a mobile telephone application, Voice Memos, to allow the interview to be accurately transcribed and minimise summarisations of the interviewees' responses (Creswell, 2013). The audio recording also facilitated conversation (without the need for taking excessive notes), observing nonverbal communication and listening attentively (Hatch, 1995). Each interview was scheduled for 30 minutes and data were collected on the efficacy of the assessment activities, impacts on individual teaching practice, assessment, planning, and beliefs about mathematics in early childhood education.

During the interview, attention was paid to participants' verbal and nonverbal communication, clarifying meaning if a response was unclear, allowing for adequate response time, keeping questions and responses brief, and avoiding giving signs of approval or disapproval to participant responses (Cohen et al., 2013; Drever, 1995).

Interviews were transcribed and thematically analysed. Text analysis identified key phrases and words in each transcript, providing a focus on the emergent themes within the data set (Miles et al., 2014; Potter & Hepburn, 2005). Table 5 shows emergent themes grouped according to the key constructs of the research questions.

Table 5

Alignment of Emergent Themes Aligned with Research Questions

Observations and Assessment	Planning	Teaching Practice	Participant Beliefs
Identification of mathematical concepts in play	Increased planning and extensions	Positive benefits for children with English as an Additional Language	Positive shift in beliefs about the place of mathematics in ECEC
Observing children's engagement sustains educator engagement	Inclusion of mathematics in program planning	Increased use of mathematical language	Positive shift in beliefs about own mathematics abilities
Learning about children's existing mathematics knowledge	Increased links between assessment and planning	Increased capacity to articulate mathematics in practice	Children's learning outcomes inform participant beliefs
Following the child's interests and achieving the assessment objectives	Mathematics planning linked to children's interests	Increased mathematics content knowledge	Play-based mathematics assessment is appropriate in ECEC
	Links between assessment, practice, and planning not evident		Lack of time and barriers to the implementation; mathematics prioritised in ECEC

The quantitative and qualitative interview outcomes provided a platform for understanding participant beliefs from diverse perspectives. Triangulating the data provided an overview of the study outcomes. For example, investigation into reported frequency and actual frequency of implementation indicated that, at times, participant beliefs and how they informed behaviour were the key to change (Schoenfeld, 2011).

4.4 Summary

In summary, the participant selection process was discussed, including the key instruments used for data collection. Phases 1 and 2 of the study design were explained, including the timeline for the implementation and data collection points. The methods used for data collection and analysis were outlined in detail. Ongoing analysis of the data allowed for constant monitoring of the study outcomes and the identification of any additional data collection necessary to address the research questions. A balance

between qualitative and quantitative data collection was also monitored, and care was taken in the research design and throughout its enactment to ensure qualitative and quantitative data were collected from a range of different sources. Sources of data provided opportunities to cross-reference self-reported outcomes from the workshops, assessment records, surveys, and semistructured interviews, providing a thorough examination of the data.

To determine if the dosage and adoption of the assessment activities influenced teaching practice and beliefs, other factors were considered, factors that have demonstrated impacts on recent implementation research outcomes (Bailey, Duncan, Odgers, & Yu, 2017; Tyler et al., 2016). Factors taken into consideration included the participants' qualifications and experiences, beliefs about mathematics in early childhood, and support within their early childhood setting for the implementation. Other impacts on the implementation included the participants' educational background, training, skills. Further factors taken into consideration were the participants' ability to implement and modify the activities to include the child's interests, meet the assessment objectives, and link the assessment outcomes with evidence-based planning for learning within their early childhood contexts. Overall, analysis maintained a balance between qualitative and quantitative data and was cross-referenced and triangulated to clarify findings and research outcomes.

Our attention now turns to Chapter 5 and the six play-based mathematics assessment activities. This chapter provides the theoretical perspectives and rationale underpinning the inclusion of spatial reasoning and geometry in each activity. This chapter also outlines how the assessment activities support links between observations, assessment and planning, and provides a practical tool for educators to implement in daily teaching practice.

CHAPTER 5: SIX MATHEMATICS ASSESSMENT ACTIVITIES

5.1 Introduction

Moss and colleagues (2016) published a significant body of research in *Taking Shape: Activities to Develop Geometric and Spatial Thinking Grades K–2*, which emphasised the important role of spatial reasoning and geometric thinking enacted in children's mathematics learning throughout the early primary school years. Their research highlighted the fact that the development of spatial reasoning underpins children's mathematics learning and capabilities. The ability to understand and think mathematically is strongly associated with visual and spatial representations (Whiteley, Sinclair & Davis, 2015), providing a way to support children's mathematical learning and processing skills.

Moss and colleagues (2016) provided activities, ideas for materials, teaching strategies, and concrete examples of how to enact spatial reasoning and geometry in practice. Their research aligns with a social constructivist approach (Vygotsky, 1978; Wood, 1998) to teaching and learning, which aligns further with the theoretical rationale for this research project with a focus on examining how individuals construct and come to understand knowledge through social interactions with others and experiences of the world around them (Taber, 2011). The outcomes of their research and their activities provided the basis for the design of the assessment activities implemented in this research project; however, specific concepts were adapted to suit an early childhood play-based context. The design of the assessment activities was also underpinned by the belief that very young children explore spatial reasoning and geometry in everyday contexts (Davis & SRSG, 2015), and as Verdine et al. (2016) suggested, "The most promising ways to improve spatial learning are to begin children's spatial education before they arrive in formal classrooms by improving access to high-quality spatial activities, especially goal-oriented tasks done in conjunction with knowledgeable adults" (p. 116).

Therefore, the six assessment activities implemented within this study were based on mathematical concepts inherent in spatial reasoning and geometry that were appropriate to a play-based learning context. Play in early childhood provides a sociocultural approach to learning, which calls for sociocultural assessment strategies

and resources. As referred to in Section 2.3.1, the activities focused on the three key areas of spatial reasoning associated with mathematics ability: perspective taking, mental rotation, and spatial visualisation. Some examples of what spatial reasoning looks like in early childhood education highlight how children explore these concepts during informal play, and provide opportunities for assessing spatial reasoning in early childhood education (see Figure 5: Assessment of spatial reasoning in ECEC).

Assessment of Spatial Reasoning in Early Childhood Education May Involve Children	
engaging in spatial visualisation by	
	drawing two and three dimensional objects from memory
	using positional and directional language and gesture to describe relationships to space, for example: on, under, beside, on top of, turn, left, right, up, down, over, next to, through
	moving their bodies in and through space and verbalising their actions
	composing and decomposing shapes to make new shapes, for example, two squares make a rectangle
	completing patterns and creating new patterns–visualising what might come next
	describing the route from home to the setting
exploring perspective taking by	
	roleplaying, for example, imagining and describing how you may see the room or an object from another's perspective
	representing data visually on charts, maps and graphs, like the routines of the room
	creating and reading maps
	working with puzzles and estimating where pieces may go, verbalising actions such as: flip, rotate, turn, slide
	orienting their bodies in space, for example, standing beside the chair, lying under the rug, sitting on top of the bench, turning left at the door, organising circle or group time
	locating objects and remembering the location of objects in space
	using positional and directional language, for example, saying or gesturing up, down, over, under, on top of, beside, above, below and so forth
using mental rotation for	
	mentally rotating objects or estimating where puzzle pieces may go, by thinking about the outcomes first before using the materials
	imagining and describing objects moving in space using mental rotations and transformations
	block play or construction and describing the position of the blocks prior to moving them

Figure 5. Assessment of spatial reasoning in ECEC.

To recap, for the purposes of this study, spatial reasoning was applied to the mathematics strand of geometry with a focus on spatial relationships in patterns, composition, and decomposition of shape, mapping, and perspective taking. Significantly, geometry provided a way to make the spatial reasoning concepts visible and perceptible when explored by children during play. The assessment activities therefore included the following: shape composition and decomposition, coding, symmetry, pattern, positional and directional language, mapping, spatial awareness, and 2D and 3D shape, including perspective taking, mental rotation, and spatial visualisation. The six assessment activities were named,

1. Tangram: "What Makes a Square?"
2. Symmetry
3. Pattern: "What Comes Next?"
4. 3D Shape: "Look, Think, Make!"
5. From Here to There
6. Mapping Pathways

Figure 6 provides a summary of each activity and assessment criteria. The activities are numbered from one to six; however, the order in which the participants implemented the activities was not necessarily sequential. It was important for the activities to align with children's interests and curriculum inquiry in each setting. For example, three participants were investigating pattern in their settings during music, art, and design; therefore, Pattern: "What Comes Next?" was implemented first. Participants were required to implement all six activities during the implementation phase of the research project and, in this way, engage with each area of spatial reasoning and geometry in practice.

Assessment Activity	Task	Assessment
1. Tangram: "What Makes a Square?"	Making a square by combining two shapes or more	Makes square using two or more shapes, names 2D shapes, uses directional and positional language, uses geometric language, for example, triangle
2. Symmetry	2D shape composer and decomposer, making a symmetrical design	Identifies line of symmetry, matches shapes, uses positional/directional language; demonstrates understandings of symmetry, for example, two sides match; two halves are the same
3. Pattern: "What Comes Next?"	Repeating pattern, making a pattern, and knowing what comes next or what is missing	Makes and extends the pattern, understands the rules of the pattern structure, for example, ababab; may count elements, recognise number/sequence; identifies what is missing
4. 3D Shape: "Look, Think, Make!"	3D shape: repeats design from memory	Names some 3D shapes and their attributes, uses positional/directional language or gesture, composes and decomposes shape; uses visualisation to see the design in the "mind's eye" and repeats design from memory
5. From Here to There	Describing and showing the movement of animals/objects from one location to another	Describes object in relation to other objects; uses positional, directional language or gesture
6. Mapping Pathways	Pathway grid for mapping using 2D symbols; orientation, coding, and sequencing	Uses positional/directional words/gestures; uses grid to map directions from start to finish; may use 2D symbols to document directions as a sequence of code; may guide others through pathway

Figure 6. Summary of assessment activities.

The suite of activities included the guidelines for assessment, which provided the rationale for each activity and a focus for observations, including "What to look and listen for" during assessment, taking into account children's nonverbal representations of their demonstrated mathematical understandings. The guidelines referenced clear links between each activity and the EYLF (DEEWR, 2009), the VEYLDF (DET, 2016), the Australian Curriculum: Mathematics (ACARA, n.d.-a) and the Victorian Curriculum F–10: Mathematics (VCAA, 2017). This was with a view to supporting participants when identifying evidence of children's spatial reasoning and geometry during play and providing ideas of what to plan next. The inclusion of links to the first three levels of the Australian Curriculum: Mathematics (ACARA, n.d.-a); and the Victorian Curriculum F–10: Mathematics (VCAA, 2017) in the guidelines was important to consider, as survey outcomes demonstrated that observations of children's mathematics knowledge were at an advanced level, and beyond participant expectations (Cohrssen et al., 2017; Gould, 2012). This is discussed further in Section 6.3.4.3.

The assessment activities were designed to be implemented during children's play, supporting links between assessment, evidence-based planning, and learning contexts that were meaningful and related to children's interests (Hirsh-Pasek, Golinkoff, Berk, & Singer, 2009). Specifically focused on small-group assessment contexts, the activities supported peer interaction, joint attention (Nuttall, 2005), and support for mathematical discussion (Ramani et al., 2014) through the provision of examples of open-ended questions to use with children during the assessment process. The assessment activities were to be conducted with a more knowledgeable other—in this instance, the educator (Verdine et al., 2015)—to provide a starting point for the identification of and planning for these concepts in daily practice and broader program planning. It was hypothesised that sustained engagement with and enactment of the assessment activities would provide more detailed and in-depth understandings of children's existing knowledge and support contingent planning.

5.1.1 Study Survey Outcomes and Design of Assessment Activities

The first three assessment activities, Tangram: "What Makes a Square?", Symmetry, and Pattern: "What Comes Next?", were based on the "top five" responses participants reported on the types of mathematics activities children engaged with during a typical week in their settings. The activities were "Doing puzzles" (87%), "Ordering and sequencing objects" (81%), and "Naming shapes" (74%) (see "Study Survey", Question 18, Appendix 19). Therefore, the activities were based on participants' familiar understandings of shape,

including composition, decomposition, and the attributes of shape. Symmetry included a focus on shape and matching, and pattern incorporated sequencing and repeating patterns of increasing complexity. Linking the activities to the mathematics already occurring in early childhood settings was intentional, as it was hypothesised that introducing concepts already familiar to participants would support the uptake of the assessment activities in daily practice, and that through the enactment of the activities, participant confidence would increase.

Counting and number were implicit within the six assessment activities as the pre-implementation study survey outcomes indicated that children frequently participated in number and counting activities with educators, for example, "Saying number words 1–10 in the correct sequence" (73%), "Identifying numerals 1–10" (70%), and "Identifying and naming numerals that match a given collection to 10" (70%). Although 51% of participants looked for evidence of children's "understanding" when observing and assessing children's mathematical thinking, the focus for these observations was reported as looking for evidence of children's number knowledge and counting (71%) (see "Study Survey", Question 18, Appendix 19). Therefore, the activities were designed with the intention to extend the focus for assessment and understandings of children's mathematics knowledge beyond number and counting.

The assessment activities were designed to focus on areas of spatial reasoning and geometry not necessarily or typically associated with early childhood mathematics, yet critical for building on children's competencies in this area (Moss et al., 2016). The three assessment activities to follow, 3D Shape: "Look, Think, Make!", From Here to There, and Mapping Pathways, were developed to reflect specific areas of mathematics that were identified in the survey outcomes as seldom observed, assessed, or taught in early childhood settings, yet important for underpinning the foundations of children's spatial reasoning and geometry learning (Davis & SRSG, 2015).

The pre-implementation survey outcomes indicated that mathematics was a subject area generally explored by children on their own, without educator participation. The following mathematics activities were identified by participants as areas of learning that children explored "mainly on their own" during play. The following percentages demonstrate which participants out of the core group, reported children exploring these areas of mathematics learning "mainly on their own":

- Construction and block play (35%)
- Using positional/directional language to describe actions during block play (59%)
- Identifying and naming 3D shapes (42%)
- Combining shapes to make new shapes (38%)
- Describing objects and experiences from another person's perspective (38%)
- Using words to describe the relationships between objects in space (50%)
- Drawing and describing 3D shapes from memory (41%)
- Drawing maps, for example, from the block corner to the sandpit (60%)
- Describing the way from one place to another (38%)

Given the survey outcomes, it was necessary for the assessment activities to actively engage participants in the assessment process, to promote joint attention and sustained shared thinking (Siraj-Blatchford, 2010b).

The pre-implementation study survey outcomes indicated that children spent a large percentage of their time exploring mathematical concepts without educator intervention. This may have been contributing toward the gaps in planning for children's learning as the pre-implementation survey outcomes suggested that mathematics was perceived as a subject that children engaged in mostly on their own, therefore having a direct impact on educators' understandings of what children know and can do. Gaps between observations, assessment, and links to planning were identified in the survey outcomes and the broader research literature, demonstrating that this is an area identified as being in need of ongoing training, mentorship, and professional learning (see Section 2.6). As Ginsburg and colleagues (2014) stated, "It is quite different to simply be able to administer or complete the observations needed for child assessments than it is to use the information obtained. Professional development on both is needed" (p. 105).

This means that there is an ongoing need to support educators when linking observations, assessment, and planning in teaching practice, and professional learning is necessary to support the acquisition of skills necessary to observe, assess and plan for children's learning (Stonehouse, 2014). It was believed that the implementation of the

assessment activities would provide a way to address the gaps identified in the Early Years Planning Cycle (DEEWR, 2015) and support assessment, evidence-based planning, and the development of early childhood mathematics curriculum.

Finally, the pre-implementation survey outcomes indicated that educators needed support when identifying a broader range of mathematical concepts, often explored by children during play. Therefore, the activities endeavoured to address the gap between what was perceived as mathematics in early childhood education—predominatly number, counting, and shape—and the identification of the mathematics *already occurring* in play-based settings. The intention of the assessment activities was to address the gap between observations, assessment, and planning by providing a practical tool for educators to implement in daily practice.

In Sections 5.2 to 5.7, each assessment activity and its application and implications for practice are discussed in detail. First, it is useful to provide an overview of the assessment records to demonstrate how they were used in conjunction with the activities to document observations, assessment, and planning during the implementation.

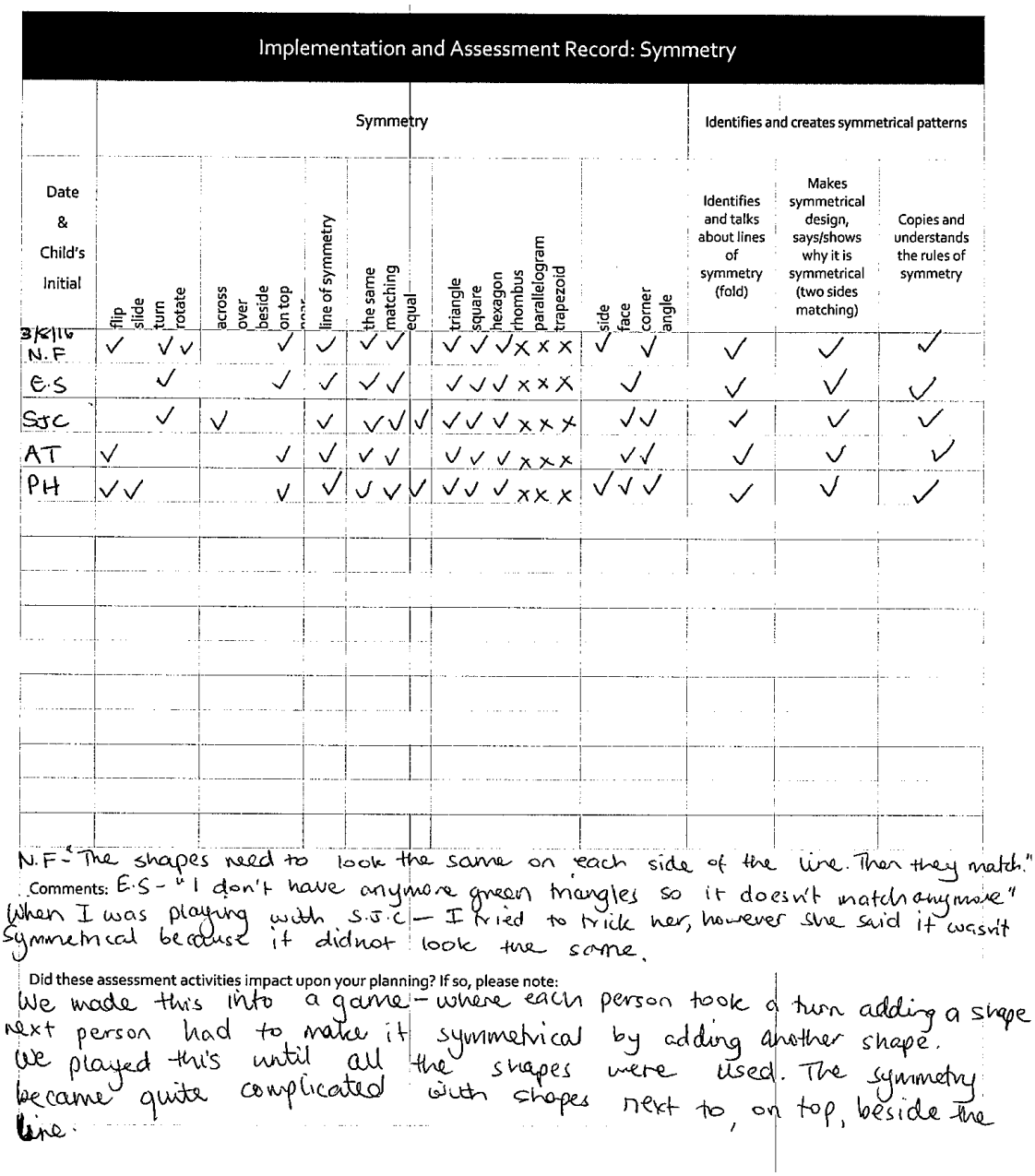
5.1.2 Assessment Records

The assessment records were designed as a tool to support participants when identifying children's existing knowledge. When implementing an assessment activity, participants were required to complete an assessment record. The assessment record listed relevant and observable objectives for each activity. This was with a view to providing the language necessary to support the identification and discussion of the concepts being observed. The assessment record captured participant comments about the implementation of the activity and impacts on planning as a direct result of the assessment outcomes. For example, the assessment records used specific mathematical language to describe what children may say and do when engaged in the spatial reasoning and geometry activities. To illustrate, children may demonstrate their understandings of "flip", "slide", "turn", and "rotate" when exploring puzzles and shapes, using positional or directional language and gesture during play. Participants were asked to analyse the assessment outcomes and indicate next steps for planning, as illustrated in the assessment record in Figure 7.

Implementation and Assessment Record Tangram: What Makes a Square?																
Date & Child's Initial								Composes/ decomposes shape			Identifies shape and attributes				Makes square; uses trial and error	
	flip	slide	turn	rotate	half turn 180° whole turn 360°	around	matching	triangle	square	parallelogram	angle	corner	side	face	part (half)	whole
Comments: Did the outcomes of this assessment impact upon your planning? Please make a note:																

Figure 7. Assessment record, Tangram: "What Makes a Square?"

As referred to in Section 4.2.4, participants emailed the outcomes of the assessment records, comments, and impacts on planning each fortnight. The example shown in Figure 8 is a completed assessment record for "Symmetry", submitted by a participant during the implementation phase.



Implementation and Assessment Record: Symmetry

Date & Child's Initial	Symmetry: flip	slide	turn	rotate	across	over	beside	on top	line of symmetry	the same	matching	equal	triangle	square	hexagon	rhombus	parallelogram	trapezoid	side	face	corner	angle	Identifies and talks about lines of symmetry (fold)	Makes symmetrical design, says/shows why it is symmetrical (two sides matching)	Copies and understands the rules of symmetry
3/2/16 N.F	✓		✓	✓				✓	✓	✓	✓		✓	✓	✓	X	X	X	✓		✓		✓	✓	✓
E.S			✓					✓	✓	✓	✓		✓	✓	✓	X	X	X		✓			✓	✓	✓
S.J.C			✓		✓				✓	✓	✓	✓	✓	✓	✓	X	X	X		✓	✓		✓	✓	✓
AT	✓						✓		✓	✓	✓		✓	✓	✓	X	X	X		✓	✓		✓	✓	✓
PH	✓	✓					✓		✓	✓	✓	✓	✓	✓	✓	X	X	X	✓	✓	✓		✓	✓	✓

Comments: N.F - "The shapes need to look the same on each side of the line. Then they match."
E.S - "I don't have anymore green triangles so it doesn't match anymore"
When I was playing with S.J.C — I tried to trick her, however she said it wasn't Symmetrical because it didnot look the same.

Did these assessment activities impact upon your planning? If so, please note:
We made this into a game — where each person took a turn adding a shape next person had to make it symmetrical by adding another shape. We played this until all the shapes were used. The symmetry became quite complicated with shapes next to, on top, beside the line.

Figure 8. Assessment record, Symmetry (AG, 3/8/2016).

In this record, the children were observed and assessed in two small groups. The observations included the child's voice and demonstrated the ways children expressed their understandings of the concepts. The assessment outcomes demonstrated children's use of positional and directional language, their understandings of symmetry, and the identification and naming of shapes and attributes. Most children demonstrated understandings of "face" and "corner", however less so for "side" and "angle", highlighting a potential area of learning to incorporate in ideas for future play-based planning.

This participant's ideas for planning were based on a game that involved turn-taking, matching, shape identification (correctly naming shapes regardless of their orientation), and the use of positional language to support the emerging symmetrical design. This supported children's use of the words "next to", "on top", and "beside", and over time could progress to include "over", "across", "slide", and "rotate". Two children also used the word "equal" to describe how both sides were matching or the same. The game further supported children's diverse understandings of these mathematical concepts in a play-based context and provided ongoing assessment opportunities for the participant. This example demonstrated the amount of observational data generated from one assessment record, which could be used to inform planning.

Participants were asked to date and complete the assessment records, documenting when the assessment was conducted, the number of children and groups who took part in each activity, the context for the assessment, and which aspects of the assessment outcomes informed ideas for planning. Participants were also asked to keep a journal to document their ideas and reflections about the assessment process, outcomes, and implications for the planning of children's mathematics learning during the implementation. As this was not consistent among participants (7%), it was decided that the assessment record alone would serve as the data for the implementation.

Each participant (n = 27) received an assessment kit during the workshop in preparation for the implementation. Each assessment kit comprised a 50-page booklet, *Guidelines to the Assessment Activities*, six cloth drawstring bags containing the mathematics assessment activities, the associated materials, and blank assessment records. Each activity was purposefully contained in a labelled, drawstring bag to make it accessible to participants and children. The following section discusses each assessment activity in detail beginning with Tangram: "What Makes a Square?"

5.2 Tangram: "What Makes a Square?"

This activity focused on the composition and decomposition of shape, with further links to identifying how combinations of shape make up everyday objects in our lives. Piaget and Inhelder's (1967) research on "perceptual development" in infants formed the background for this activity. In brief, their research broadly demonstrated that infants can perceive shape, and in the right circumstances, infants can perceive the differences between shapes. However, further research has suggested it is not until young children coordinate their movements and

actions systematically that they begin to actively explore, identify, and link the individual attributes of shape together to make meaning (Clarke, 2004; Clements, 1998). Providing opportunities for small groups of children to manipulate, explore, and discuss how a set number of shapes can be composed and decomposed to represent something else, and to further understand how each shape is identified based on its attributes, was important to consider (Ramani et al., 2014) and became a key aspect of this activity. A small-group focus was important as it provided assessment opportunities for participants and supported children's perceptual and conceptual understandings of shape. The assessment activity included the materials shown in Figure 9.



Figure 9. Assessment activity: Tangram: "What Makes a Square?"

A tangram was chosen to provide a set number of shapes that could be explored in many ways, as a puzzle or in response to *Grandfather Tang's Story* (Tompert & Parker, 1997). The book demonstrated ways to compose and decompose shapes to represent animals and people. The concept was playful and creative. Exploration of the tangram encouraged small groups of children to identify, match, compose, and decompose shapes using words or gestures to signify "turn", "flip", "slide", and "rotate" as they engaged with the tans (shapes). Children develop their spatial reasoning skills—and by implication, their mathematics skills—by manipulating shapes, discussing part–whole relationships, observing, identifying, and discussing the attributes of shape, and exploring the relationships between them (Clements & Sarama, 2014). The play-based assessments supported peer talk and "joint

problem-solving skills" to work toward achieving a common or "joint goal" (Ramani et al., 2014, p. 327).

5.2.1 Introduction and Rationale for Assessment of Shape

Shape forms an integral aspect of children's geometric development, which evolves when children engage in shape composition and have opportunities to explore understandings that one large shape can comprise a collection of smaller shapes or, as referred to by Clements and Sarama (2014), when children can "construct and duplicate units of units (shapes made from other shapes) intentionally, and understands each as being both multiple small shapes and one larger shape" (p. 265).

Providing participants with the mathematical language to name the concepts during the assessment supported children's understandings of their explorations of shape as mathematical. Opportunities to explore shape and part–whole relationships are linked to children's understandings of number and algebraic reasoning (Uttal & Sheehan, 2014) and is therefore an important step toward establishing foundations for algebra. Further, with intentional support, children have the capacity to identify that two triangles make a square; describing one triangle as representing one half of the two equal parts of the square supports foundational knowledge of fractions (VCAA, 2017).

When grouped together, shapes may be associated with a familiar form, which engages visualisation skills essential for problem-solving, working memory capabilities, and mathematics learning (Moss et al., 2016) (see Section 2.3.3.1 for further discussion). This activity was designed for participants to assess children's existing knowledge of the composition and decomposition of shape, and how combinations of shape could transform to create new forms and objects with a view to contingently planning for the ongoing development of these skills.

The Tangram: "What Makes a Square?" assessment activity was designed for participants to observe children

- making a tangram (square), in part or whole;
- communicating their understandings verbally and nonverbally, "flip", "slide", "turn", "rotate" when making the puzzle;

- identifying the attributes of shapes; for example, a triangle always has three sides;
- composing and decomposing shapes to create new shapes or representations.

Participants were required to have the assessment activity and book available to explore with children. It was recommended for participants to have drawing materials, templates, and coloured paper available during the assessment to provide for necessary extensions.

It became apparent from the pre-implementation survey outcomes that participants did not feel confident identifying mathematical concepts in play-based contexts, and that 27% of participants did not perceive shape or spatial reasoning as mathematical. Strategies for each assessment activity that highlighted how to identify these concepts during play and emphasise participants' active involvement in the assessment process were necessary to establish children's knowledge about shape. For example, MM wrote, "We learned that whenever an adult was at the activity more children expressed interest and engaged with the task. Children stayed for longer periods of time" (MM, 5/8/16). To reiterate, when educators are actively engaged in assessing children's knowledge, the upper limits of a child's understanding can be assessed and inform planning that is authentic, useful, and meaningful to the child (see Appendix 1, "Tangram: 'What Makes a Square?'", pp. 5–11). Section 5.3 focuses our attention on Symmetry.

5.3 Symmetry

Symmetry is one aspect of geometry that can connect children's mathematical thinking to everyday objects, patterns, and play (Davis & SRSG, 2015). This assessment activity focused on reflection symmetry, using a single line of symmetry as an introduction to the mathematics inherent within these concepts. Any pattern, shape, or object folded along the vertical line of symmetry will have two equal parts. Children intuitively understand symmetry and often detect it in everyday contexts, for example, in each other, or as represented in the shape of a leaf or as seen in architecture. Therefore, this assessment activity highlighted the links between children's mathematical thinking and their interests in everyday objects around them (Eberle, 2014; Ha, 1989; Seo & Ginsburg, 2004). This provided an opportunity to reinforce the mathematical language and thinking implicit within children's explorations of symmetry, highlighting the relevance of using mathematics to explain their everyday environments. When educators assess and intentionally teach

symmetry, it supports children's ability to recognise and contextualise shape, pattern, and number (Uttal & Sheehan, 2014). The assessment activity included the materials shown in Figure 10.

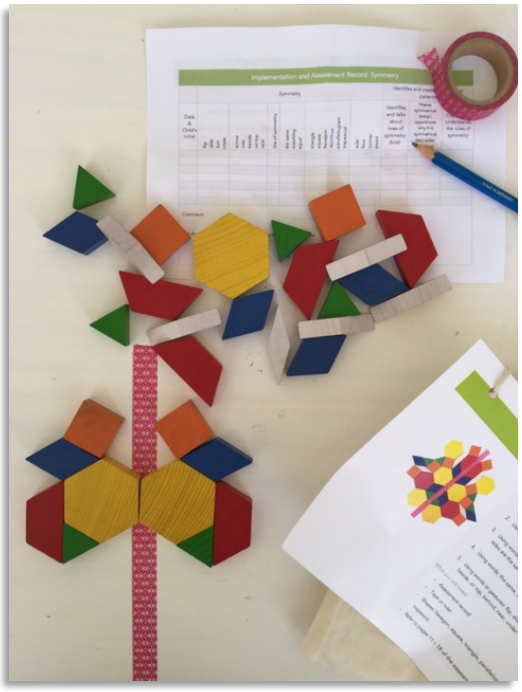


Figure 10. Assessment activity: Symmetry.

The symmetry assessment activity was designed for participants to observe children

- using words or actions to identify the line of symmetry;
- using shapes to match the design on either side of the line;
- using words or actions to describe symmetry, for example, both sides are the same when folded in half;
- using words "same", "side", "face", "corner", "angle";
- using words or gestures "flip", "slide", "turn", "rotate", "across", "over", "beside", "on top", "behind", "near", "under".

Included in the guidelines were suggestions for activities that would introduce the mathematical concepts of symmetry to children, including examples of open-ended questions to use in discussion with children. These questions were intended to support joint attention (Moore, Dunham, & Dunham, 2014) and sustained shared thinking (Siraj-Blatchford, 2010a) during the assessment process. Participants were guided to engage in explicit and purposeful

assessment strategies. The open-ended questions facilitated communication (verbal and nonverbal) between the participant and the child, with a view to determining the upper limits of each child's understandings. Suggestions for open-ended questions included,

- "What do you notice (about the two sides)?"
- "What do you think the shape will look like when it is unfolded?"
- "Why do you think that?"
- "I wonder if the two sides are the same (equal)?"
- "How can we test this to find out?"
- "How do you know if these sides are matching?"

Participants were also encouraged to ask children to tell them or show them "more" to gain insights into how children were communicating their understandings and knowledge of symmetry. During the activity, participants were required to have the shapes, the tape (or objects to create the line(s) of symmetry), words to describe the attributes of each shape, gestures and words to describe the movement of the shapes, and the assessment record to document outcomes.

5.3.1 Introduction and Rationale for Assessment of Symmetry

Throughout the implementation, participants were encouraged to introduce the concept of reflection symmetry to children using the activities outlined in the guidelines as a starting point. The workshop stressed the importance of linking the assessment objectives with children's interests, as ideally, the assessment objectives were designed to be transferred to different contexts, for example, during block play, snack time, or in the outdoor environment. The guideline provided the mathematical language and concepts to discuss and explore symmetry with children. Participants were encouraged to work with a wide variety of materials that aligned with children's interests and abilities to achieve the assessment objectives. For example, participants incorporated children's preferences for gross motor activity, using larger objects and spaces to assess symmetry such as large wooden blocks on a mat, large sheets of paper folded in half and painted to create symmetrical designs, and children arranging their own bodies and each other in the outdoor environment to create symmetry. The participant took aerial photographs to share with children and discuss if the design they had created with their bodies was symmetrical, and if so, why? Children's understandings of symmetry were also assessed while a child was painting "wrapping paper"

for a gift and further, painting a "house with symmetry windows" (IY, 23/11/16). This assessment activity was designed to support educators when identifying children's demonstrated understandings of symmetry during play and across curriculum domains (see Appendix 1, "Symmetry", pp. 11–18). Our attention now turns to Section 5.4, which describes Pattern: "What Comes Next?", highlighting the links between mathematics and pattern.

5.4 Pattern: "What Comes Next?"

Explicit teaching strategies are necessary when revealing the connections between patterns and mathematics to young children (Fox, 2007). Therefore, knowing how to assess children's patterning mathematically is important. When exploring pattern, children may begin to make connections about information within their world, to predict and generalise further beyond what is in front of them (Clements & Sarama, 2014). For example, children may repeat "clap, tap, clap, tap . . ." and with intentional guidance, recognise this pattern as having an ABABAB structure. Identifying the structure of a pattern helps children to identify the structure of numerical and mathematical sequences as "having one thing stand for another is the beginning of algebraic representation" (Clements & Sarama, 2009, p. 191) and supports children's understanding of symbols as representations of something else (Carter & Fuller, 2016; Zittoun, 2010). Completing pattern sequences relies on spatial processes like visualisation and orientation and supports children's spatial reasoning skills. The assessment activity included the materials shown in Figure 11.

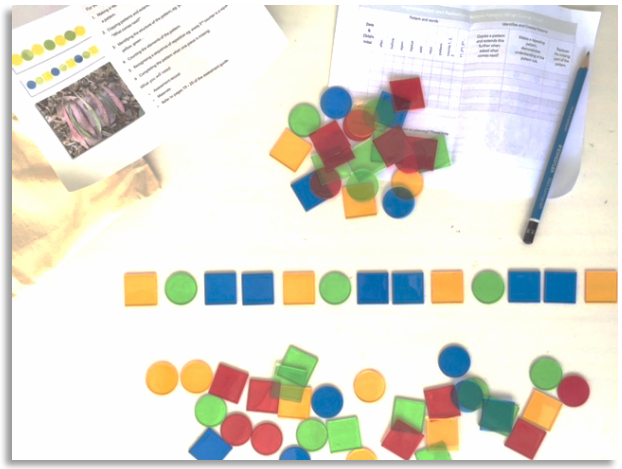


Figure 11. Assessment activity: Pattern: "What Comes Next?"

5.4.1 Introduction and Rationale for Pattern: "What Comes Next?"

How an educator assesses a child's knowledge of pattern is important, as patterns are sequences, determined by a rule. When children recognise the rule of a pattern, it supports visualisation and prediction (Uttal et al., 2013). Children begin to understand what will come next and why, for example, repeating patterns in counting and skip counting. This is a useful skill to develop as essentially all mathematics is based on pattern and structure (Yeatts, 2014), which suggests the need to intentionally link children's incidental explorations of pattern to mathematical concepts and language.

The guideline included suggestions for introducing repeating patterns to children and included engaging in a pattern walk to observe repeating patterns in the environment, demonstrating how patterns link mathematical understandings to the everyday. Associations between mathematics and the environment establish mathematics as relevant and useful for communicating ideas and understandings of the world (Clements & Sarama, 2014). Participants were encouraged to ask children what they noticed, and to communicate their thinking and understanding of the pattern rule. Suggestions also included noticing repeating patterns in a rhyme or beats in music to provide opportunities for children to explore and predict what will come next. The pattern assessment activity was designed for educators to observe children

- making a repeating pattern using words or actions to describe why it was a pattern;
- copying patterns and extending them further, responding to the question "What comes next?";
- identifying the structure of the pattern, for example, yellow, green, yellow, green, yellow, green . . .";
- counting the elements of the pattern;
- recognising a sequence of repetition, for example, every third counter is a square;
- completing the pattern when one piece was missing.

Participants were encouraged to use natural materials, objects from their programs, and outdoor environments, which were familiar to children and aligned with children's interests and ability, for example, incorporating movement or large objects to assess repeating pattern

during gross motor explorations and/or finding patterns in nature (see Appendix 1, "Pattern: 'What Comes Next?'" pp. 20–26). The following Section 5.5 focuses on the assessment activity 3D Shape: "Look, Think, Make!" outlining explicit links between geometry, spatial reasoning and working memory capabilities.

5.5 3D Shape: "Look, Think, Make!"

Exploring 3D shape during play presents a dynamic way to understand and assess geometry in action (Uttal & Sheehan, 2014). This assessment activity was based on research evidence suggesting that children's mathematical understandings and abilities benefit from being engaged in activities that encourage geometric composition and decomposition (Davis & SRSG, 2015; Moss et al., 2016). Children live in 3D environments, and providing opportunities for children to make geometric sense of their world connects seemingly abstract mathematical concepts with their everyday experiences (Clements & Sarama, 2014; Fisher, Ferrara, Hirsh-Pasek, Newcombe, & Golinkoff, 2009).

During this assessment activity, children manipulated and explored 3D shapes and imagined or visualised combinations of 3D shapes as representations of familiar objects, for example, composing shapes to resemble a rocket. Combining 3D shapes to create recognisable objects is an important skill "essential to the development of [children's] geometric intuition about shapes and to their geometric sense of their surroundings" (NCTM, 2000b, p. 201). It is beneficial for children's learning to engage in activities that link abstract concepts to their everyday understandings and environments (Hawes, LeFevre, Xu, & Bruce, 2015). Children worked in small groups or pairs. Participants encouraged discussion including the use of spatial language, combinations of shape, and attributes. Children created an object using combinations of 3D shapes, then placed a cover over their object so it was no longer visible. Other children were challenged to replicate the object, working from memory. The assessment activity included the materials shown in Figure 12.



Figure 12. Assessment activity: 3D Shape: "Look, Think, Make!"

5.5.1 Introduction and Rationale for 3D Shape: "Look, Think, Make!"

Imagining what 3D shapes look like when they are rotated, or to understand how an object is still the same object regardless of its orientation, is important knowledge to develop, as many forms of mathematics require this visualisation skill (Okamoto, Kotsopoulos, McGarvey, & Hallowell, 2015). Through purposeful explorations, children begin to develop the ability to visualise shape and combinations of shape, understanding that the orientation of a shape does not change its properties. For example, a triangle standing on one point is still a triangle. Research has indicated that the ability to visualise and hold images in the mind's eye is an important skill that supports mathematical reasoning (Davis & SRSG, 2015; Moss et al., 2016; Uttal & Sheehan, 2014). This importance is underscored by research that has further suggested children are more likely to find mathematics easier when they remember and mentally manipulate visual–spatial information (Davis & SRSG, 2015; Kyttala & Lehto, 2008; Thompson, Nuerk, Moeller, & Kadosh, 2013). Therefore, this activity assessed children's working memory capabilities to support the development of skills in this area.

The 3D shape assessment activity was designed for educators to observe children

- identifying and describing one or more 3D shape, for example, "cube", "cylinder", "sphere", "cone", "rectangular prism", "triangular prism", "hexagonal prism", "square pyramid", "hemisphere", "pentagonal prism";
- using words and actions when combining shapes, for example, "flip", "slide", "turn", "rotate";

- using words to describe position: “beside”, “on”, “under”, “below”, “above”, “between”, “over”;
- repeating a design from memory (working memory);
- identifying “corner”, “edge”, “side”, “face”, “angle”, “curve”, “straight edge”.

Developing children’s working memory is an important skill, as being able to hold information in the mind’s eye is necessary for the completion of mathematical tasks (see Section 2.5.2). Working memory is important when processing information relevant to the task at hand, and particularly important for holding information in situ while completing mathematical tasks (Beilock & Maloney, 2015; Yu, 2015). Research suggests that children have the capacity to develop their working memory skills at a young age (Uttal et al., 2013). Assessing, analysing, and planning to move children beyond their existing knowledge and current level of mastery requires explicit teaching strategies based on regular assessment and *recent* evidence (see Appendix 1, “3D Shape: ‘Look, Think, Make!’” pp. 27–34). Section 5.6 now turns our attention to focus on the assessment activity From Here to There, highlighting the significance of supporting children’s acquisition of spatial language to support the communication of spatial relationships.

5.6 From Here to There

This assessment activity was based on children’s demonstrated verbal and nonverbal communication of position and direction during play (Uttal et al., 2013). This activity was designed to provide opportunities for children to demonstrate knowledge of relationships between themselves, objects, and others in space. When engaged in this activity, participants used positional and directional language and gestures to describe their actions. For example, participants may say, “I am putting the platypus *in* the water; it is swimming *around* the rock” or “The koala is climbing *up* the tree; see it’s *on* top” as they engage in the activity with children. Children are naturally aware of spatial relationships, noticing and describing movement, location, orientation, and shape (Hobenshield Tepylo, Moss, & Stephenson, 2015). This assessment activity highlighted children’s existing knowledge of “both numerical and spatial geometrical concepts” (NRC, 2006, p. 184). Developing these concepts supports the necessary skills for mapping, coding, sequencing, visualisation, and problem-solving. The assessment activity included the materials shown in Figure 13.



Figure 13. Assessment activity: From Here to There.

During the assessment activity From Here to There, participants were provided with the following guidelines to observe and document children:

- Using positional language/gesture when describing the location of objects in relation to other objects: “beside”, “on”, “under”, “below”, “above”, “between”, “over”, “beneath”, “in front of”, “behind”, “inside”, “outside”;
- Using directional language or gesture when moving objects, for example, the koala is climbing “up” the tree, the platypus is swimming “across” the water: “over”, “down”, “around”, “through”, “in”, “out”, “turning left”, “right”.

5.6.1 Introduction and Rationale for Assessment: From Here to There

All mathematics is based on relationships (Moss et al., 2016); therefore, it is important to provide children with many opportunities to demonstrate their existing knowledge of position and direction, using gesture, words, and representations of space to support the communication of their understandings to others (Ferrara, Hirsh-Pasek, Newcombe, Golinkoff, & Lam, 2011). For example, the position of an object can only be described in relation to someone or something in space. Research has suggested that spatial thinking supports *all* maths learning (Davis & SRSG, 2015); therefore, by focusing on spatial thinking, educators can do two things at once: support the development of children’s spatial thinking *and* their mathematics skills (Clements & Sarama, 2017). During the workshop, participants were encouraged to engage children in imaginative play scenarios whereby their

existing knowledge could be assessed (see Appendix 1, “From Here to There”, pp. 35–40). Section 5.7 discusses Mapping Pathways, which outlines the importance of developing spatial reasoning and geometric concepts as essential skills for life.

5.7 Mapping Pathways

This assessment activity incorporated multiple spatial reasoning and geometric concepts essential for mapping (Uttal & Sheehan, 2014). Mapping enables children to describe their position in space and to demonstrate their relationships to objects and others, explore concepts of scale, coding, and the use of 2D symbolic representations of 3D objects. Mapping incorporates many mathematics concepts, highlighting further that all mathematics is relational (Uttal et al., 2013). Understanding symbolic representations lays the foundation for the learning other mathematical concepts, such as algebraic thinking (Clements & Sarama, 2014). Mapping also provides further opportunities to introduce children to concepts of scale, which support understandings of estimation, reasoning, and problem-solving and enables children to demonstrate and communicate their understandings of location, position, and direction in space (Moss et al., 2016). The assessment activity contained the materials shown in Figure 14.



Figure 14. Assessment activity: Mapping Pathways.

5.7.1 Introduction and Rationale for Mapping Pathways

This assessment activity established the purpose of mapping to provide 2D representations of 3D worlds on a smaller scale. Children physically move through a 2D “map” or grid, experiencing positional and directional language in action. This involves sophisticated reasoning skills, as the child giving the instructions sees the grid from the

other's point of view and therefore provides instructions based on the perspective of another. This activity provided many opportunities to assess children's existing knowledge of spatial concepts and further, revealed how a 2D map can provide a model of their world (Moss et al., 2016). The development of spatial reasoning is an essential skill for mapping, with direct links to coding, sequencing, and problem-solving (Uttal et al., 2013).

When assessing children's knowledge of mapping, educators benefit from engaging with children in activities that explore how to communicate location, position, orientation, direction, perspective, and scale. Infants often begin exploring these spatial concepts by locating objects or others in space, as young children are naturally curious about and interested in modelling understandings of their world (Moss et al., 2016). This points to the fact that spatial relationships between objects and places can be described using mathematical language, reinforcing mathematics as a useful part of our everyday communication (Clements & Sarama, 2014). Educators identify these spatial concepts as children explore them during play, for example, when using gesture, words, drawings, making models during imaginative or block play, or using something to represent something else, like a symbol. Exploring symbolic representation also lays the foundations for understanding symbols in mathematics, for example, numerals or simple algebra: =, –, +, ÷, x and other mathematics symbols which young children may already be familiar with <, >, ≠, ∑, ∞ and ready to explore (O'Nan Brownell, Chen, & Ginet, 2013). Being able to visualise information, or hold a series of directions or symbols in their mind's eye, can also support the necessary skills for coding sequencing and problem-solving (Moss et al., 2016; Orr & Geva, 2015).

Participants were encouraged to explore these concepts with children by making obstacle courses, looking at maps of local and familiar areas, and identifying familiar landmarks. Mapping can support children's understandings of location and sense of belonging (DEEWR, 2009). Mapping also introduces children to perspective, for example, seeing the world from a "bird's eye" view or from the point of view of another. Young children require explicit teaching to develop these skills (Davis & SRSG, 2015).

The mapping assessment activity was designed for participants to observe children

- using the pathway grid on the floor to map directions from start to finish;
- using positional and directional language or gesture: "turn", "left", "right", "move forwards", "backwards";

- using symbols to document a sequence of movements (coding), for example, the arrows and shapes provided;
- documenting the map, which may involve using a smaller version of the grid to write or draw on.

Participants were provided with tape to make a grid on the floor (for example, two columns and five rows), grid paper for children to document their work (optional), drawing materials, arrows and objects for "obstacles" on the floor grid, and directional stickers to place on children's clothing to support understandings of "left", "right", "forwards", "backwards". The stickers could also be placed on an object, for example, a doll or bear that could be moved by children through the grid.

Mapping Pathways provided the necessary precoding skills to support children's understandings of symbolic representations, sequencing, and coding. To reiterate, this was important to consider when designing the assessment activities as the survey outcomes indicated that for many different reasons, a large percentage (61%) of participants were not integrating ICT (information communication technology) in practice. Therefore, the assessment activities addressed ways for children to experience and develop precoding and coding skills without necessarily using ICT (see Appendix 1, "Mapping Pathways", pp. 41–52).

5.8 Summary

In summary, it was believed that through the enactment of the six assessment activities, links between theory and practice would be of potential benefit to the participants in the implementation, having a positive impact on educator beliefs about mathematics assessment, practice, and pedagogy in play-based curriculums (Kelly & Perkins, 2012; Warren et al., 2011). The assessment activities intentionally included spatial reasoning and geometric thinking to support participants in identifying and using this language and these concepts with children. In short, it was hypothesised that the very act of participating in the implementation would lead to meaningful change for the educators involved in the study and, therefore, by implication, the children they teach. The key point underpinning the rationale for the activities is that children need explicit teaching strategies to support the development of their mathematics learning, and educators are required to provide a wide range of opportunities for children to practice and develop these skills (ACECQA, n.d.; DEEWR, 2009). Further, educators need to develop strategies to assess children's unique

demonstrations of their understandings of the world (Davis & SRSG, 2015; Pollitt et al., 2015) and link these outcomes with explicit teaching strategies and evidence-based planning for learning (DET, 2016).

In Chapters 6 and 7, the outcomes of the participants' implementation of the six assessment activities are presented. The impacts of the implementation on teaching practice, including observations, assessment, and planning, are presented in detail. The impact of the implementation on participant beliefs about mathematics in early childhood education and participants' beliefs about their own mathematics abilities are also shown in detail. First, our attention turns to Chapter 6, which presents the key findings from Phase 1 of the research design and includes the pilot survey and trial of the assessment activities.

CHAPTER 6: PHASE 1 RESULTS

6.1 Introduction

This chapter presents Phase 1 of the study results. The results for the pilot survey and the trial of the assessment activities are presented in sections 6.2 and 6.3.

This chapter discusses the results of the pilot survey and trial of the assessment activities, highlighting how the outcomes were used to develop the final survey instruments, inform modifications to the assessment activities and records, and develop the workshop content and guidelines for implementation. The trial of the assessment activities was integral to the research project and provided an opportunity to test the functionality of the materials with educators in their settings prior to the four-month implementation phase.

6.2 Pilot Survey Results

The pilot survey was necessary to test the validity of the survey outcomes to ensure the data would respond to the research questions (Cohen et al., 2013). The pilot survey served five main purposes, providing a way to (1) test the questionnaire items, (2) determine whether the questions were clear and measurable, (3) determine whether the survey outcomes would answer the research questions, (4) identify and address gaps in the survey data and (5) test the design of the survey and participant response rate to each item. Based on the outcomes of the pilot survey, these five areas are discussed throughout sections 6.2.1 and 6.2.2.

6.2.1 Pilot Survey Design

The pilot survey was designed to see if the outcomes clearly captured participants' understandings of mathematics teaching practice, including observations, assessment, and planning, beliefs about mathematics in early childhood, and beliefs about their own mathematics abilities (see Section 4.2.2). The structure of the pilot survey was based on a five-point Likert scale rating of *strongly agree, agree, neither agree nor disagree, disagree*, and *strongly disagree.* Outcomes across the entire pilot survey suggested it was necessary to remove the mid-point measure in the final survey, as overall the *neither agree nor disagree* measure received the highest participant response rate (Garland, 1991). This was necessary to prompt an *agree* or *disagree* response from participants and gain clearer understandings of participant opinion in the data. Figure 15 illustrates this further.

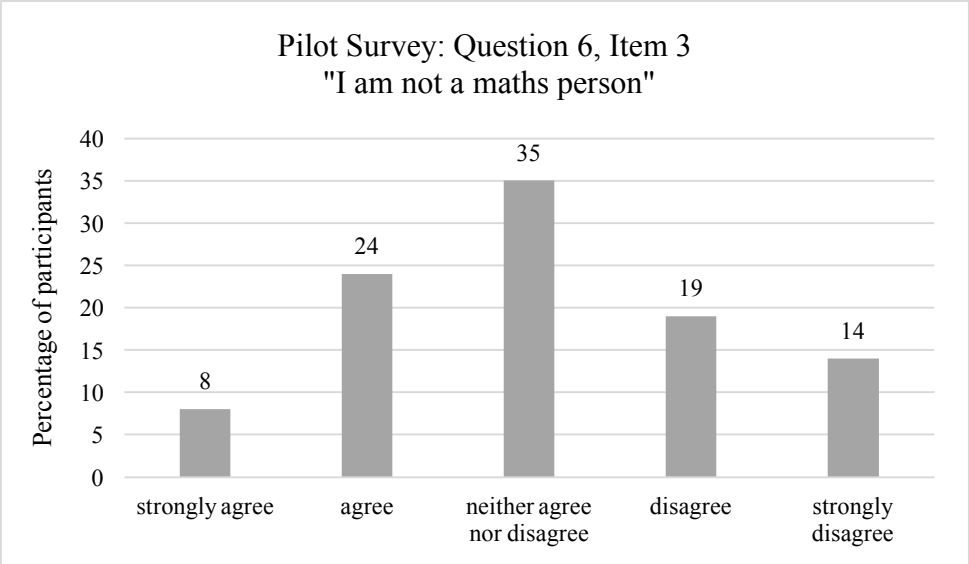


Figure 15. Pilot survey response: Question 6, Item 3.

Removing the mid-point measure prompted participants to make a choice between the *agree* or *disagree* categories, making the distinction between the responses to the items clearer.

Overall, the five pilot survey items requiring Likert-scaled responses received a 99% response rate. The five questions requiring a brief written response received a 29% response rate. Scaled and written responses were therefore combined to prompt a written response and support understandings of the scaled outcomes. This provided qualitative data which, when combined with the quantitative data, added depth of understanding to the participant responses.

Outcomes indicated that 72% of the participants defended play when responding to questions about mathematics and play-based learning, suggesting that mathematics and play were at odds in play-based learning contexts. These outcomes aligned with the research literature (see Section 2.5.1). The pilot survey questions were reworded for clarity, and additional questions about how mathematics was being assessed and taught in play-based programs were added to the survey to address potential gaps in the data collection.

Gaining insights into participants' beliefs about mathematics in early childhood was necessary when comparing the survey outcomes pre- and post-implementation to determine if the implementation had an impact on participant beliefs. This is because beliefs are complex (Beswick & Callingham, 2014; Zhang & Wong, 2015), and survey items that would allow the

impacts of the implementation on participant beliefs to be measured, compared, and critiqued were important to the overall study design.

6.2.2 Pilot Survey Modification

The pilot survey tested each questionnaire item, and the outcomes informed modifications to further understand participant responses about their mathematics teaching practice and beliefs about mathematics. Sections 6.2.2.1, 6.2.2.2, and 6.2.2.3 provide examples from the pilot survey outcomes which explain why modifications were made. The first section focuses on observations.

6.2.2.1 Observations

Pilot survey Question 13 asked participants to provide a written example of what they "would do to find out more about what children know and can do" mathematically. The outcomes for Question 13 are shown in Figure 16.

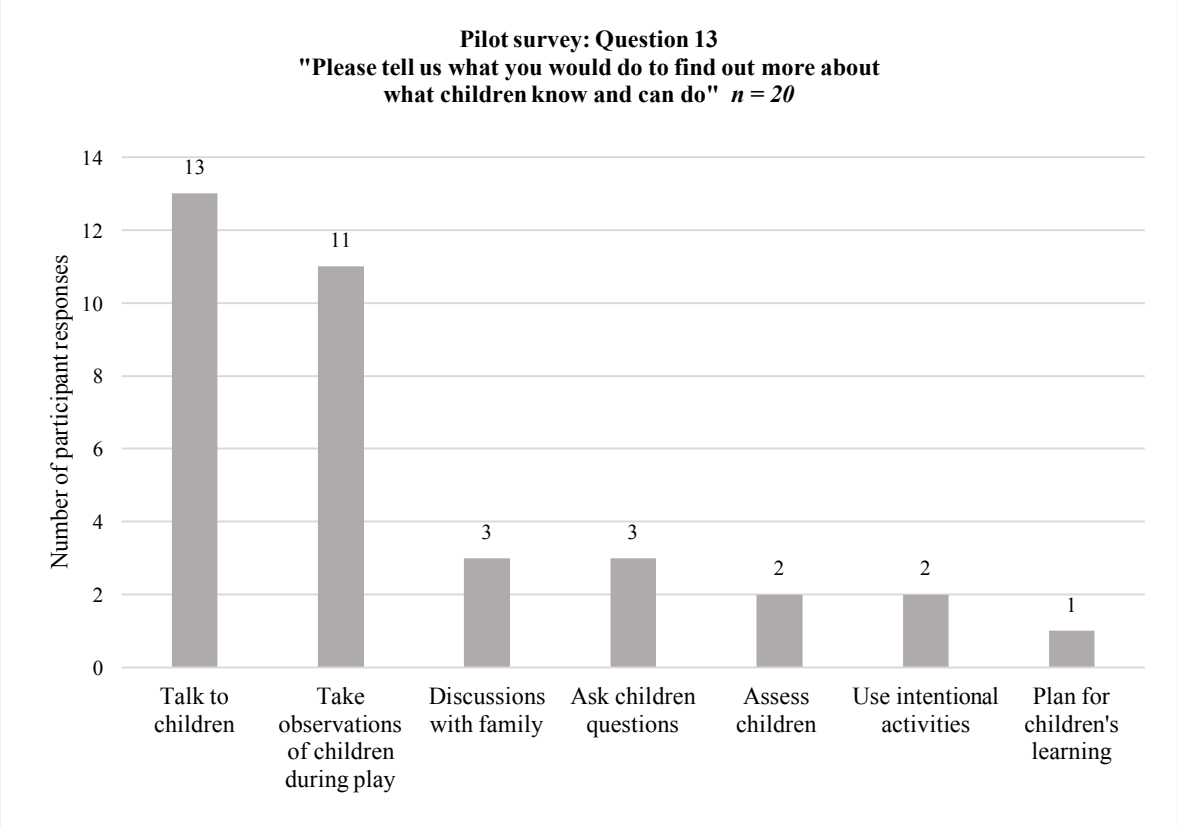


Figure 16. Pilot survey Question 13.

Question 13 required a written response from participants, and 20 responses were received. These responses were analysed thematically, and common themes emerged to describe what participants did to find out more about what children know and can do. The

themes were calculated by the total number of responses (Figure 16). The outcomes for Question 13 revealed that participants were typically assessing children's mathematics knowledge informally during play 55% of the time, and 65% of the participants reported finding out about children's knowledge by talking to children. Further analysis demonstrated that a majority of the observations being recorded were anecdotal and took the form of learning stories, predominantly recorded during play (78%). These learning stories typically formed part of children's portfolios and were used as daily reflections either in the setting or emailed to parents and families. Responses demonstrated that photographs and learning stories were in and of themselves regarded as assessment of children's learning (68%). The pilot survey outcomes demonstrated that links between observations and assessment were not reported, and the use of assessment to find out what children know and can do was low. For example, in Question 13, 55% of participants reported taking observations, 10% of participants reported documenting observations for assessment, and 5% of participants reported using the assessment outcomes for planning to support children's learning. In response to these outcomes, the survey was modified to include questions that requested participants to provide examples of ways they actively sought information about children's existing mathematics knowledge.

The pilot survey outcomes suggested that just over half the participants (55%) reported documenting observations of children's learning; however, there was insufficient data from the survey to know if assessment was directly informing planning. To understand this gap, it was necessary to elicit further information as the gap in the data may have been attributable to the pilot survey questions. Therefore, the final survey was modified to include questions about the assessment of children's mathematics knowledge and how it informed planning to ensure the survey outcomes would contribute towards answering the research questions. Modifications also included a request for participants to provide written examples of their practice, highlighting how observations informed assessment and planning and, in this way, providing a combination of qualitative and quantitative data to understand if and why these gaps in the Early Years Planning Cycle (DEEWR, 2015) existed.

6.2.2.2 Assessment

During daily teaching practice, there is provision for spontaneous learning experiences based on the educator's summative assessment of children's learning, which informs modifications to teaching strategies and content in the moment. However, recording assessment is an essential aspect of teaching practice, necessary to reflect on children's

learning outcomes, document children's learning and development over time, and inform curriculum planning (DEEWR, 2009). Recording assessment also provides educators with a record of their teaching practice and planning, opportunities for critical reflection, and ideas for program planning. The pilot survey outcomes indicated that the critical links necessary between observations, assessment outcomes, and planning were either lacking in teaching practice and not occurring as part of the Early Years Planning Cycle (DEEWR, 2015), or not captured and represented in the pilot survey questions. It was therefore important to elicit further information about the links between assessment and planning to determine if and where the gap existed.

Across the entire pilot survey, the overall outcomes from the 16 questions and 39 item responses suggested that assessment was one of the least significant ways educators found out about what children knew and could do mathematically (10%). Participants also reported links between assessment outcomes and planning as one of the least significant ways to plan for children's mathematics learning (5%). Just over half the participants agreed (51%) that children learnt a great deal about mathematics through everyday play-based activities; however, only 36% of participants agreed that the inclusion of mathematics learning in everyday routines and spontaneous play-based experiences was important. The results also suggested that evidence of children's mathematics knowledge was contingent on participants recognising incidental opportunities to support children's mathematics learning during play, and further, evidence of children's mathematics knowledge was contingent on participants identifying the mathematics inherent in children's explorations and play. The pilot survey outcomes demonstrated that the top three mathematical concepts identified during play were shape, number, and pattern. These three concepts are not necessarily representative of the range of mathematical concepts and ideas children explore innately during every day routines and play (Pollitt et al., 2015).

Pilot survey data demonstrated that participants were observing areas of mathematics traditionally associated with early childhood education, for example, knowing and saying the names of shape, recognising numbers, and counting by rote (Clements & Sarama, 2014). Furthermore, observations were not necessarily linked to assessing children's mathematics understandings during everyday routines and play-based experiences, as the pilot survey outcomes suggested that mathematics was considered a standalone subject, taking the form of a specific mathematics "lesson" that was not compatible with play (Question 6, Item 2).

Therefore, participants were not necessarily looking for evidence of children's mathematical understandings during play and outside of formal mathematics lessons.

Participants (44%) agreed they were not recognising mathematics during children's play unless the area of play was associated with "number", "counting", or "doing shapes", and yet a majority (78%) of all observations took place during play. This indicated the mathematics that occurred during play, but outside the areas commonly identified as mathematics, were seldom recognised. These outcomes suggested contradictions in the enactment of evidence-based planning in practice that warranted further investigation, as the outcomes demonstrated that perceptions of children's mathematics competencies were limited, and furthermore, perceptions of mathematics curricula in early childhood were limiting children's learning.

Twenty-seven percent of participants assumed that the research project was advocating the teaching of mathematics as a discrete subject in early childhood education. This was an important misinterpretation to address, as the research project was designed to investigate play-based mathematics assessment activities in play-based environments. This indicated the importance of highlighting and clarifying the focus of the study on play-based assessment and play-based planning strategies during the subsequent survey and workshop.

The outcomes of the pilot survey suggested that a majority of the observations about children's mathematics knowledge were embedded in teaching practice, with formative assessment and analysis of children's learning taking place spontaneously as an informal adjunct to teaching (56%). For example, four participants made comment that they just "knew the children they taught", and knowledge and assessment of children's learning was "inside their heads" (PS7, 8/8/2016; PS15, 9/10/2016; PS19, 24/8/2016; PS3, 2/9/2016). To avoid speculation, further information was necessary to understand the identified gaps in the enactment of observations, assessment, and planning as highlighted in the pilot survey outcomes, and modifications were necessary to address the pilot survey questions and methods of data collection.

6.2.2.3 Evidence-based planning

Close to half the pilot survey respondents (49%) agreed that children need planned activities to learn mathematics, and yet 64% reported that their observations and analysis informed curriculum planning only "*some of the time*". Nearly half the participants (48%) agreed that they were confident in their ability to observe what children knew about

mathematics; however, as stated, the pilot revealed that these participants were predominantly looking for evidence of children's mathematics knowledge as number, counting, and shape. For example, "Maths is about numbers and timetables" (PS3, 15/4/16), "We look at shape, number, counting" (PS9, 23/4/16), and mathematics is "Knowing their numbers, rote counting, knowing shapes" (PS27, 9/4/16).

These findings were similar to findings from research conducted by Clements and Sarama (2009, 2014, 2017), who reported that educators have a tendency to focus on the naming and recall of mathematical "facts" rather than focusing on children's understandings of mathematical concepts and the relationships between these concepts (Rudd, Lambert, Satterwhite, & Zaier, 2008; Satlow & Newcombe, 1998). This suggested a need to broaden perceptions and understandings of the mathematical concepts explored by children during play, and how best to identify and observe them. This included observing children's processes of understanding rather than a focus on the product of mathematics knowledge and facts. These outcomes further informed the final survey design and influenced the choice of the assessment activities, workshop, and delivery of the implementation. For example, three of the assessment activities were linked to familiar concepts of shape, however incorporated a broader range of mathematical concepts and teaching strategies to support and extend children's explorations of mathematics during play (Moss et al., 2016).

The pilot survey demonstrated how 38 educators were observing and documenting children's mathematics knowledge in six early childhood settings in Melbourne, Victoria. Pilot survey data highlighted the importance of gaining further insights into what educators consider evidence of children's mathematics knowledge, how this evidence is being documented and further, how educators interpret and understand children's demonstrated mathematics knowledge and how this knowledge informs curriculum planning. For example, the pilot survey outcomes indicated that participants were relying on children's verbal explanations to understand children's existing mathematics knowledge. This suggested that when children communicated their mathematics knowledge nonverbally, it was not being recognised. These outcomes demonstrated that participants expected children to verbally articulate their mathematics knowledge, suggesting an assumed association between mathematics competencies and children's capacity to articulate their reasoning verbally. This suggested that unless children were talking about their mathematics knowledge, educator inquiry into how children were communicating their understandings nonverbally was low.

It was therefore necessary for the subsequent study survey to elicit information about the mathematical concepts being identified in children's play and educators' methods of observations, assessment, and planning for children's mathematics learning. The pilot survey also indicated that it was necessary to add questions relating to participants' beliefs about mathematics in early childhood to further understand the relationships between educator beliefs about mathematics and mathematics teaching practice.

In summary, the pilot survey addressed the five key purposes of (1) testing the questionnaire items, (2) determining whether the items were clear and measurable, (3) determining whether the survey outcomes would answer the research questions, (4) identifying and addressing gaps in the survey data, and (5) testing the design of the survey and participant response rate to each item. The outcomes informed the necessary adjustments to ensure the final survey design was robust and comprehensive (see Appendix 18 "Pilot Survey Analysis and Modifications to the Study Survey"). Having presented the outcomes of the pilot survey, Section 6.3 turns to focus on the trial of the instruments for the implementation, including the assessment activities, the assessment records, and the assessment activity guidelines.

6.3 Trial of Assessment Activities, Records, and Guidelines

Three resources were trialled in Phase 1 of the research: (1) a suite of assessment activities, (2) assessment record cards to support systematic implementation of the activities and document assessment, and (3) assessment activity guidelines to support the implementation process. Three participants from three early childhood centres took part in the trial. The goal of this part of the trial was to gain insights into the enactment of the assessment activities through a small focus group of participants. As discussed in Chapter 5, the mathematics assessment activities were designed to support educators in the identification and assessment of children's mathematics knowledge in play-based learning contexts. The activities focused on areas of mathematics that were not always identified as mathematical—spatial reasoning and geometry—but were frequently explored by children during play (Moss et al., 2016). This was important to consider, as research has indicated that high-quality educational experiences in early childhood have a positive impact on outcomes in school and later life (Wylie, Hodgen, Ferral, & Thompson, 2006) and that children's early experiences of mathematics impact their learning outcomes now and in the future (NCTM, 2000b). The play-based assessment activities were designed to contribute toward observing, assessing, and

planning for children's ongoing mathematics learning, as the initial pilot survey outcomes indicated that children's mathematics learning was not being prioritised in program planning.

The assessment records provided support for the systematic implementation of the activities and guidance for participants when identifying children's demonstrated understandings of the mathematical concepts explored during play. The guidelines provided ideas for pre-assessment activities to introduce spatial reasoning and geometry concepts to children, including suggestions for planning, scaffolding, and extensions. The assessment activities, assessment records, and assessment activity guidelines were trialled over two weeks in three Melbourne-based settings (see Section 4.2.4). The trial was important as it provided an opportunity to test the resources with educators in their everyday programs to ensure the resources could be implemented and incorporated into daily teaching practice and planning.

Following the trial, participants provided documented and verbal feedback gathered during semistructured interviews about their experience of

- using the assessment activities during daily practice in their settings;
- using the assessment records to document links between observations, assessment, and planning;
- using the guidelines in conjunction with the activities.

The data provided information about how participants enacted the assessment activities in practice, how the activities supported the identification of mathematics within play-based programs, and whether the materials supported participant observations, assessment, and links to planning. The trial outcomes were used to modify the assessment resources and refine the assessment records and guidelines prior to the implementation phase. Sections 6.3.1, 6.3.2, and 6.3.3 present the trial outcomes of the assessment activities, assessment records, and assessment activity guidelines in detail. First, our attention turns to Section 6.3.1, which presents the outcomes of the trial of the assessment activities.

6.3.1 Trial of the Assessment Activities

Three participants from three centres trialled the assessment activities in their settings. Of the three participants trialling the activities, two reported that the activities aligned with their existing programs, and children engaged in the assessment tasks with educators and peers. Three participants reported "surprise" (AA1, 8/6/16; AA2, 12/6/16; AA3, 4/6/16)

when identifying children's existing mathematics knowledge as they had not realised the extent of children's existing mathematics skills. Two participants also identified children who "should have known more" (AA1, 8/6/16; AA2, 12/6/16). For example, participants had assumed children's mathematics competencies based on assessment outcomes in other curriculum domains, namely, language and literacy. One participant noted the gaps in her centre's curriculum planning, reporting that their room had "a lack of specific planning when it comes to math concepts, I feel we have underestimated the children's knowledge and capabilities when it comes to more complex math language and concepts" (AA3, 8/6/16). Two participants used the assessment outcomes toward children's overall numeracy assessment within their settings, suggesting that the activities were a relevant addition to the existing assessment strategies currently used in their programs, and supplemented assessment outcomes.

Participants reported including the assessment outcomes in parent–teacher interviews for discussion with families, indicating how the outcomes could support educators when providing formal assessment documentation for discussion. Outcomes were reported as being useful for completing Transition and Learning Development Statements (DEEWR, 2009) for children entering primary school the following year. Outcomes from the trial demonstrated that the activities could be modified to link to children's interests, were play-based, and formed part of daily teaching practice and program planning. Section 6.3.2 discusses how the assessment records were used in conjunction with the assessment activities and how the records were integral to data collection and the fidelity of the implementation.

6.3.2 Trial of the Assessment Records

The assessment records were designed to document a range of children's spatial reasoning and geometric capabilities. The assessment record shown in Figure 17 provides an example of how participants implemented the assessment activities and recorded observations assessment and ideas for planning during the trial.

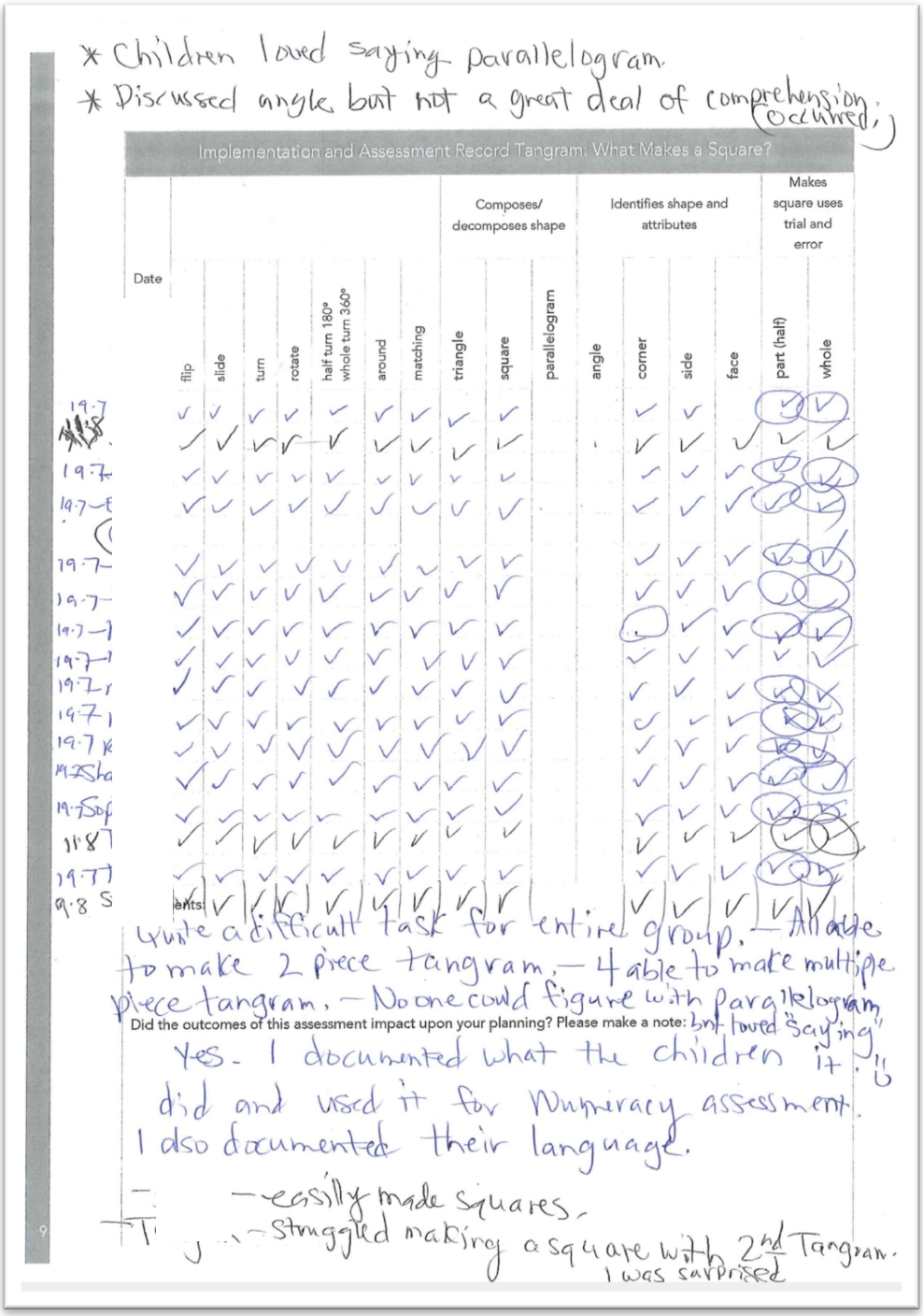


Figure 17. Example of raw data: Completed assessment record (AA, 19/7/16).

In addition to the assessment records provided by participants, a large volume of children's artefacts, observations, and learning stories were submitted as evidence of children's learning. This indicated the need to address what would constitute "data" for the research project, and to keep this bounded, it was decided that the assessment record alone would provide the necessary evidence for analysis. This highlighted the need to address the

assessment process during the first workshop, prior to the implementation of the assessment activities, to focus on how to complete the assessment record, analyse outcomes, and document ideas for and links to planning on the assessment record. Similarly, the trial outcomes revealed that links to planning were at times unclear, and these key points were subsequently discussed with participants during Workshop 1 to address how to use the assessment record for documenting observations, assessment, and planning. Section 6.3.3 discusses the trial of the assessment activity guidelines, which were written to support participants when enacting the implementation of the assessment activities in their settings.

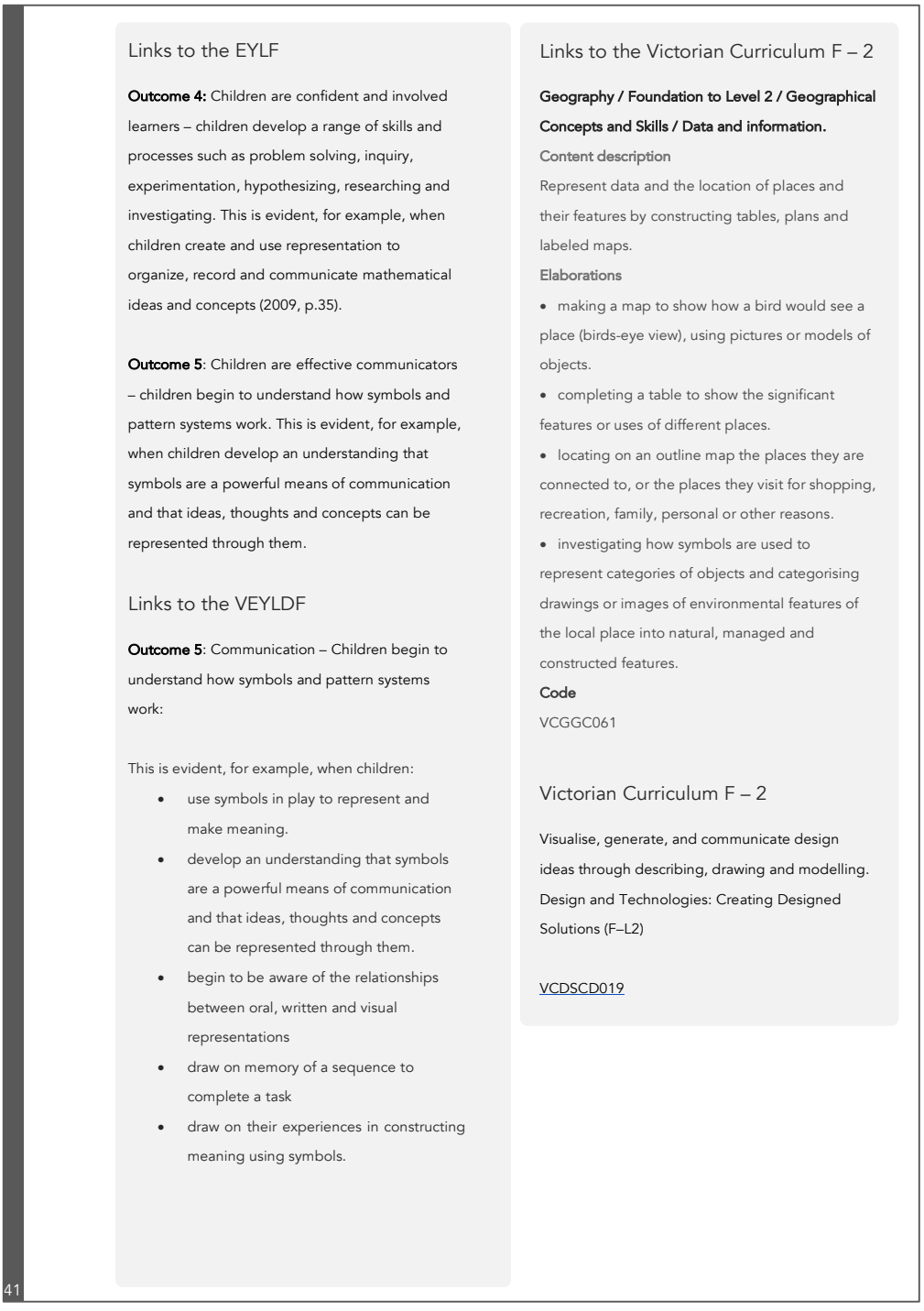
6.3.3 Trial of the Assessment Activity Guidelines

The assessment activity guidelines contained information about each assessment activity. The guidelines comprised an introduction and rationale for each activity, pre-assessment mathematics activities to introduce key concepts and focus mathematical thinking, practical advice for the implementation of the activity, and explanations about how to record the assessment and link outcomes to evidence-based planning. The guidelines also included ideas for extensions and scaffolding to guide participants when planning next steps for children's learning.

The aims of the assessment activity guidelines were thus to support participants during the assessment process in identifying children's current mathematics knowledge, to inform planning next steps for learning, and to provide examples of what the assessment activities might look like in practice. The pilot survey outcomes demonstrated a wide range of responses to conceptual understandings of mathematics and assessment in early childhood. It became evident that it was challenging for some participants when linking assessment outcomes with ideas for planning and in knowing how to scaffold and plan extensions for children's individual mathematics learning (see Section 6.2.2.3).

The first three Levels of the Victorian Curriculum F–10: Mathematics (VCAA, 2017) and the Australian Curriculum: Mathematics (ACARA, n.d.-a), provided a way to link the assessment outcomes with specific mathematics strands, while indicating "where to next" along the child's learning continuum (see Section 1.2.3). Both curricula are used widely in educational settings throughout the state of Victoria; therefore, it was necessary to include both curricula in the guidelines. The assessment activities provided participants with evidence of children's current mathematics knowledge and opportunities to ascertain each child's ZPD (Vygotsky, 1978) with a view to inform planning, provide scaffolding, and support children's individual mathematics learning. The extract shown in Figure 18 from the guidelines

provides an example of how the assessment activity—Mapping Pathways—was linked to the EYLF (DEEWR, 2009), the VEYLDF (DET, 2016), and the Victorian Curriculum F–10: Mathematics (VCAA, 2017). Three assessment activities—Tangram: "What Makes a Square?", Symmetry, and 3D Shape: "Look, Think, Make!"—were also linked to the Australian Curriculum: Mathematics (ACARA, n.d.-a), providing scope for assessment, indicators of progress, and ideas for planning.



Links to the EYLF

Outcome 4: Children are confident and involved learners – children develop a range of skills and processes such as problem solving, inquiry, experimentation, hypothesizing, researching and investigating. This is evident, for example, when children create and use representation to organize, record and communicate mathematical ideas and concepts (2009, p.35).

Outcome 5: Children are effective communicators – children begin to understand how symbols and pattern systems work. This is evident, for example, when children develop an understanding that symbols are a powerful means of communication and that ideas, thoughts and concepts can be represented through them.

Links to the VEYLDF

Outcome 5: Communication – Children begin to understand how symbols and pattern systems work:

This is evident, for example, when children:

- use symbols in play to represent and make meaning.
- develop an understanding that symbols are a powerful means of communication and that ideas, thoughts and concepts can be represented through them.
- begin to be aware of the relationships between oral, written and visual representations
- draw on memory of a sequence to complete a task
- draw on their experiences in constructing meaning using symbols.

Links to the Victorian Curriculum F – 2

Geography / Foundation to Level 2 / Geographical Concepts and Skills / Data and information.

Content description

Represent data and the location of places and their features by constructing tables, plans and labeled maps.

Elaborations

- making a map to show how a bird would see a place (birds-eye view), using pictures or models of objects.
- completing a table to show the significant features or uses of different places.
- locating on an outline map the places they are connected to, or the places they visit for shopping, recreation, family, personal or other reasons.
- investigating how symbols are used to represent categories of objects and categorising drawings or images of environmental features of the local place into natural, managed and constructed features.

Code

VCGGC061

Victorian Curriculum F – 2

Visualise, generate, and communicate design ideas through describing, drawing and modelling. Design and Technologies: Creating Designed Solutions (F–L2)

VCDSCD019

41

Figure 18. Mapping Pathways links to frameworks and Victorian Curriculum.

The assessment activity guideline was refined in response to feedback received after the trial of the resources. For example, key findings highlighted that the activities relied on children having adequate fine motor skills to manipulate the materials during the assessment process. Therefore, links between the activities and gross motor play were emphasised in the guidelines, including large block play, construction, the use of outdoor equipment, movement, and dance. The purpose of the guideline—that it should be used in conjunction with the activities to support links between assessment and planning—were emphasised during Workshop 1. The trial outcomes also indicated a broad range of implementation processes that did not support the intentions of the assessment activities. This included assessing children individually rather than in small-group contexts, or assessing children in large-group contexts whereby children were subjected to long wait times and disengaged with the process. The intentions of the assessment activities and processes for implementation were important to address during the workshop to support participant understanding and implementation consistency.

The trial provided valuable information and insights into the enactment of the assessment activities in practice. Overall, the outcomes of the trial were positive. It was beneficial to conduct Workshop 1 knowing the assessment activities made sense to participants, were useful when assessing children's learning, were engaging, and could be integrated into everyday play-based teaching practice and early childhood programs. Our focus now turns to Section 6.3.4, which discusses how the key points of the trial outcomes informed the design of Workshop 1.

6.3.4 Trial Outcomes and Workshop Design

Data from the trial of the assessment activities and survey informed the design of Workshop 1 (see Appendix 2, "Trial Outcomes Inform Workshop Design"). The workshop focused on how to implement each assessment activity and how to use the assessment records and guidelines in practice. Six key points from the trial outcomes informed the design of the workshop. These key points were emphasised during the workshop and included

- small-group size for assessments to support peer engagement and learning and provide multiple opportunities for assessment;
- the inclusion of mathematics-related vocabulary during assessment;

- links between assessment outcomes and the Australian Curriculum: Mathematics (ACARA, n.d.-a) and the Victorian Curriculum F–10: Mathematics (VCAA, 2017) to support ideas for planning;
- recognition of verbal and nonverbal communication of mathematical ideas;
- using open-ended questions during the assessment process;
- links between the assessment activities and children's interests.

The aim of the workshop was to introduce the participants to the suite of play-based assessment tools and provide a forum for the use of the activities in small groups. This was with a view to facilitating discussion about the resources and to further understand how the activities would relate to participants' understandings of early childhood mathematics.

Based on knowledge and evidence of children in their settings, participants explored and discussed how the assessment activities could be implemented in practice. The workshop focused on play-based strategies to assess children's mathematics understandings, and real-world examples supported links between what was occurring in the workshops and participants' early childhood play-based programs. The assessment activities were purposefully play-based to align with philosophies of how children learn (DET, 2016) and to support the uptake of the assessment activities in existing teaching practice. The workshop was designed to support participants when assessing children's verbal and nonverbal mathematics knowledge in their settings and focused on the use of open-ended questions during the assessment process, to sustain joint attention in the assessment task and provide assessment opportunities.

The following sections focus on four of the key outcomes from the trial in detail. These outcomes informed modifications to the delivery of the workshop, assessment activities and guidelines. These outcomes include the importance of enacting the assessment activities with small groups of children, the use of mathematical language with children as they are engaged in the exploration of mathematical concepts, the usefulness of the curricula in demonstrating children's learning trajectories, and the importance of assessing children's verbal and nonverbal demonstrations of their mathematics knowledge during play. First, Section 6.3.4.1 looks at the significance of a small-group size when enacting the assessment activities in practice.

6.3.4.1 Group size

The assessment activities were purposefully designed for small groups of children to support peer engagement and provide greater opportunities for assessing children's understandings, as when peers interact and discuss their thoughts and ideas within an assessment context, there is the potential to gain insights into children's knowledge from the child's perspective. Trial outcomes indicated that assessing children's mathematics knowledge in small groups allowed participants more opportunities to observe and assess children's knowledge and "ways of knowing" (AA1, 5/6/16). The small-group focus was important as it supported play between peers and, therefore, the assessment was more likely to be child led than adult directed. However, data from the trial indicated that misconceptions occurred, and participants were assessing children individually rather than in small groups. Individual assessment of children was reported as being time consuming and repetitive; however, assessing children individually was not the intention of the activities. When asked, participants reported they had defaulted to the way mathematics assessment is usually conducted, which is one-to-one and generally teacher directed. This outcome highlighted the importance of emphasising a small-group assessment focus when enacting the assessment activities with children. The workshop provided an opportunity to enact the activities with small groups of participants, to practice and support an intentional *and* play-based approach to assessment. The following Section 6.3.4.2 emphasises the pivotal role of the educator when using mathematical language with children as they engage in the exploration of mathematical concepts and how using mathematical language with children supports opportunities for assessment.

6.3.4.2 Inclusion of mathematics vocabulary during assessment

During the trial, participants valued knowing what "mathematical language" to use with children and what to look and listen for during assessment. Naming the mathematical concepts as children were engaged in the activity provided a way to assess children's knowledge, as participants were engaged in the activity with children and responding to verbal and nonverbal communication. This facilitated assessment of children's nonverbal understandings, as children demonstrated their receptive language skills and understandings of the spatial reasoning and geometry concepts without necessarily providing the language to describe what they were doing. The role of the educator was pivotal in providing children with the language they needed to identify and name these mathematical concepts in action as they occurred. In this way, participants were providing children with the necessary

mathematical language to communicate their thinking during play. In the following section, the importance of providing participants with mathematics language, an understanding of children's learning trajectories, and ideas for assessment and planning are presented.

6.3.4.3 Links to the Curricula: Mathematics

Trial participants indicated that the links between the early learning frameworks (DEEWR, 2009; DET, 2016), the Victorian Curriculum F–10: Mathematics (VCAA, 2017), and the Australian Curriculum: Mathematics (ACARA, n.d.-a) were useful, as the curricula demonstrated children's learning trajectories and the expected levels of competency at Foundation, Level 1 and Level 2. In addition, the curricula provided participants with specific mathematics-related language and ideas for planning that were not evident in the frameworks. The curricula demonstrated what type of mathematics children would be introduced to in their Foundation year. Both curricula remained in the guidelines to support participants with ideas for planning. The frameworks also remained in the guidelines and were often supported by additional information from the first three levels (Foundation, Level 1, Level 2) of the Victorian Curriculum F–10: Mathematics (VCAA, 2017) and the Australian Curriculum: Mathematics (ACARA, n.d.-a) to support the identification of mathematical concepts in play, provide links to planning, and provide participants with an overview of children's learning trajectories during their early years education. The frameworks (DEEWR, 2009; DET, 2016) discuss the importance of continuity for children when transitioning across early learning environments, and the provision of the curricula provided a way to demonstrate the types of mathematical concepts and language children would be learning throughout their early years. Section 6.3.4.4 now turns to focus our attention on the importance of recognising children's nonverbal representations of their mathematics knowledge during play.

6.3.4.4 Recognition of nonverbal communication of mathematical ideas

Trialling the assessment activities revealed that participants included children's nonverbal use of movement and gesture to communicate mathematical meaning. This was a significant finding as children were reported as using a combination of "words and gestures" in the assessment records, demonstrating that a focus on "what to look and listen for" was being enacted and identified during assessment. A key goal of the assessment outcomes was to emphasise the importance of children's nonverbal communication, as often—in relation to mathematics—children's nonverbal communication of their understandings remains undetected. The pilot survey demonstrated this further, highlighting that participants mostly looked for children's verbal expressions of their mathematical understandings. The three

participants (AA1, 8/6/16; AA2, 12/6/16; AA3, 4/6/16) reported being surprised at the amount of knowledge children had regarding mathematics and how children expressed this knowledge through combinations of gesture, words, drawing, and movement. These findings also demonstrate that observations of children's mathematics knowledge were at an advanced level, that is to say, beyond what participants anticipated or expected (Pramling Samuelsson & Pramling, 2009).

6.4 Summary

The feedback from the pilot survey and trial contributed to the refinement and development of the assessment activities. To be successful, the activities had to be adopted into routine teaching practice; therefore, the activities were trialled to ensure they aligned with play-based approaches to teaching and learning. The trial demonstrated that the activities could be left in the environment for children to explore, and the activities could align with children's existing interests, for example, symmetry in block play (AA1, 5/6/16), shape composition and decomposition during snack time (AA2, 12/6/16), and symbolic representation and mapping (AA3, 8/6/16). At times, children led the assessment process, filling in the assessment record and using the guidelines with adults and peers. When the activities were left in the setting for children to explore, it made the assessment process familiar and part of everyday routines and play. This was important to consider, as most mathematics anxiety stems from the inherent pressure of being "tested" and getting the answer "right" (Lake & Kelly, 2014). This form of play-based assessment allowed mathematics to be an open inquiry, an exploration, and a discussion held with children, which endeavoured to shift traditional beliefs about mathematics assessment from testing to play. The play-based activities were intended to support children's confidence when engaging with and learning about mathematical concepts. A large part of problem-solving and mathematics involves creativity (Moss et al., 2016); therefore, suggested ideas for assessment were play-based, creative, and engaging. The activities were designed to support participants in the assessment process, which followed the child's interests and was relevant to capturing information about each child's spatial reasoning and geometry knowledge to support their individual learning.

In summary, the pilot survey and trial outcomes identified important gaps in the instruments that were addressed prior to the implementation. Of great significance was the knowledge that the activities could be successfully implemented in a play-based setting and could be enacted during practice, in this way validating the study design. The trial ensured

the materials were ready for implementation and that implementation data would address the research questions. Overall, the trial provided an important opportunity to test how the enactment of the assessment activities in practice would address the gaps identified in the pilot survey, namely, the links between mathematics, play, assessment, planning, and understandings of what constitutes mathematics in early childhood education. Overall, the outcomes of the trial were positive. It was beneficial to conduct Workshop 1 knowing that the assessment activities provided evidence of children's mathematical understandings, worked in play-based programs, were engaging for educators and children, and could be integrated into everyday play and teaching practice. In Chapter 7, the results from Phase 2 of the study are presented. Chapter 7 begins by focussing our attention on the outcomes from the study survey, followed by the results of the workshop and implementation. This chapter also examines how the outcomes address the research questions.

CHAPTER 7: PHASE 2 RESULTS

7.1 Introduction

This chapter presents the results from Phase 2 of the study. The findings from Workshop 1 are presented. The findings from the pre-implementation study survey outcomes are compared with the post-implementation study survey outcomes and address Research Question 1: teaching practice, observations, and curriculum planning. The implementation results are also presented and include frequency of implementation. The results for each assessment activity are presented, and data presented reflect examples that highlight impacts on observations, assessment, and planning. Research Question 2 regarding participant beliefs about mathematics is addressed. Results include participant beliefs about mathematics in early childhood and beliefs about their own mathematics abilities. The findings draw on the pre- and post-implementation study survey, the workshop data, the implementation assessment records, the semistructured interview data and analysis. First, Section 7.1.1 presents the workshop data, before turning to focus on Research Question 1, teaching practice, observations and planning.

7.1.1 Workshop 1 Data

During Workshop 1, participants worked in small groups with the activities to support peer learning, discussion, and engagement. The workshop focused on ways to reconstruct participants' existing knowledge (Spillane, 2000) and support the active uptake of new knowledge in practice. This, at times, proved challenging for participants who, for example, held traditional perceptions about the place of mathematics assessment in early childhood education. These traditional perceptions were linked to experiences of mathematics at school as "time testing" (DC, 23/7/16), being "made to" (MN, 23/7/16) answer questions or recite times tables in front of peers and fear of getting the answer wrong, and "just not getting maths" (TL, 23/7/16), as described by participants in the pre-implementation study survey responses.

Workshop 1 focused on the benefits of assessing small groups of children to support peer interaction and child-led assessment contexts (Smith, 2003). Participants were introduced to the activities and "played" in small groups together, engaging in peer discussion and peer learning to highlight the benefits of a small-group focus—namely, sustained engagement and opportunities for individual assessments in an authentic context. Discussion about linking the activities with children's interests focused on how to do so in

small-group assessment contexts, and participants provided examples of what this might look like in their setting. However, at times, knowledge from the workshop was not enacted once participants returned to their centres, as reports indicated that, like the findings from the trial of the assessment activities (see Section 6.3.1), children were assessed one-to-one, became "disengaged" (OR, 8/8/16), and did not like being "tested" (TL, 12/10/16). These outcomes indicated that the activities were not being enacted playfully or did not align with children's interests. Six participants became frustrated and disengaged with the process. Support and coaching were provided during Workshop 1 and throughout the implementation as a large number of participants (75%) reported negative beliefs toward mathematics and assessment in early childhood.

It became evident that each participant had a different approach to play-based philosophies of teaching and learning, and the implementation had to be flexible to align with individual and centre philosophies. Given survey outcomes indicated participant beliefs about their own mathematics ability were low, it was important for the implementation materials to support participant engagement beyond the workshop environment and for the activities to be enacted in their settings. It was hypothesised that a focus on spatial reasoning and geometry would challenge existing beliefs about what mathematics was and could be in early childhood education. The following section now turns to focus on the implementation outcomes, with a specific focus on Research Question 1, examining teaching practice, observations, assessment and planning.

7.2 Teaching Practice

Teaching practice forms part of the Early Years Planning Cycle (DEEWR, 2015), which includes observations, assessment, and planning for children's learning. Teaching practice formed a significant focus for the research project as it presented a way to address the gaps identified in the research literature, gaps which were identified as existing between educator observations of children's mathematics learning and links to assessment and planning (see Section 2.2.2). The results highlighted the significance of the implementation outcomes in relation to these three aspects of teaching practice: observations, assessment, and planning. The discussion now turns to focus on participant observations.

7.2.1 Observations: Study Survey Results

The results from the pre-implementation study survey indicated that 90% of participants were confident in their ability to observe what children know about mathematics (Figure 19). The subject areas observed by participants were predominantly counting (59%), shape (48%), and pattern (38%). The pre-implementation study survey outcomes demonstrated that participants predominantly used "talk" (69%) to elicit children's mathematical understandings and existing knowledge. It is interesting to note that the pre-implementation study survey outcomes also indicated that participants (69%) saw evidence of children's mathematical thinking as verbal, which included "math talk", "language", "conversations", "discussions", and "math-related words". Examples included asking "math questions" (33%), such as asking children to count (59%), name shapes (48%), and to verbally explain the reasoning behind their thinking (28%). These outcomes correspond to the pilot survey outcomes, which indicated that participants relied on children's capacity to verbally understand and express their mathematics knowledge (see Section 6.2.2.3). The pre-implementation survey findings also demonstrated participant reliance on children's ability to verbally communicate their mathematics understandings, indicating that when looking at the subject area of mathematics, children's nonverbal communication was rarely observed and not often taken into consideration (see Figure 19). These outcomes support implementation data, which also indicated that participants aligned children's mathematics abilities with their ability to verbalise their thinking.

These outcomes were supported further by participants reporting they *never or almost never* asked children to use drawings or graphs to represent their mathematics knowledge (32%), participants *never or almost never* used ICT (60%), and just over half the participants asked children to represent their mathematics knowledge using gesture or movement *sometimes* (57%). This evidence supports the belief that nonverbal demonstrations of children's mathematics knowledge were not being considered as evidence of their learning. This was significant to note given 51% of children attending the 15 services taking part in the study were reported to have English as an additional language (EAL). This is discussed further in Sections 7.4.6 and 7.6.6.

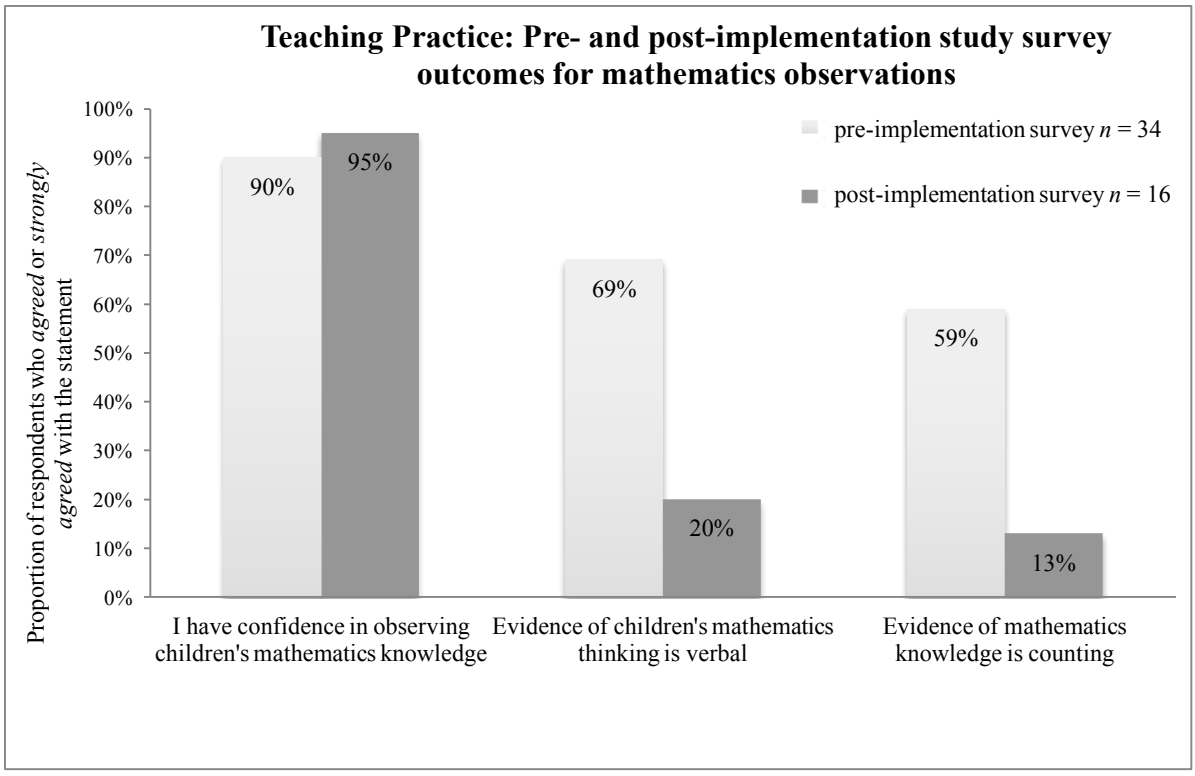


Figure 19. Teaching practice: Observations study survey outcomes.

Of the 34 pre-implementation study survey respondents, 27 participated in the implementation. Of the 27 participants, 16 took part in the post-implementation study survey. The attrition rate is discussed further in Section 7.6.7. At the post-implementation study survey, outcomes for "evidence of children's math thinking is verbal" were significantly lower (20%), which demonstrated that greater recognition and inclusion of children's nonverbal mathematics understandings occurred during observations. These findings are supported by post-implementation survey outcomes, indicating an increase in the recognition of drawings and/or graphs (20%) and gesture and movement (50%) as evidence of children's mathematics knowledge.

To reiterate, the results indicated that prior to the implementation, participants were confident when observing children's mathematics knowledge; however, observations were limited based on children's verbal expressions of counting, shape, and pattern. These findings are supported by the research literature, which confirms that children also represent their knowledge nonverbally through gesture, movement, dance, drawing, and graphs, and that children's knowledge in this subject area encompasses a broader range of mathematical concepts beyond what is commonly and currently being identified in early childhood settings (Cohrssen et al., 2015; Davis & SRSG, 2015; Lake & Kelly, 2014; Moss et al., 2016; Verdine

et al., 2014). However, importantly, at the end of the implementation, participants (49%) reported that they were identifying and observing a broader range of mathematical concepts during play-based practices. This increase in the recognition of mathematical concepts included observations of children's spatial concepts and language (33%) and evidence of children communicating their mathematics knowledge both verbally and nonverbally (37%). Participants also reported children sharing their mathematics knowledge and ideas with their peers as evidence of the children's understandings (18%).

The results indicated that participant confidence in observing children's mathematics knowledge increased slightly by 5% across the four-month implementation phase. Although only a slight increase in confidence, this outcome is significant, as evidence of *what* participants were observing as evidence of children's mathematics knowledge had shifted significantly. Participants reported identifying a broader range of mathematical concepts during children's play, including verbal and nonverbal evidence of positional and directional language (33%) and broader concept areas such as links to mathematics in the child's everyday environment (43%), mapping (27%), and symmetry (20%).

Implementation and survey results demonstrated that participants' observations of children's mathematics learning included combinations of "learning stories", reflections, and photographs. Participants (68%) described photographs of children's artefacts as their observations, which were included in portfolios as a record of children's "learning journey" (DC, 11/10/16) for parents and families. Daily and weekly diary reflections were also used to communicate "snap shots" (KC, 10/9/16) of children's learning outcomes to parents and families. Participants (47%) described the use of reflections and children's portfolios as evidence of children's learning. However, the documentation alone provided little information about assessment of children's learning and how links were being made to program planning. Data from a semistructured interview expands on this further:

> Cohesion is so important and what we are doing and saying, at the moment, is not assessment. I don't agree with it. They are saying our portfolios are assessment and I am saying "no they are not"—no one is actually using our portfolios to inform planning, to form objectives for the children, they are just like [pause] for the parents, as a keepsake to look back on. (HH, 23/11/16)

These outcomes demonstrated the different ways in which participants understood and documented children's learning, the function of observations as evidence of children's

learning and further, how this evidence linked to assessment and planning. How 29% of participants linked observations to assessment and planning remains unclear.

Survey data indicated that a large percentage of participants reported being "time poor" (86%) and unable to allocate time toward mathematics assessment. Finding time for observing children's mathematics knowledge was challenging and difficult to "fit it into the program" (TL, 20/7/16). Significantly, at the pre-implementation survey, a reported average of five minutes per week was allocated to observing children's mathematics learning. Further reports about barriers to observing children's learning included beliefs about the place of mathematics in early childhood, child-centred learning, following the interests of the child, and fulfilling the existing demands of program planning. At the post-implementation survey, observations of children's learning increased from five minutes per week to an average of 20 minutes per week during the implementation. However, for a majority of the participants, time spent on observations and assessment declined once the implementation finished (see Section 7.3.3). The discussion now turns to focus on assessment.

7.2.2 Assessment: Study Survey Results

The findings from the pre-implementation study survey indicated that over half the participants (58%) were confident in knowing the best ways to assess children's mathematics learning; however, a large percentage of these participants (67%) were unsure of how to identify and assess mathematics in their play-based early childhood programs. Just over a third of participants (37%) reported that assessment-informed planning for mathematics learning was occurring in practice *sometime*s (see Figure 20). At the pre-implementation survey, examples of links between assessment and planning were low (11%), and to reiterate, the average time spent on observing and assessing children's mathematical understandings were reported equally as being five minutes or less per week. It was hypothesised that a focus on assessment would support links between assessment and evidence-based planning for learning and highlight the fundamental role of assessment in the enactment of the Early Years Planning Cycle (DEEWR, 2015).

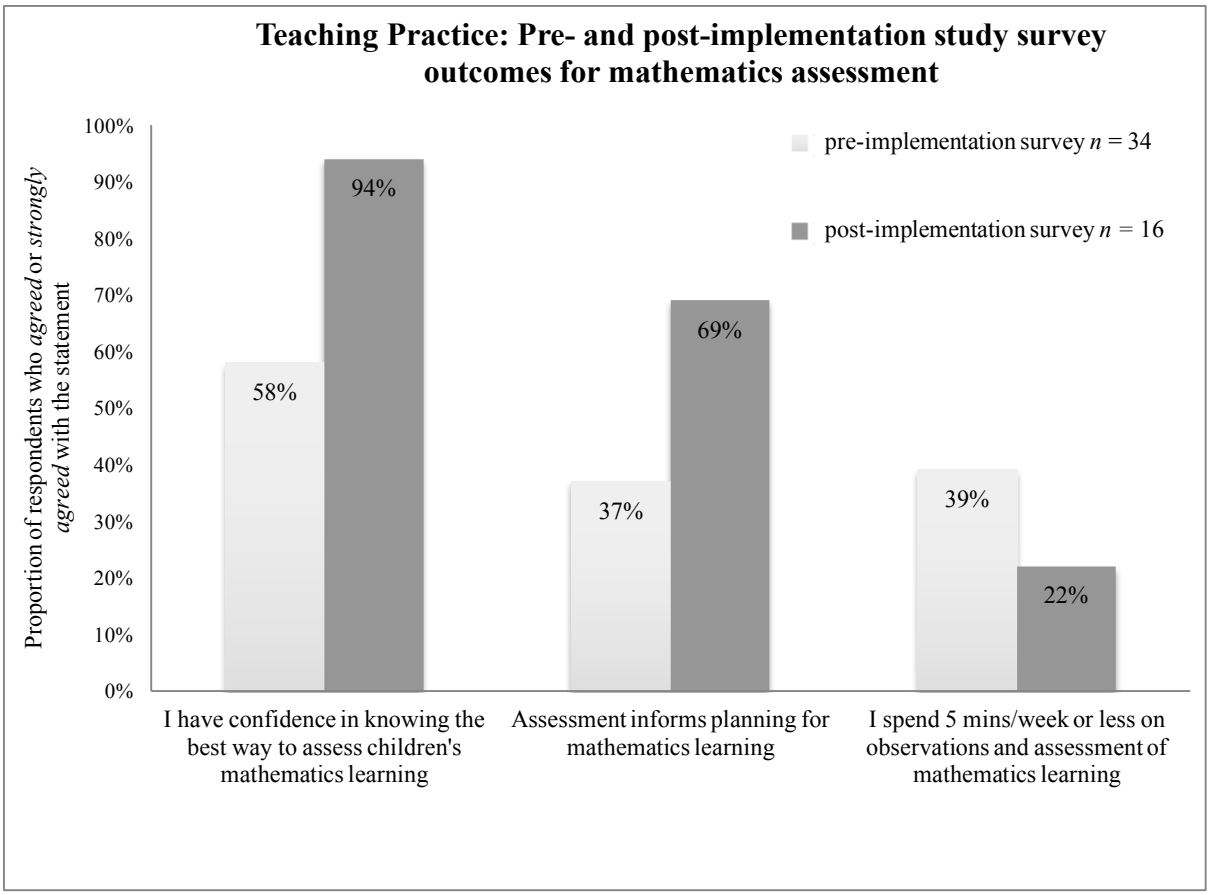


Figure 20. Assessment study survey outcomes.

After the implementation, the study survey outcomes demonstrated that participant confidence in knowing the best ways to assess children's mathematics learning increased by 36%, including an increased understanding of how to identify mathematics during children's play (28%). Participants reported knowing how mathematics assessment informed planning for learning and how to link assessment outcomes with planning, which at the post-implementation study survey had increased significantly by 32%. Furthermore, post-implementation survey outcomes indicated that participants were spending more time on assessment. An average of one hour or more per week was reported as being spent on assessing children's mathematical understandings (86%). This indicated a significant increase in the amount of time being allocated to the prioritising of mathematics in planning.

Figure 21 indicates that when finding out about children's mathematics knowledge, participants asked children to do the following either *never or almost never* or *sometimes* (pre-implementation study survey, Item 15).

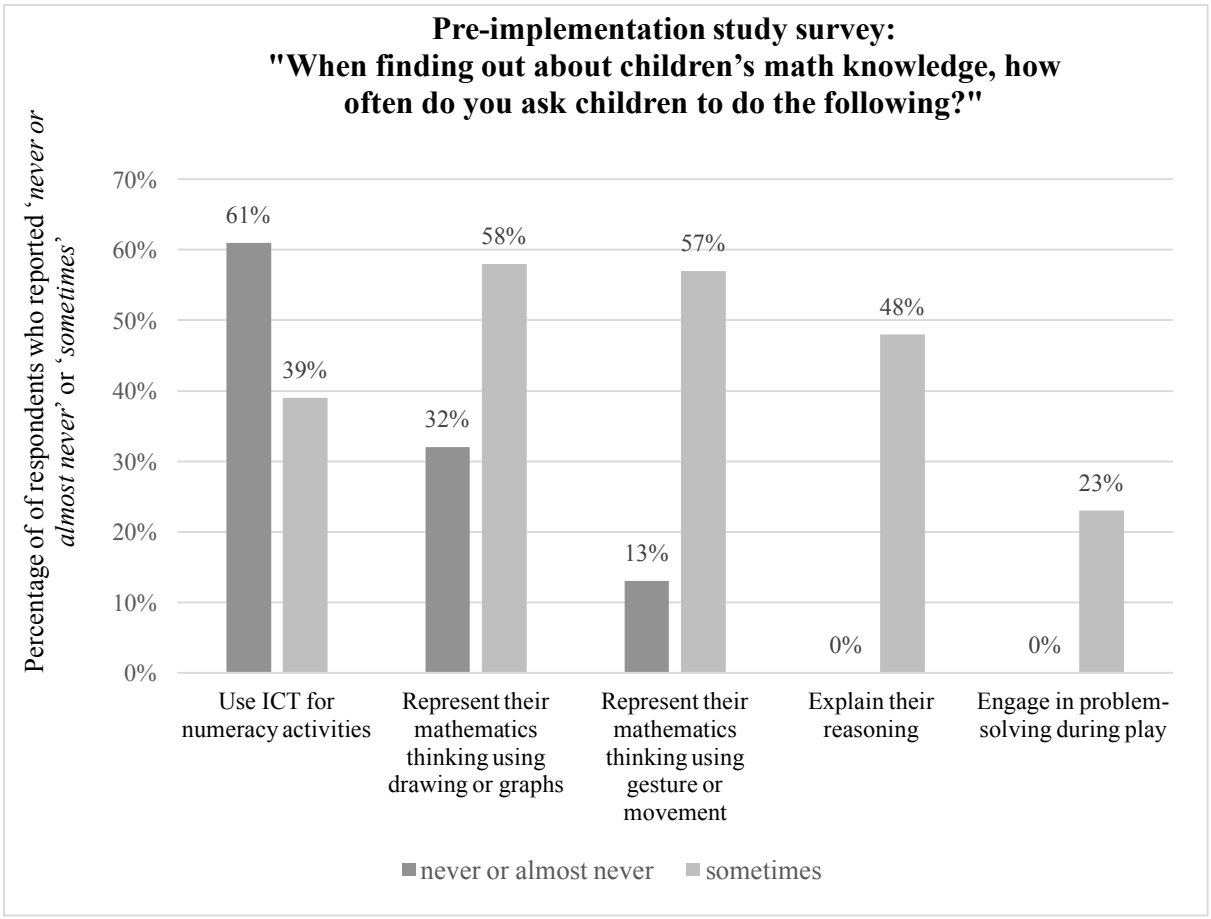


Figure 21. Pre-implementation study survey, Item 15: Participant responses.

The survey outcomes highlighted areas of teaching practice where educators could expand on their engagement with children to broaden their understandings of children's existing mathematics knowledge. These outcomes demonstrated the importance of educators encouraging children to draw and graph their mathematics thinking, incorporate ICT, use gestures and movement to represent their thinking nonverbally, discuss and demonstrate their reasoning, and engage in problem-solving (Niklas & Tayler, 2017). Figure 22 demonstrates the shift in outcomes in the post-implementation study survey.

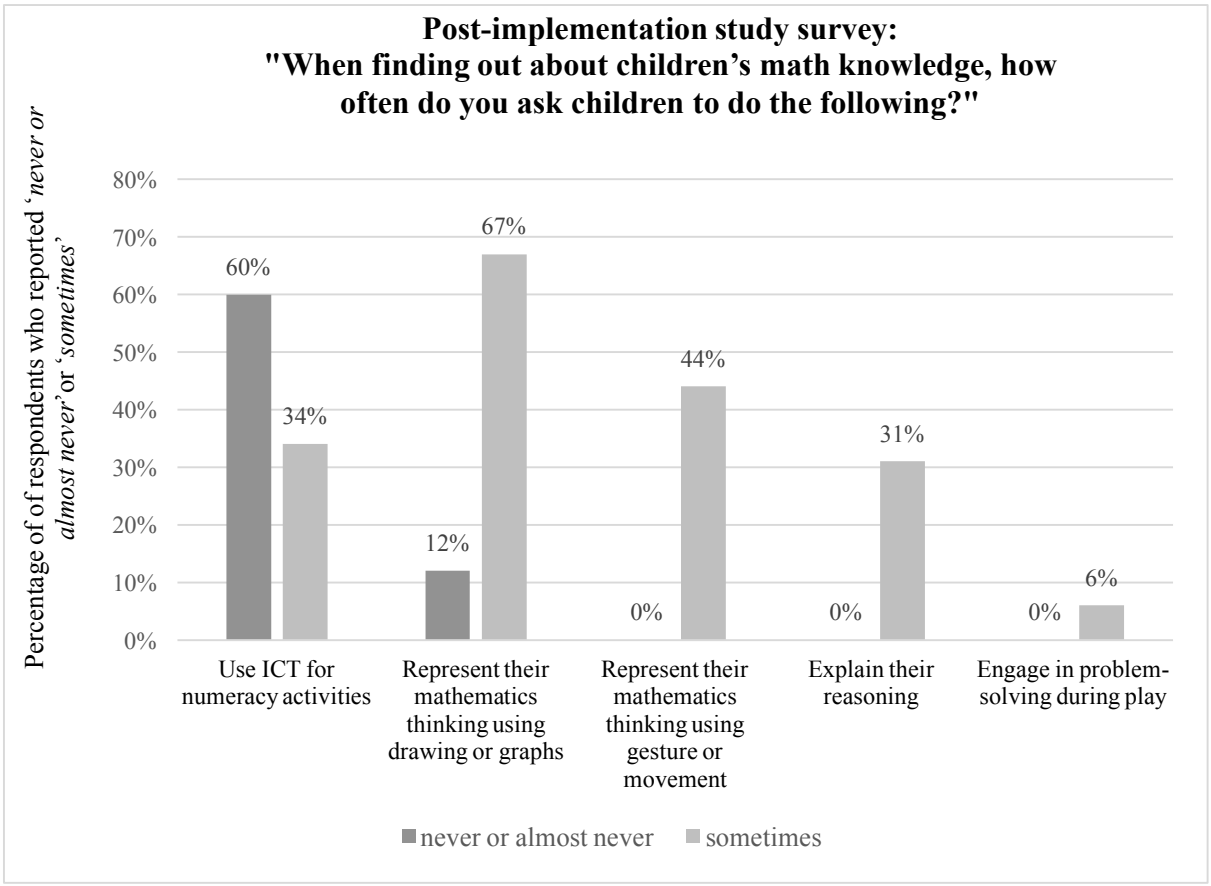


Figure 22. Post-implementation study survey, Item 15: Participant responses.

Notably, the use of ICT for numeracy activities only shifted very slightly; however, shifts in the recognition and assessment of children's nonverbal mathematics knowledge shifted, indicating that participants were recognising the many varied ways in which children communicate their mathematics knowledge during play.

Of further interest were reports from two participants who implemented the assessment activities as both formative and summative assessment tools. The assessments were repeated at fortnightly intervals to monitor children's learning and monitor the impact of their teaching practice and planning on children's learning outcomes. This indicated that the activities could provide participants with evidence for self-assessment and critical reflection on their teaching practice and pedagogy. This was important as in early childhood education, children's successful learning outcomes can reflect high-quality teaching practices, which should be acknowledged in recognition of what works well in practice. Having evidence of children's learning outcomes over time enables educators to see the impact of their teaching and furthermore, understand the significant role explicit teaching strategies play in supporting

children's learning and development in play-based programs. Our focus now turns to planning.

7.2.3 Curriculum Planning: Study Survey Results

The findings from the pre-implementation survey demonstrated that participants (21%) were spending an average of 15 minutes per week planning for children's mathematics learning (Figure 23). This outcome was of notable interest as 39% of participant responses also indicated that time spent on observations and assessment was less than five minutes per week, raising questions about how and what participants were using as evidence to inform planning for children's learning.

The pre-implementation survey responses included references to learning through "play" and "open-ended, play-based activities" which employed "open-ended teaching strategies" in practice (41%). Although a large number of participants (76%) supported children's mathematics learning during spontaneous and incidental play, these participants (42%) also agreed that children needed planned activities to actually learn mathematics. The outcomes indicated a gap between what was reported as necessary to support children's mathematics learning and what was being enacted by participants in practice. Overall, outcomes demonstrated that just over half the participants (55%) surveyed were confident in knowing the best practices and strategies to plan for children's ongoing mathematics learning; however, participants reported doubt in their ability to teach mathematics (68%) and further, reported being unsure of how to teach mathematics in a play-based context (47%).

Just over a third of participants (37%) reported that assessment informed their curriculum planning "quite a lot" indicating a gap in the amount of evidence-based planning for mathematics learning occurring in daily practice, as seen in Figure 23.

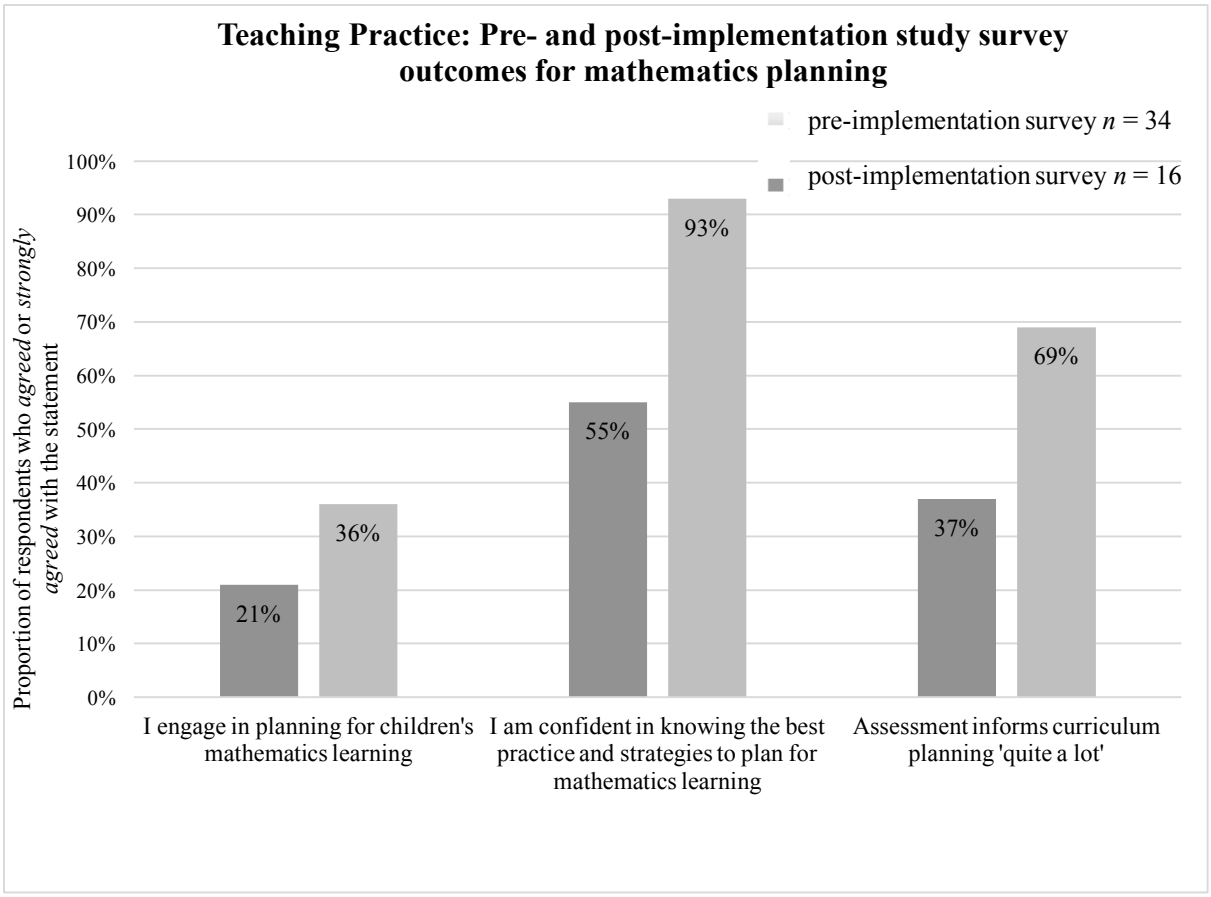


Figure 23. Comparison survey outcomes: Planning.

Post-implementation, participants reported a significant increase in confidence (38%) when knowing what and how to plan for children's mathematics learning during play. This increase in confidence was noted in the implementation outcomes, which demonstrated an increase (32%) in the use of assessment to inform planning. Shifts in the links between assessment and evidence-based planning for learning were evident. This shift was closely related to reported understandings of what children knew *and* understood about mathematics, as the assessment outcomes supported participants when identifying the next steps for planning along each child's learning continuum. Overall, there was a 15% increase in the amount of mathematics planning being enacted in daily practice, and although minimal, this indicated that a small number of participants (eight) were increasing the amount of mathematics occurring in their daily program planning.

Participants (13%) reported that over the course of the implementation, the assessment activities supported the identification of gaps in their own teaching practice and planning. Therefore, by encouraging the use of intentional assessment strategies—which indicated a

small-group focus, peer engagement, and joint attention between the child and the participant—the activities supported understandings of how to link the assessment outcomes to planning. Having discussed the pre-implementation and post-implementation study survey outcomes for observations, assessment and planning, our attention now turns to focus on implementation research and the implementation results in detail.

7.3 Implementation Results

Implementation research facilitates the uptake and enactment of recent research findings into routine practice (Bhattacharyya et al., 2009). Research findings when enacted have the potential to act as a catalyst for change in this area. The nature of implementation research can be unpredictable, and outcomes are reliant on many factors. This research project used an implementation model that endeavoured to support the uptake of new ideas and activities in practice.

To provide a context for the implementation results, it is useful to briefly revisit a sample of the diverse range of centres and participants who took part in the study, illustrating that research in early childhood settings and education is often complex and unique. Of the 15 centres represented in this study, each centre had a different approach to and philosophical beliefs about assessing and teaching mathematics in early childhood. Within each centre, participants also had individual approaches to and beliefs about mathematics and assessment, which at times conflicted with centre philosophies, parent expectations for their children's learning, and the implementation objectives. For many reasons, understandings of "routine practice" differed across the 15 centres, as would be expected in a city such as Melbourne, with significant socioeconomic variation and cultural diversity. Although a small sample size, the 15 centres represented in this study were representative of the sociocultural diversity within Melbourne's early childhood settings and socioeconomic variation among centres. The 27 participants were representative of a wide range of teaching qualifications and experience.

For example, LJ reported that most parents and families of the children in their centre were without access to computers and email, most families did not have English as their first language, and the demands of long working hours on families made communication with parents difficult:

> My families don't have computers or ready access to email, they want their kids to learn to read and write, they want their kids to have what they don't have. They want to know why their kids are not learning how to write, they want to know why I'm

> not teaching that [pause]. Maths is not a priority for these families, they want their kids to know how to read and write. (LJ, 23/7/16)

A high percentage of parents and families attending this centre wanted their children to learn how to read and write in English. This affected the prioritising of mathematics in the centre's program planning and further impacted the time allocated to the research project.

Throughout this study, 23 of the 27 participants enacted the implementation with varying degrees of rigor, and four participants submitted minimal data or none at all. The implementation outcomes were influenced by many factors including participant beliefs about mathematics and assessment in early childhood, beliefs about their ability to teach mathematics, and traditionally held views of what mathematics is in early childhood education. Across the 15 centres participating in this study, data indicated that understandings of routine teaching practice varied widely, and participant definitions of play-based learning ranged from explicit teaching, assessment, and planning to free play without adult intervention. The following section elaborates on the context of the implementation, and discussion focusses on the impacts of the sample on the implementation.

7.3.1 Impact of the Sample on the Implementation

The research project highlighted the diversity among the centres participating in the implementation. This diversity included differences between the provision of indoor and outdoor programs, availability of resources and materials, community and family support, and the range of participant qualifications and experience. For example, one centre voluntarily ran an early morning "breakfast club" when educators realised the demands on working families meant a large percentage of children attending their service did not eat breakfast daily and was adversely impacting children's engagement with their learning (IY, 25/9/16). Another centre reported educators had limited access to one centralised computer with intermittent online access. This limited access to resources and restricted what could be achieved during planning time (TL, 30/8/16). The location, size, and space of each centre also varied and impacted program planning. For example, one centre's program plan was informed by a large outdoor area and access to an adjoining park, and the centre philosophy had a key focus on the environment and sustainability. Children spent more time outdoors; however, educators did not align mathematics learning with outdoor play. BR reported the use of ICT and iPads in their setting, with children having access to robotics resources (23/10/16), and in two other settings, children used interactive whiteboards and computers.

Although ICT was available, a further three settings stated that the use of ICT in their programs did not align with their centre's philosophy.

These examples highlighted the range of access children had to assessment and mathematics in their early childhood environments. This showed that the problem of providing equitable access to mathematics teaching and learning for all children is ongoing and difficult to solve (Cohrssen & Page, 2016; DEEWR, 2009). This points to the need to establish a clearer understanding of what the expectations for an early years mathematics curriculum are, and how clarifying these expectations can support educators in their teaching practice and planning to ensure all children have equal provision and opportunities to explore important and foundational mathematical concepts and learning.

These outcomes illustrated the significant role the research design played in providing an equitable and consistent approach toward assessment and planning for all children within the early childhood settings. The implementation criteria requested that every child be offered the opportunity to take part in each assessment activity. The research design, therefore, provided continuity in these complex environments, which included many varied and diverse approaches to teaching, assessment, and planning in early childhood settings (see Saracho, 2017). The following section focuses attention on the implementation model as it was enacted in practice, and how, through the enactment of the implementation, changes in participant beliefs about mathematics in early childhood became evident.

7.3.2 Enacted Implementation Model

The following example was chosen as it demonstrates how the reciprocal influence of the research model informed the implementation outcomes. QL stated she was "not a maths person" and "hated maths" (12/9/16). The participant implemented the activities because she had committed to the project and reported a "moral" responsibility to complete the research project (23/11/16). She was "made to" take part in the study by centre management to meet annual requirements for the provision of professional development, although this information was not disclosed at the time of consenting to the study (23/11/16). During the implementation of the assessment activities, QL realised she could "do maths" and that "maths is in the everyday" (18/10/16), which QL described as daily routines, such as snack time, preparing for outdoor play, pack-up time, and incidental play in the outdoor environment (18/10/16). This increase in confidence and shifts in beliefs led to a higher implementation rate of the assessment activities, the outcomes had a positive impact on teaching practice, and links between assessment and planning for children's learning were

evident. Witnessing children's positive learning outcomes engaged the participant in the implementation further, as did children's focus on and engagement with the assessment tasks. QL reported "success" when assessing a child who found joint attention and peer engagement challenging, yet the child spent over 40 minutes engaged in the assessment process with peers (15/09/16). QL had not realised that "maths could support concentration" (23/11/016). This led to a shift in beliefs about her own mathematics ability and the potential of a play-based approach to mathematics. QL's confidence about how to assess and plan for children's mathematics learning increased throughout the implementation and included links to literacy, imaginative play, and music. The impact of the implementation on QL's beliefs about her own mathematics abilities and subsequent impact on pedagogy and practice demonstrate the reciprocal nature of change during the implementation.

The implementation of the assessment activities took place across four months, during Terms 3 and 4 of the school year. Participants were required to implement each activity (six in total) with small groups of children across the four-month implementation phase and endeavour to use the activities to assess every child in their setting at least twice. Participants were required to submit the assessment records each fortnight. Over time, the implementation rate decreased; however, this was not always indicative of the quality of the assessment and planning enacted in practice. For example, the first four rounds of data collection demonstrated the highest rate of implementation; however, these first four rounds of data also indicated that links between observations, analysis, and planning were seldom being made (22%).

At Week 4 of the implementation, assessment records demonstrating links between observations and analysis for children's individual planning were minimal and in most cases were not evident or missing from the data. Furthermore, the submitted assessment records demonstrated that there was little evidence of observations, links to analysis, and indication of how assessment informed planning. Of the 27 participants, six (22%) consistently provided evidence of clear links between observations, assessment, and planning for learning across the implementation phase. Of the six participants, only two had studied graduate mathematics. The remaining four participants reported not "liking maths" and having mathematics anxiety in the pre-implementation survey, indicating that the enactment of the implementation had an impact on their beliefs. A further 30% of the participants demonstrated shifts in their teaching practice and began to make links between observations, assessment outcomes, and planning, as evidenced in the data between Weeks 3 to 16 of the

implementation. This section provided insights into how the implementation model was enacted and the demonstrated impacts on teaching practice and beliefs. The following section focuses on the implementation rate and the factors impacting the enactment of the implementation.

7.3.3 Implementation Rate

As the implementation progressed throughout Term 4 of the school year, participants reported being "time poor" (86%) and "struggling" to meet the demands of "busy" program planning and the research expectations (see Appendix 21, "Educators Report Being "Time Poor"). Participants reported being "time poor" as the highest ranking factor impacting their ability to implement the activities, providing a reason for the notable decline in implementation data over time. For example, demands on program planning were reported as preparations for celebrations, parent–teacher reporting, orientation for new children, unexpected staff changes, behaviour management, preparations for festivals, preparing and completing Transition and Learning Development Statements (DEEWR, 2009), illness, lack of centre support, and inadequate materials. Figure 24 provides an overview of the implementation response rate for each round of data collection.

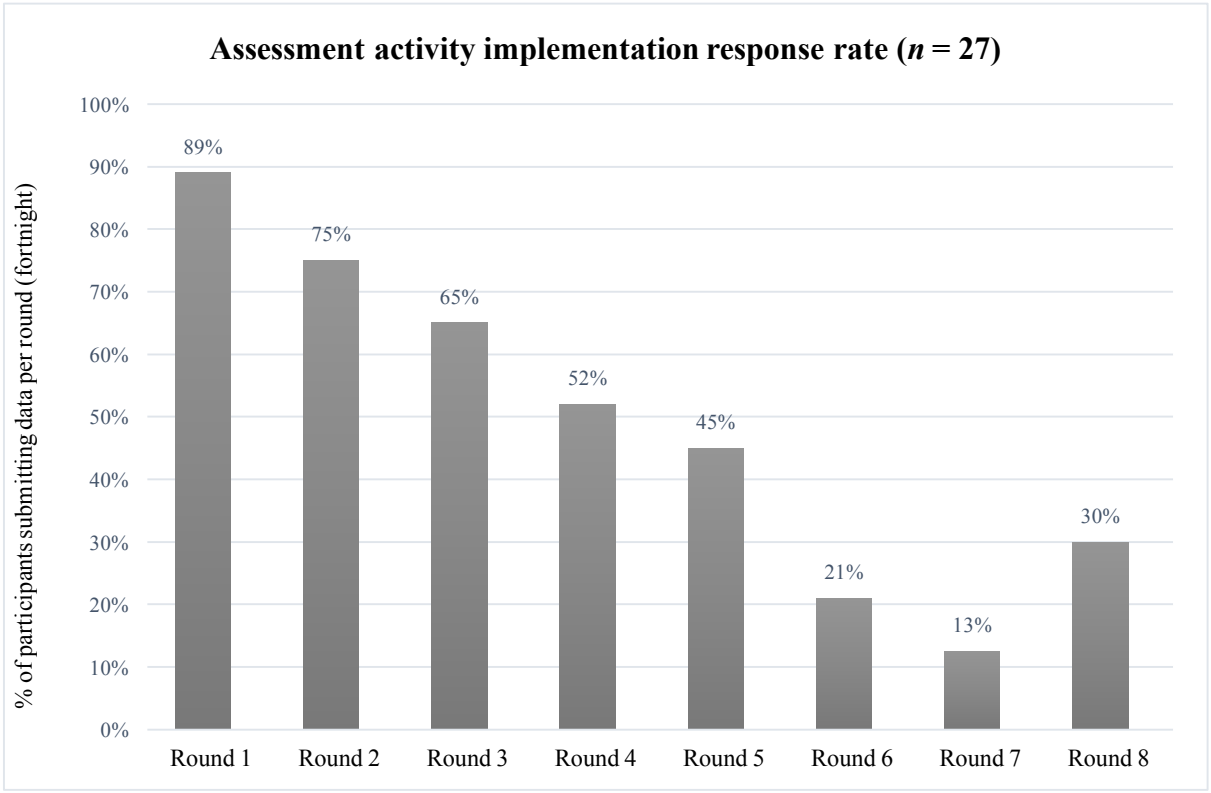


Figure 24. Data collection Rounds 1 to 8, Terms 3 and 4, 2016.

Data indicated that allocated planning time was often encroached on by the demands of the broader program. For example, during her interview, MN was visibly stressed as she spoke about the demands on her planning time, management, and staff ratios: "Everything, everything has to fit into that time [pause]. I have two educators in the room one [pause] but if she is away she is not replaced; I do what she would do as well as what I have to do and I still have to get everything in on time, as well" (MN, 19/11/16). Other participants reported the allocation of planning time was used for scheduling meetings with parents, administrative tasks, missing lunch breaks if staff members were absent, catching up on administrative responsibilities, for example, completing children's tasks and artworks to meet parent expectations of "quality work" (TL, 12/11/16), or supporting children with challenging behaviours. Participants rated being "time poor" as a significant factor impacting the continuity of assessment of children's mathematics learning. The outcomes of the semistructured interviews demonstrated that meeting the demands of their daily program plan was reported as being "stressful" by every participant.

The implementation phase took place during Terms 3 and 4 of the school year, and Term 4 is typically a busy time of the year for educators as demands on their time include the completion of Transition Learning and Development Statements (DEEWR, 2009) for children transitioning to formal school, reports, school visits, children's portfolios, rehearsals for end of year performances, and celebrations. This provided an insight into the contextual constraints of mathematics practice in early childhood programs, as outcomes were indicative of the provision afforded mathematics during the busiest time of the year.

Data further indicated that early childhood teaching was "stressful" (QL, 12/9/16), "demanding" (OR, 3/10/16), and "unpredictable" (NR, 15/10/16), and that "documentation took time away from teaching" (PC, 23/11/16) and further, allocated planning time was "taken up" by administration and parent meetings (HH, 23/11/16). Only 25% of the participants reported receiving support from colleagues and centre management to implement the research project in their settings.

Four participants withdrew from the project: one in Week 1, one in Week 4 due to illness and already feeling "too far behind" (EL, 9/9/16), one in Week 5 because of increasing work-related stress, and another in Week 6, who reported that the activities did not relate to children's interests and therefore the activities were not implemented with children. The participant wrote, "All of our experiences are linked to children's interests and therefore children would have to be showing an interest for us to even consider putting out an

experience such as these assessment tasks" (DH, 8/9/16). This excerpt is indicative of the challenges the participant faced when identifying spatial reasoning and geometry in children's play and linking the concepts in the assessment activities with children's interests. Furthermore, the children did not have access to the assessment activities and therefore did not have an opportunity to express their interest. These findings are in sharp contrast with research literature, which indicates that children explore spatial reasoning and geometry concepts naturally, during play (Clements & Sarama, 2014; Moss et al., 2015; Pollitt et al., 2017; Uttal & Sheehan, 2014); however, when unrecognised by educators, these concepts remain a neglected priority in early childhood education (Clements & Sarama, 2014).

Reported links between mathematics and program planning and reports of incidental moments for mathematics learning were infrequent, for example, during routines or outdoor play. The following example indicates the challenges participants faced when finding time within their programs to assess children:

> The 3D shapes we put with play dough and they used it with playdough, and used it to build and stuff, but again it's really hard as a teacher to spend that time with the children to do this; you can only do so much in a session because we operate an indoor outdoor program so half the children might be inside and half the children outside so you have got one educator who is inside and one outside, so when you are inside having that time to really sit down and focus while you're trying to manage the room and something goes on it is very challenging as a teacher, if you know what I mean, and um, that's what I struggled with to be honest. (TL, 18/11/16)

This example highlights that educator interactions with children are necessary to drive the co-construction of learning and as Whitin and Whitin (2003) wrote: "Materials themselves do not teach mathematics (p. 39). The onus is on the educator to identify and support the acquisition of the mathematical concepts children are exploring during play, and in this way, to drive the learning. However, where obstacles prevent educators from engaging with children in this way—in this example, the challenges posed by supervising children in the context of an indoor/outdoor program—then opportunities to support learning are missed.

Figure 25 demonstrates the rate of implementation per participant. Conducting the implementation during Term 4 of the school year was useful because it demonstrated how children's mathematics learning was planned for during the "busiest" time of the year, indicating the minimum amount of mathematics teaching and learning occurring in program

planning. The implementation was reported by participants (32%) as an addition to an already full program plan (semistructured interviews, 2016); however, beyond the implementation, data indicated that a minimal amount of mathematics teaching and learning was occurring across programs at that time of the school year. As demonstrated in Figure 25, the outcomes highlighted that the priority afforded mathematics learning during the time of the research project was low.

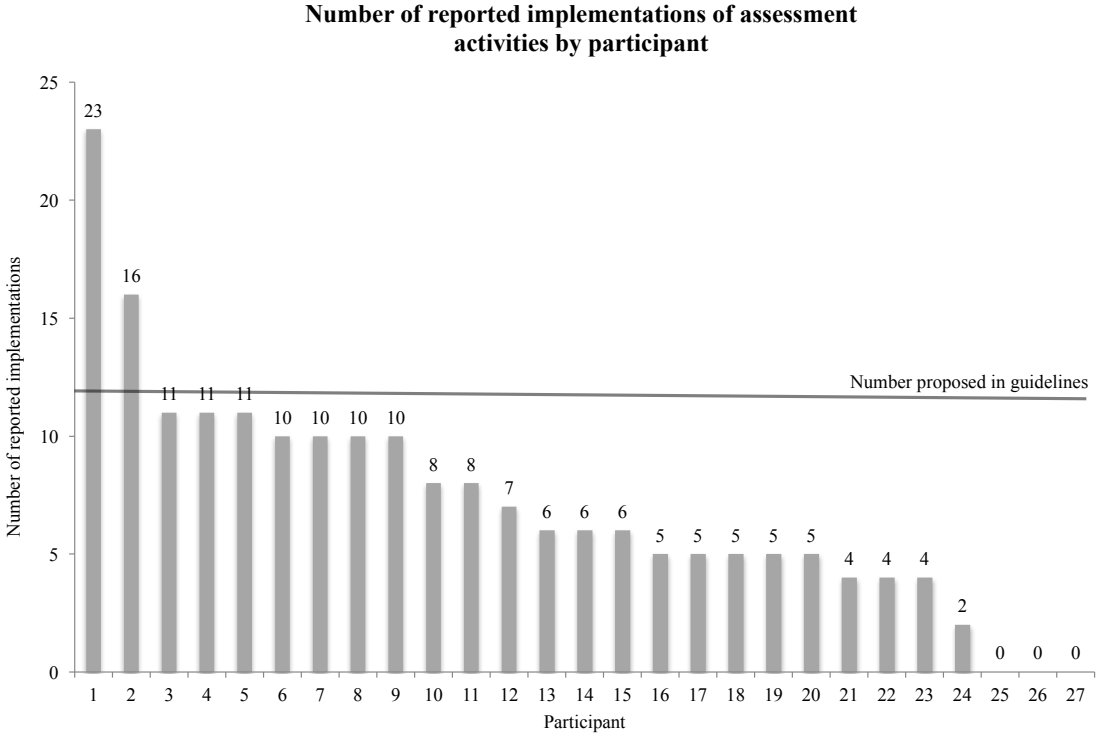


Figure 25. Frequency of implementation per participant.

The findings demonstrated a broad range of implementation outcomes, indicating that the frequency of the enactment of the activities varied significantly, for example, from 23 activities in four months to none at all. Three of the four participants who withdrew from the study did not submit any data.

The quality of observations, assessment, and planning also varied considerably, as data from the implementation demonstrated that there were tenuous links between the assessment outcomes and planning (37%) to no evidence of assessment, analysis, or links to planning having occurred at all (63%). These outcomes also suggested that the rate of assessing children's mathematics knowledge varied significantly between participants and centres, as participants reported that during the implementation phase, the assessment activities were the

main form of mathematics assessment conducted in their settings (semistructured interviews, 2016).

Figure 25 is therefore indicative of the amount of mathematics assessment and planning that occurred at the time of this study. These outcomes also demonstrated wide-ranging differences between the amount of mathematics assessment and planning conducted by individual participants during the implementation. Figure 26 illustrates this variation in detail, as it is indicative of the rate of implementation for each assessment activity by participant:

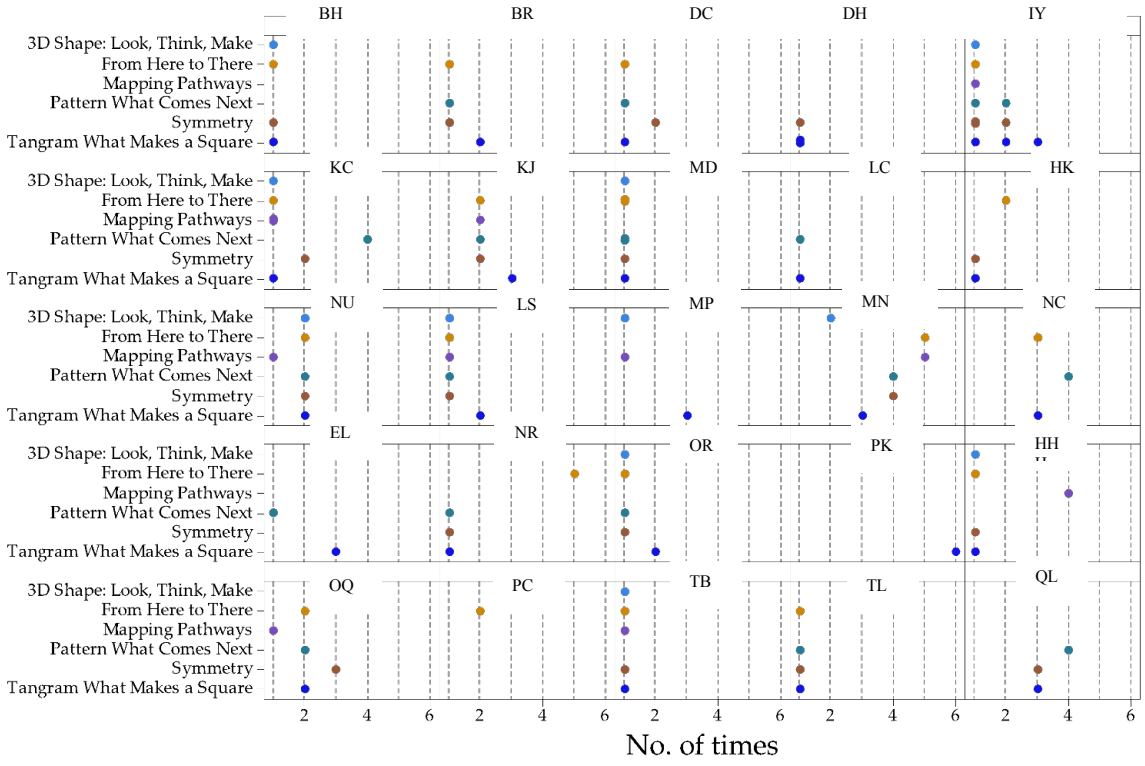


Figure 26. Fortnightly assessment rate of each activity by participant.

The information on the left of Figure 26 lists the assessment activities, and the horizontal axis shows how many times the activity was implemented by each participant, illustrating the variation in outcomes. For example, MP implemented one activity, Tangram: "What Makes a Square?", three times, whereas MN repeated all six activities, some up to five times each during the implementation phase. These outcomes indicated the frequency with which each activity was implemented and overall demonstrated the different implementation rates for each participant across the 15 settings. Implicit in these outcomes is the unpredictability of the quantity and quality of mathematics teaching and learning afforded to children across this sample of early childhood settings. Notably, the top two ranking activities

were Tangram: "What Makes a Square?" implemented 48 times and Pattern: "What Comes Next?" implemented 34 times, which aligned with participant reports (pre-implementation study survey) about shape and pattern being a core focus for children's mathematics learning within their programs (see Section 7.2.1).

Participants' philosophies of teaching and learning at times created barriers toward the implementation; for example, three participants shared a teaching philosophy that focused exclusively on following the child's interests. When explicitly following the interests of the children in her setting, a participant reported that children were not interested in mathematics: ". . . shape, pattern, mapping, geometry, the bigger shapes or the symmetry one" (TL, 2/9/18) and therefore not all of the assessment activities were introduced to children during their daily program.

Participants had between 12 to 37 children attending their settings per week, and reports indicated that the number of children attending their services impacted their ability to assess all children in a fortnight. The number of staff and staff qualifications also affected the amount of support participants received when enacting the implementation. The implementation outcomes varied significantly, as three participants completed up to four assessments in four months, compared to one participant who submitted 23 assessment records and assessed all children (21) in her setting each fortnight. These outcomes indicated that ongoing assessment for children is achievable.

Participants (32%) also reported outdoor play was not associated with mathematics assessment and learning. This indicated how finding time for assessment was challenging for some participants, as within Victorian early childhood settings children are—where possible—encouraged to explore and play in the natural outdoor environment (DEEWR, 2009). These outcomes aligned with participant beliefs about mathematics as an academic subject, not generally associated with outdoor play (32%). However, in contrast to these findings, data indicated that seven participants adapted the assessment objectives for use in the outdoor environment to include patterning on tricycles, mapping, obstacle courses, treasure hunts, and shape hunts during outdoor play.

In summary, the outcomes illustrated a wide range of implementation data. Across the 15 settings, there was variability between what was being implemented and how it was being implemented. Implicit within these findings was the snapshot of the quality and quantity of mathematics learning afforded to children during the implementation phase. Impacts on the

implementation included number of staff in each centre, number of children in each centre, collegiate support for the implementation, participant beliefs about mathematics and assessment, level of qualification, experience, ability to enact the assessment activities, and the available time and priority afforded mathematics in each setting.

Although there was variation in the quality and quantity of assessment and planning, data from the semistructured interviews indicated that participant beliefs about mathematics and assessment in early childhood had the greatest impact on the overall implementation outcomes (78%). This outcome suggested that alongside being "time poor" (86%), participant beliefs influenced the priority afforded mathematics learning within curriculum and therefore the time allocated to mathematics assessment and planning. The following section focuses on the impacts of the implementation on teaching practice and planning, and changes in educator beliefs about mathematics in early childhood education.

7.3.4 Implementation Outcomes: Teaching Practice and Planning

Data indicated that 32% of participants reported an impact on their mathematics teaching practice, 38% reported an impact on their planning, and 42% reported an impact on their observations, knowing what to look and listen for when identifying mathematics in play-based curricula. A large percentage of participants (63%) reported being unaware of the mathematics they were already doing in everyday teaching practice until they identified and named the concepts occurring in children's play. Identifying the spatial reasoning and geometry in play made it visible and therefore recognisable. The following data provide examples of the impacts of the activities on participant teaching practice:

> I did not realise I was doing maths until I named it. It gave me a broader language to use with the children and reminded me that even though they are 4 and 5, you can still use complex terms. You don't need to dumb it down for them. (OP, 9/9/16)

> Being able to explain to parents what maths looks like in an early childhood setting and articulating this in practice was important. (IY, 26/11/16)

> I am doing these things all the time, but did not realise it was maths. I did not associate the words with maths. (LC, 18/8/16)

During the implementation, participants reported an increase in confidence and being less overwhelmed by the thought of teaching the subject in practice. Participants also reported

that having the language and ability to articulate the mathematics occurring in their practice increased their confidence. For example,

> I can do this! I can teach maths [pause]. I had not thought about it in this way before [pause]. I was talking to the maths teacher from primary and telling her what we were doing and she was very interested [pause]. You have given us the language to articulate this in our practice, particularly with parents when they question the learning in play [pause]. We can actually tell them what we are doing and it feels good to see them understand it. (KC, 23/10/16)

and a further example relating to changes in beliefs and confidence:

> I always believed maths was about numbers, about counting the value of something, weighing things, how deep is something [pause]. It is so much more than that—so doing this has been quite valuable for me as an educator; it has almost been like a little in-service I have done. I have changed—it is a lot more than what I once thought it [mathematics] was. Particularly with language next to, beside, on top [pause]. I thought that was just words that we use to describe something, but to understand the mathematical meanings behind that, then you start to become really aware of the words you use with children in their play. (LS, 22/11/16)

The impacts were positive and shifts in participants' confidence were notable. Figure 27 illustrates that impacts on teaching practice and planning were at times significant; however, shifts in practice and planning were not always the same. Data indicate that the enactment of the assessment activities did not always have an equal impact on participants teaching practice and planning, as at times the assessment activities informed planning and teaching practice differently.

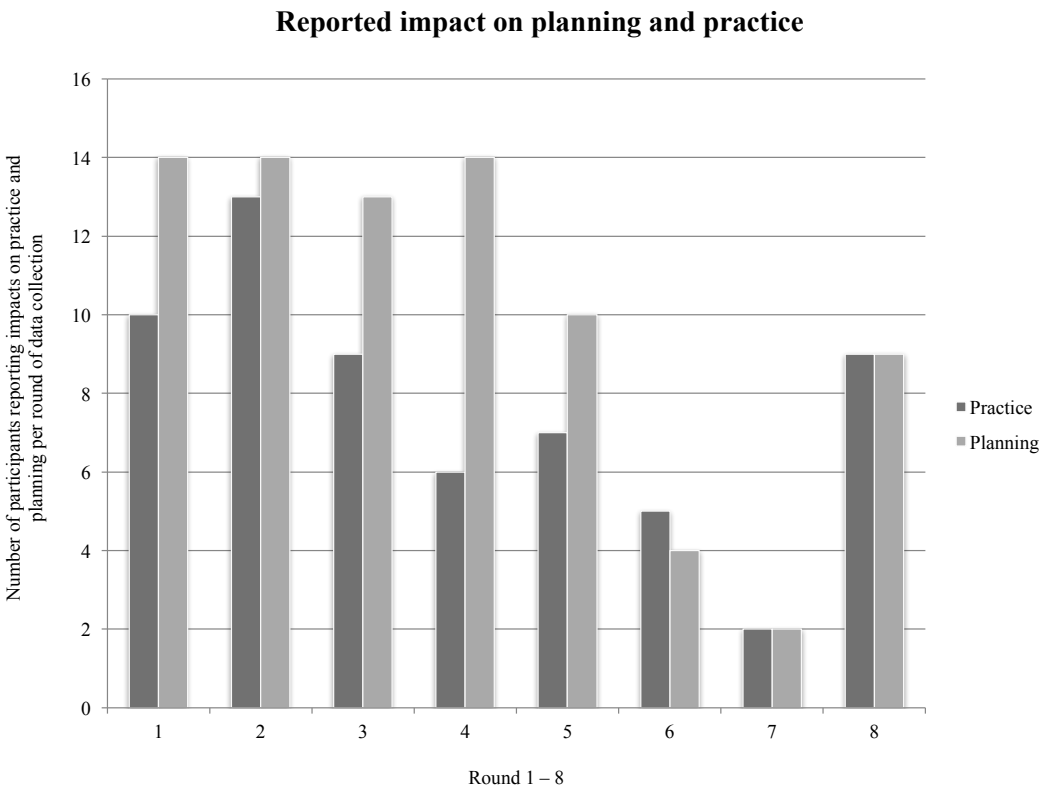


Figure 27. Impacts on planning and practice.

The greatest impact on teaching practice and planning was at the beginning of the implementation when the highest number of assessment activities were enacted. Figure 27 demonstrates that the implementation had the greatest impact on planning, notably at Round 4 when, even though there was a decline in the enactment of the activities, impacts on planning continued to increase. This was for two reasons. First, six participants reported that the assessment outcomes were being linked to multiple ideas for planning and therefore their data submission included multiple examples of planning ideas and ongoing learning experiences. For example, NU took the assessment outcomes from Mapping Pathways to inform planning for coding, orienteering, and robotics. NU reported not repeating the assessment for Mapping Pathways as her 4-year-old group had surpassed the assessment criteria and were "off the scale" (NU, 23/11/2016), engaging in increasingly sophisticated mathematics tasks. NU did not refer to the Victorian Curriculum F–10: Mathematics (VCAA, 2017) and the Australian Curriculum: Mathematics (ACARA, n.d.-a), as the children had met the expected outcomes for Level 3. Therefore, for many participants recorded impacts on planning were significantly higher at Round 4.

Second, 15 participants required mentoring and ongoing coaching to make the necessary link between teaching practice and evidence-based planning, as participants' individual assessment records indicated that by Round 4, the gap between their teaching practice and links to planning was widening for these participants. When teaching practice and planning aligned, it was indicative of the fact that the assessment outcomes generally informed links between practice *and* evidence-based planning, which was the aim of the implementation. Across the implementation, 79% of participants achieved this outcome. Seventeen participants (62%) reported changes to the way they thought about mathematics teaching practice, and 19 participants reported change to the way they planned for children's mathematics learning (70%).

The enactment of the activities had an impact on teaching practice and links to planning for children's learning (Schoenfeld, 2011). This was evident when participants did not implement the activities, as there was no reported change in their teaching practice and planning. For example, one participant's data stood out as she reported believing in the importance of mathematics assessment, play-based approaches toward mathematics in early childhood, supporting children's mathematics learning, and further, the need for play-based mathematics resources. However, the participant did not implement any of the activities and did not submit any data relating to mathematics assessment or planning over a four-month period. The participant neither withdrew from the study nor actively participated in it. During the semistructured interview, she spoke of her anxiety about teaching mathematics, and although she reported beliefs about the importance of mathematics education in early childhood, she did not demonstrate evidence of teaching it. The participant spoke of feeling anxious and diverting children's attention away from mathematics and further, reported an increased heart rate as she spoke about mathematics during the interview. Her beliefs impacted the decisions she made during practice. The data outcomes reflected her conflicting beliefs; however, in this instance, negative beliefs about her ability and fear of mathematics outweighed positive beliefs about the benefits of mathematics education for children.

To reiterate, the implementation outcomes were varied, and the rate of implementation ranged from consistent to none at all. Outcomes were indicative of the amount of mathematics teaching practice—including observations, assessment and planning—occurring across the 15 centres, and implicit within these outcomes was the amount of mathematics teaching and learning occurring for children. The following section discusses perceptions of mathematics as a standalone subject.

7.3.5 Standalone Mathematics

The pre-implementation study survey results demonstrated that in this study, 75% of children explored mathematical concepts either on their own or with peers during play. Participants reported setting up "standalone" numeracy tables for children to explore, which were not reliant on educator intervention for children to "learn" mathematical concepts. Examples of numeracy tables included a puzzle area, a pattern table, a shape-matching activity on a lightbox, and a number (matching quantity and numerals) table for children to engage with during open-ended play. Perceptions of mathematics as a standalone subject remained evident during the implementation, even after the introduction to the assessment activity guidelines, workshop, coaching, and focus on the importance of the co-construction of children's mathematics learning.

In the following example (see Figure 28), data demonstrated how assessment activity outcomes (3D Shape: "Look, Think, Make!") prompted the creation of a mathematics area for children to explore. It was unclear how the participant arrived at these outcomes as there was little recorded evidence of observations and assessment. It was also unclear how the concepts being explored at the mathematics area related to the assessment activity or objectives, which were to create, visualise, and replicate objects made from combinations of 3D shapes. The "Maths Area" included many mathematical concepts: 2D printed shapes, printed algebraic symbols (addition and subtraction), number and counting to 10 with either numerals or fingers, a card relating to angles, a pattern card and materials, one card of printed 3D shapes, and an illustration of 2D and 3D shapes.



Figure 28. Example of a "Maths Area" (KB, 9/4/16).

The participant reported trying to engage children in patterning activities at this table; however, children quickly "lost interest" (LC, 2016). These outcomes highlighted the importance of linking assessment with ideas for planning that are within the child's ZPD (Vygotsky, 1978) and aligned with children's interests to sustain children's engagement in their learning. To achieve this, observations and evidence of what children already know are necessary. The learning objectives in this example are unclear. The Maths Area included a wide range of complex mathematical concepts, including several mathematics strands (VCAA, 2016) for children to explore on their own. However, children require explicit teaching strategies and purposeful planning to support understandings of key mathematical concepts, the meaningful relationships between these mathematical concepts, and their relevance to real-world contexts. This high level of standalone activity was interesting to note, as it was indicative of the gap between the instructional formats necessary to support children's learning and participant beliefs about how mathematics should be taught in early childhood education (Moss et al., 2015; Ramirez et al., 2013; Rosenfeld, 2010).

As discussed in Section 7.3.3, a high percentage of participants reported being "time poor" (86%) with busy programs; therefore, mathematics learning areas were reported as a way of providing opportunities for children to explore mathematics on their own, without relying on adult support. However, the extant literature indicates that children benefit from

the provision of explicit teaching strategies when learning mathematical concepts and developing new skills (see Section 2.2.2). Misunderstandings about mathematics formed in the early years can have a lasting impact on later mathematics learning and achievement (Clements & Sarama, 2014). The attention now turns to the six assessment activities, and Section 7.4 presents the implementation outcomes for each activity in detail.

7.4 Assessment Activity Outcomes

This section presents the outcomes for each assessment activity from the highest to the lowest rate of implementation. Figure 29 is a summary of the number of times each assessment activity was implemented during the four-month implementation phase, ranging from Tangram: "What Makes a Square?" (48 times) to Mapping Pathways (18 times).

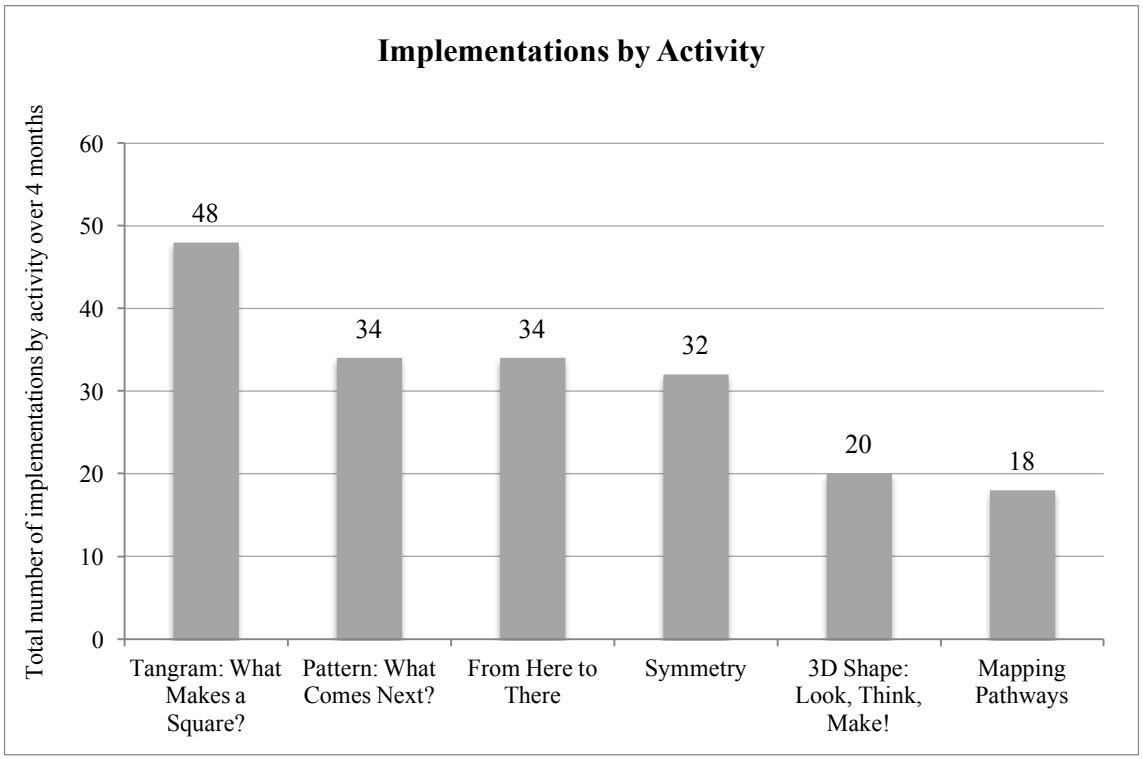


Figure 29. Implementation rate for each assessment activity.

Figure 29 demonstrates that Tangram: "What Makes a Square?" was implemented more frequently than the other activities, which linked to participants' ranking of shape (48%) as the most frequently observed and named mathematical concept in their settings, therefore already familiar to participants in practice. It was noted that most participants (95%) enacted Tangram: "What Makes a Square?" first, and this rate of implementation may have been influenced by the novelty of the assessment activities and research project. This may have been influenced further by the fact that Tangram: "What Makes a Square?" was listed first in

the guidelines, even though participants were encouraged to implement the activities in an order that suited their program planning and aligned with children's interests.

The following sections present the results for each assessment activity in detail. Examples were chosen from the data that demonstrate optimal assessment outcomes and links to planning. Optimal outcomes occurred when the assessment activities were enacted with small groups of children, the assessment activities and assessment objectives included children's interests, the assessment records were complete and linked to planning for learning, and participants engaged with children during the activity. The focus now turns to the assessment activity Tangram: "What Makes a Square?"

7.4.1 Tangram: "What Makes a Square?"

Children were introduced to the storybook *Grandfather Tang's Story* (Tompert & Parker, 1997) as an introduction to Tangram: "What Makes a Square?" Children were encouraged to compose and decompose the shapes of a tangram to create their own ideas, animals, or objects, as depicted in the book (see Section 5.2). An example of Tangram: "What Makes a Square?" as enacted during the implementation is shown in Figure 30.

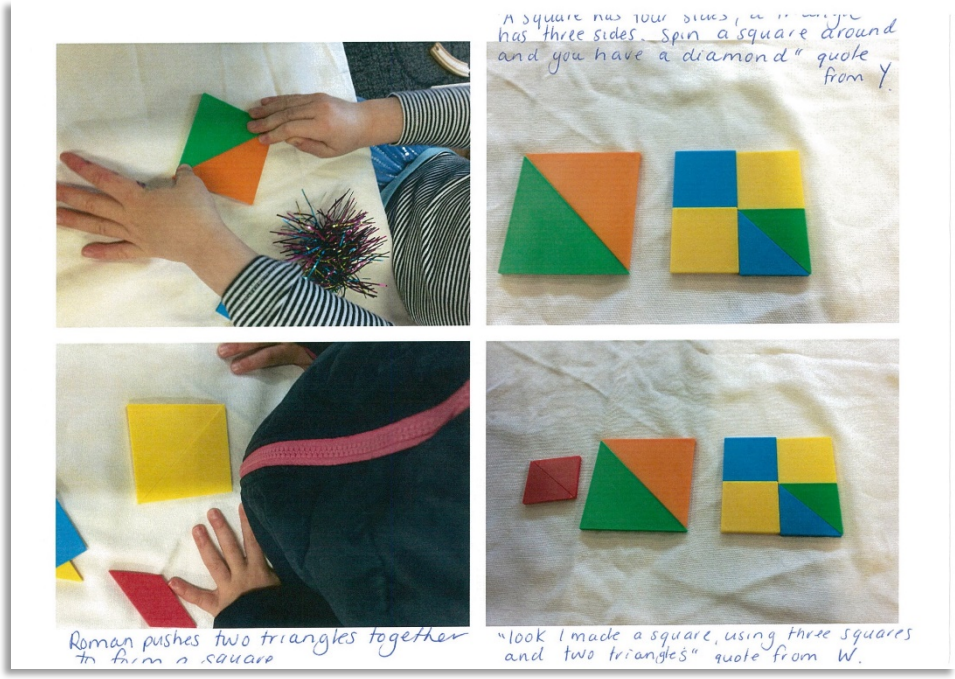


Figure 30. Tangram: "What Makes a Square?" (LS, 5/8/16).

This artefact was submitted with the assessment record and demonstrated children's composition and decomposition of shape, positional and directional language, and a high

level of sustained engagement (two sessions, each 30 minutes or more). The participant reported the following outcomes:

> E loved this experience. E is usually a whirlwind, stopping rarely. This experience with him was incredible. Both sessions we worked together for at least 30 minutes [pause]. The space on the floor provided no restrictions for E to spread out and really explore the shapes [pause]. We will revisit these shapes again and introduce more of the language. (LS, 2/9/16)

The assessment record demonstrated the language and gesture used by children to communicate their explorations and understandings of shape, including the attributes of shape and how groups of smaller shapes could be combined to make larger shapes. Sustained engagement in the activity provided extended opportunities for assessment, resulting in planning to support children's understandings of the attributes of shape, introduce more positional and directional language, and the potential to introduce number, counting, algebraic language, and symbols (three squares plus two triangles):

> A square has four sides, a triangle has three sides. Spin a square around and you have a diamond. (Y, 5/8/16)

> Look I made a square using three squares and two triangles. (W, 5/8/16)

> R pushes two triangles together to make a square. (LS, 5/8/16)

Implementation data indicated that children engaged with the ideas in the book *Grandfather Tang's Story* (Tompert & Parker, 1997), made animals and figures by composing and decomposing shapes, and further, were linking their learning to their environment, everyday routines, and play. For example, during breakfast, a participant identified an incidental opportunity to reinforce concepts of shape with a child who recognised that, like using a tangram, a square piece of toast cut into quarters could make a rectangle, and that the four smaller squares made up the larger square of toast. The participant reported that a week later, the child re-engaged with Tangram: "What Makes a Square?" and referred to the composition and decomposition of the shape as being "just like toast" (IY, 5/8/16), as seen in Figure 31. Children also explored their understandings of fractions: "When we were having breakfast, we spoke about cutting the square into equal halves and then quarters. We introduced the shapes of triangles and rectangles or the quarters being triangles or squares" (IY, 5/8/16).



Figure 31. Tangram: "What Makes a Square?" (IY, 5/8/16).

The results indicated that children could quickly master these skills and apply these concepts in different contexts. When the participant engaged in explicit teaching strategies to support children's understandings of flip, rotate, and turn, the outcomes—after a three-day interval between assessments—provided evidence that in a very short time, children had mastered these spatial reasoning skills. The focus now turns to Pattern: "What Comes Next?"

7.4.2 Pattern: "What Comes Next?"

Pattern: "What Comes Next?" explored structural and mathematical understandings of pattern and was implemented 34 times, ranking equal second with From Here to There. When implementing this assessment activity, participants were encouraged to use natural materials and familiar objects from their programs to adapt the activity to suit children's interests and ability (see Section 5.4). Participants reported going on "pattern walks" (KC, 12/8/16) and "shape treasure hunts" (LJ, 5/8/16) and focusing on mathematical language (first, second, third, odd, even) when recognising pattern structure and emphasising the attributes of pattern as recognised in children's play. Participants linked explorations of pattern with children's interests, including the use of interactive white boards, patterns in movement and music, singing, painting, sandpit play, and drawing on the iPad.

Participants (17%) reported that their understandings of mathematics in pattern and their capacity to identify the attributes of pattern had increased. Three participants noted children's preference for gross motor outdoor explorations during play and modified their teaching strategies and planning to support children's interests when engaged in the assessment task. For example, participants used buckets and spades during sandpit play to create repeating patterns, a movement pattern on a trike, movement patterns during dance, and repeated cycles of movement around an obstacle course. This demonstrated that the assessment objectives were transferrable to objects and movement to follow the interests of

the child, yet still met the assessment criteria. These outcomes also highlighted the unique ways children explored their understandings of these concepts, indicating the need for flexible play-based methods of mathematics assessment. For example, as seen in Figure 32, artefacts from Pattern: "What Comes Next?" show that children's understandings of pattern are sometimes linear, vertical, and can continue around corners.

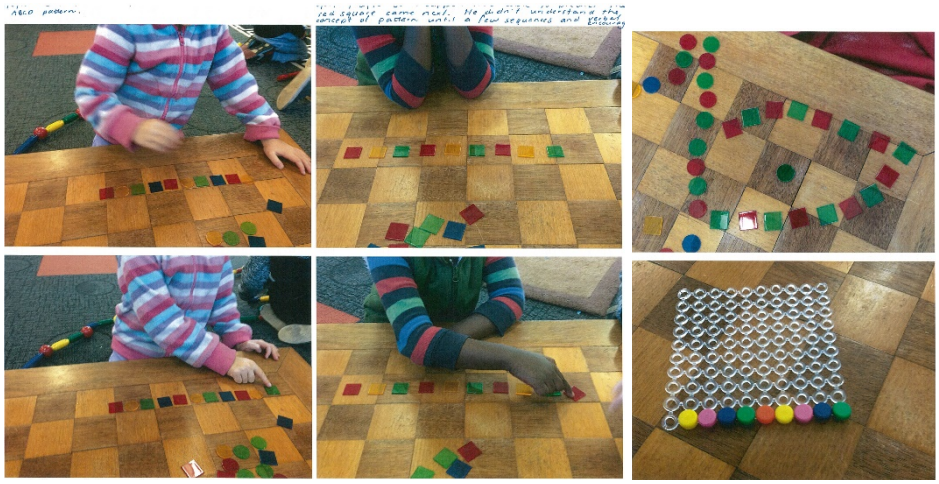


Figure 32. Pattern: "What Comes Next?" artefacts (LS 2/9/16).

Participants (47%) reported that observing children's "emergent" mathematical understandings across other curriculum domains demonstrated the interrelatedness of mathematics across curriculum, for example, science, art, language, and literacy. Participants reported the unique ways children were exploring these concepts. This demonstrated how the activities could be integrated into children's open-ended explorations and play, and that the activities were being enacted playfully and with flexibility. The following example highlights this further, as BR wrote,

> M was at the drawing table the day after [completing the assessment activity] and was drawing large rectangles (as borders) around a piece of A4 paper. She alternated between two colours and then said, "It's a colourful pattern". (6/9/16)

Data reflected that participants were more aware of and intentionally looking for evidence of children's mathematical understandings across broader curriculum areas. For example, KC wrote about introducing pattern to her 4- to 5-year-old group during a pattern walk, during discussions at group time about sitting "boy, girl, boy, girl", and during explorations of sound patterns. These explorations of pattern included mathematical language, children's interests, and ideas for further planning that ranged from the use of

recycled materials to the digital "smart board" (19/8/16). KC reported the impacts of the assessment activities on her planning, demonstrated in Figure 33.

> Yes, [the assessment activities] definitely did inform my planning—planned to do movement patterns in music & also use symbols to represent meaning. Noted some children need to have mathematical language: odd, 1st, 2nd, before reinforced. Observed an increased awareness and recognition of pattern. (KC, 19/8/16)



Figure 33. Pattern: "What comes next?" artefacts (KC, 19/8/16).

Evidence suggested that the activities could be introduced in small- or large-group settings (see Figure 34). For example, LS introduced the concept of repeating pattern during group time prior to assessing children's understandings in smaller groups.

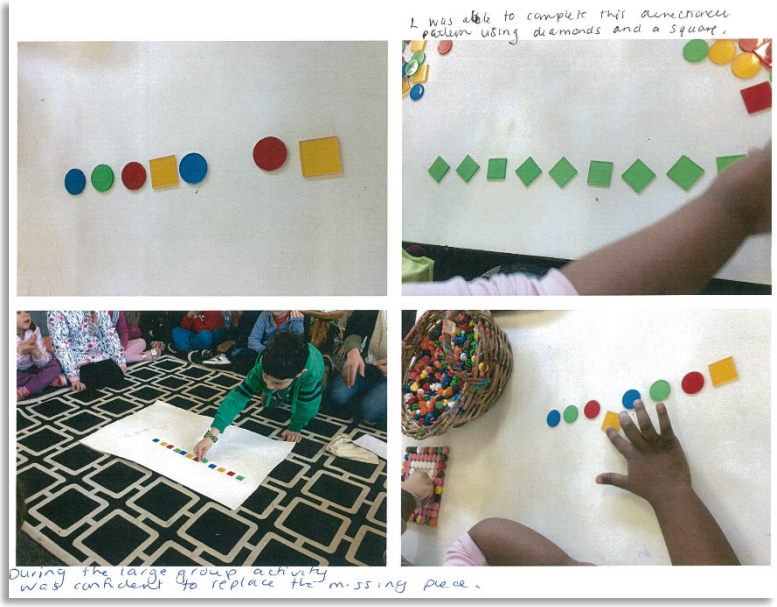


Figure 34. Large-group activity (LS, 24/8/16).

Children began to recognise pattern in the environment and linked their knowledge to real-world concepts. LS wrote,

> Later in the week we found a caterpillar in the garden. W quickly pointed out black and red striped patterns on the caterpillar's back. This would not have been noticed if the concept of pattern was not introduced earlier in the week. After observing the children's enjoyment with working with patterns and after finding the caterpillar in the garden we continued to search the environment for more patterns. I was surprised to see how quickly the children understood this concept. (24/8/16)

One of the key tenets of a play-based curriculum is that it is founded on the interests of the child (DEEWR, 2009). The assessment outcomes demonstrated that the mathematics concepts in Pattern: "What Comes Next?" could be linked to children's interests and used to inform planning in a way that aligned with existing play-based philosophies of learning. The following section discusses the outcomes of From Here to There.

7.4.3 From Here to There

From Here to There was based on concepts of position and direction (verbal and nonverbal) (see Section 5.6) and ranked equal second with the implementation of Pattern: "What Comes Next?" (34 times). Although implemented as frequently as Pattern, From Here to There elicited the broadest range of assessment outcomes. For example, almost half the participants (47%) were initially unaware that positional and directional language related to mathematics. The range of assessment outcomes included the following: making an obstacle course to expand on positional and directional gesture and related language, links to storytelling and literacy, sharing the activity with family to support home learning, and in one example, planning to make a stop motion film with children to expand on their learning (see Figure 35).

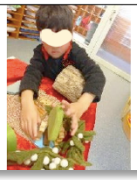
16.10.2016 M (5.1)	 	"The kangaroo is on the log, the Koala is in the water." *Can you put the koala inside the tree?* "Inside...no!"
16.10.2016 Y (4.7)	 	"S, where are the animals? Do you know where they are?... behind the tree?" Y questioned me while she was moving the animals around.
16.10.2016 A (5.11)	 	"Behind the tree, in the water, over the log."

Figure 35. From Here to There (TB, 16/10/16).

In Figure 35, the assessment outcomes were visible and measurable. The participant engaged with children during the assessment process and reported her enthusiasm when identifying children's existing knowledge and observing changes in children's learning outcomes over time. This can be linked to research conducted by Brown and Inglis (2013), who suggested that an educator's "professional growth" (p. 13) is affected when seeing the impact of their teaching reflected in the learning outcomes of the children they teach. Further, observing growth in children's learning and development is a key motivator for teaching (Lake & Kelly, 2014). The assessment outcomes provided evidence and confirmation that the assessment, planning, and teaching strategies enacted by the participant were having a positive impact on children's learning outcomes. When the activities were consistently and rigorously implemented, the outcomes provided participants with ongoing evidence of the impact of their teaching on children's learning. Participants (12%) reported a sense of achievement as the assessment records documented their success over time; this had an impact on participant confidence and engagement with the activities.

Figure 36 highlights NU's achievements in supporting children's learning outcomes. NU worked with children to brainstorm positional and directional words and together they created a mind map, prior to engaging in the assessment activity. NU wrote, "We compiled a mind map of all the directional words that we could think of. I later challenged the children to use their directional words with their parents at home" (NU, 9/10/16).

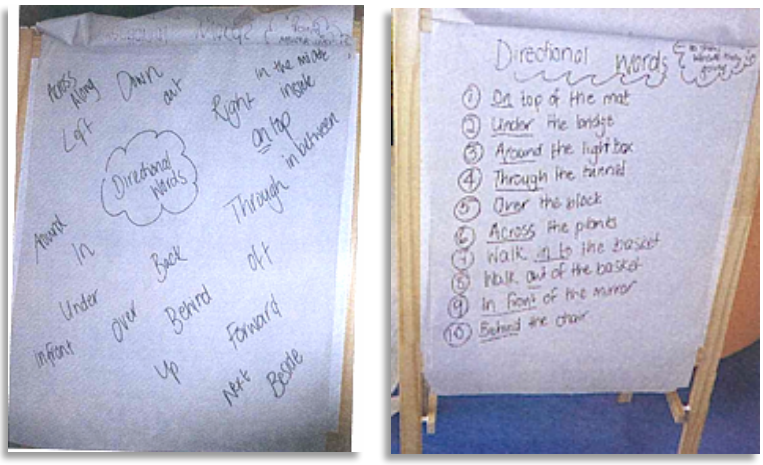


Figure 36. From Here to There assessment artefacts (NU, 9/10/16).

With the guidance of NU, children created an obstacle course and documented the directions they were moving in, identifying relevant directional words at each step (see Figure 37 and 38): "We set up an obstacle course inside and wrote down the directions. At each step, we asked the children to identify the directional word. This was a task that children really began to identify with" (NU, 9/10/16).

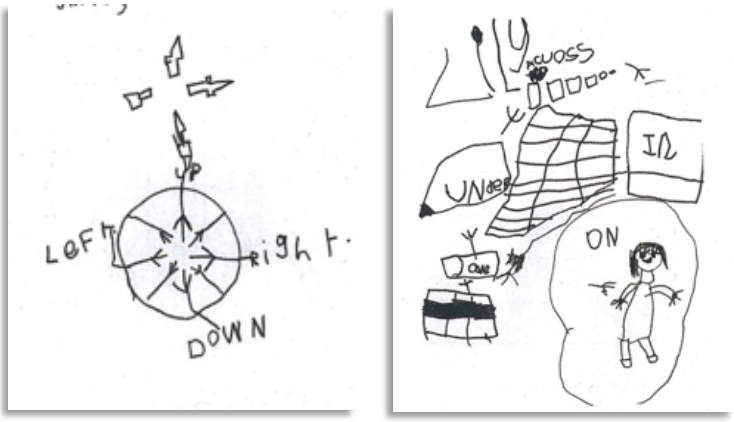


Figure 37. From Here to There assessment artefacts (NU, 9/10/16).

NU also reported, "Each child then drew their concepts of directions. Some utilised arrows while others drew out the obstacle course. One even drew herself in different directional positions" (NU, 9/10/16).

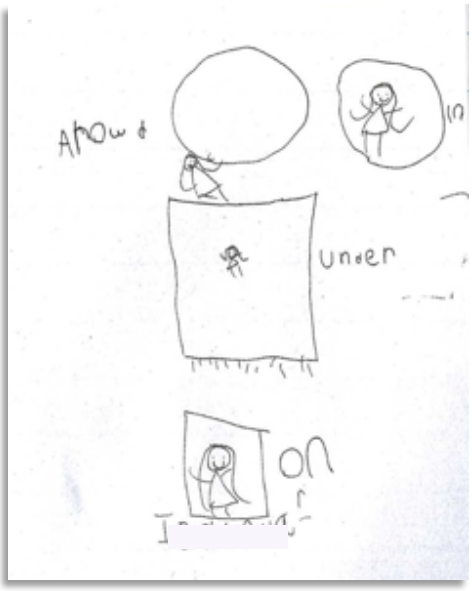


Figure 38. From Here to There assessment artefacts (NU, 9/10/16).

Documenting children's assessment outcomes led to an increase in confidence as participants could articulate children's learning outcomes to colleagues, parents, and families. KC wrote about her intentionality when using positional and directional language with children during outdoor play:

> I have integrated the maths with the outdoors—between the cedar trees, beneath the olive tree, beside the bushes, on the bridge, over boulders, rolling down the hill. I have purposefully used the words that the children are not using to reinforce the relational concepts. (KC, 14/10/16)

These examples demonstrate the different ways children expressed their knowledge and the different strategies participants employed to assess children's understandings. This example also demonstrates how it was possible to link the assessment activities with children's interests and still meet the assessment objectives. The following section discusses the implementation outcomes for Symmetry.

7.4.4 Symmetry

Symmetry (see Section 5.3) was implemented 32 times. The artefact shown in Figure 39 provides an example of how the assessment activity was enacted in practice. The child created the line of symmetry by using string and two tape dispensers. Each child took turns as they built a symmetrical design together.



Figure 39. Symmetry artefact (BH, 3/8/16).

Symmetry was reported as being an activity that children explored mainly on their own or with peers (32%), for example, in art (self-portraits), in the block corner during construction, making butterflies, mirror symmetry, and symmetry in pattern. However, reported outcomes of using open-ended questions during assessment resulted in a deeper understanding of children's knowledge of symmetry. For example, discussions about what makes something symmetrical included conversations about radial, horizontal, and vertical lines of symmetry and 3D symmetrical designs. For example, in Figure 40, Child A wanted to know what would happen if she removed the line of symmetry from her work, questioning if it would still be symmetrical.

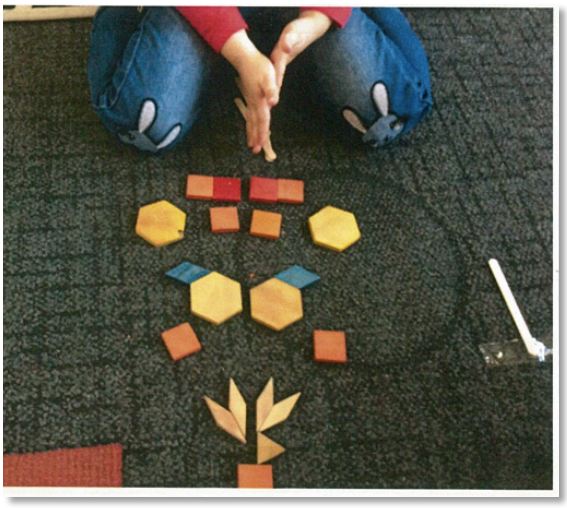


Figure 40. Symmetry explorations (HW 5/9/16).

The participant wrote, “A: created her pattern and then removed the line to see if it would change!” (IY, 5/9/16), indicating the participant’s engagement in the assessment process and further, the child’s depth of inquiry. This artefact suggests that children’s higher order thinking skills were being supported, indicative of how the participant intentionally engaged in open-ended inquiry and discussion during the assessment process.

The following example provides insights into how the symmetry assessment outcomes informed explicit teaching, planning, and extensions for learning:

> This task highlighted to me some children who would benefit from additional activities in this area as well as explicit teaching [pause]. In the week after completing this activity with the children I added a large line of masking tape down the centre of the block building. The children did not initially make the connection and used the blocks as they normally would. During our “Morning Meeting” on the third day, I reminded the children about the word symmetrical and asked them to create a symmetrical building in small groups in the block corner. This provocation enabled them to tackle the task, making a stronger connection. (TB, 18/8/16)

Children had the opportunity to apply their understandings of symmetry to a new context, and further, the participant had more opportunities to assess children’s learning in a familiar play-based setting. This learning experience provided multiple assessment opportunities, as although the context for the assessment shifted, the assessment objectives remained the same—to create symmetry. The children’s understandings of symmetry were linked to their interests in block play and construction, as seen in Figure 41. The assessment activity now included three dimensional objects and shapes and provided opportunities for children to discuss and explore radial and vertical symmetry across a large area—the additional space added scope for children to challenge their thinking further, as the activity became more complex and difficult to achieve the further they moved away from the line of symmetry.



Figure 41. Symmetrical building in the block corner (TB, 18/8/16).

This example demonstrates peer engagement and large-scale concepts of symmetry that were open ended, creative, and exploratory. The children placed a potted daffodil on the line of symmetry during their construction as they had been exploring symmetry in nature and linked their knowledge of these concepts to their explorations.

It was evident that, with participant scaffolding, children engaged in richer learning experiences and achieved deeper understandings of these concepts. Further ideas included explorations of symmetry in nature based on bulbs children were growing at their centre and explorations of symmetry in art. The participants continued to explore ideas for planning and extending children's learning. There were times when participants reported impacts on teaching practice began to exceed the implementation rate (Figure 24). At this time, participants were reporting significant shifts in their teaching practice, as evidenced in data outcomes, artefacts, and ideas for planning.

In the following example, symmetry was implemented with a 3-year-old group of children. Data demonstrated how, with explicit teaching and high-quality teaching practice, young children developed their understandings of symmetry. Symmetry was implemented with a 3-year-old group of children. The following outcomes were documented by IY during the assessment process with "B" as she identified teachable moments and supported the child's self-regulation skills to sustain engagement in the assessment task (see Figure 42). Data demonstrated the quality of IY's teaching practice in supporting the child's inquiry into symmetry:

With the block symmetry B became very frustrated when he was trying to understand the rotation you spoke about. He tried to kick the blocks down in frustration. We ended up standing up and looking down at the pattern so he could see it from a different perspective. I read the book *As the Crow Flies,* by Gail Hartman to him. This helped him to calm down and look at the problem again. He stood with the line of symmetry between his legs looking down. He carefully bent down and asked me to help him move the blocks a little so they were "symmetry". This also supported him to make such an elaborate pattern. When "E" came along he shared the story with her and showed her how to stand and look down so you could make sure it matched. She found this concept very funny but was also very encouraging of what he had created and supported the continued persistence with the task. They both continued the vertical patterns together. (IY, 2/9/16)

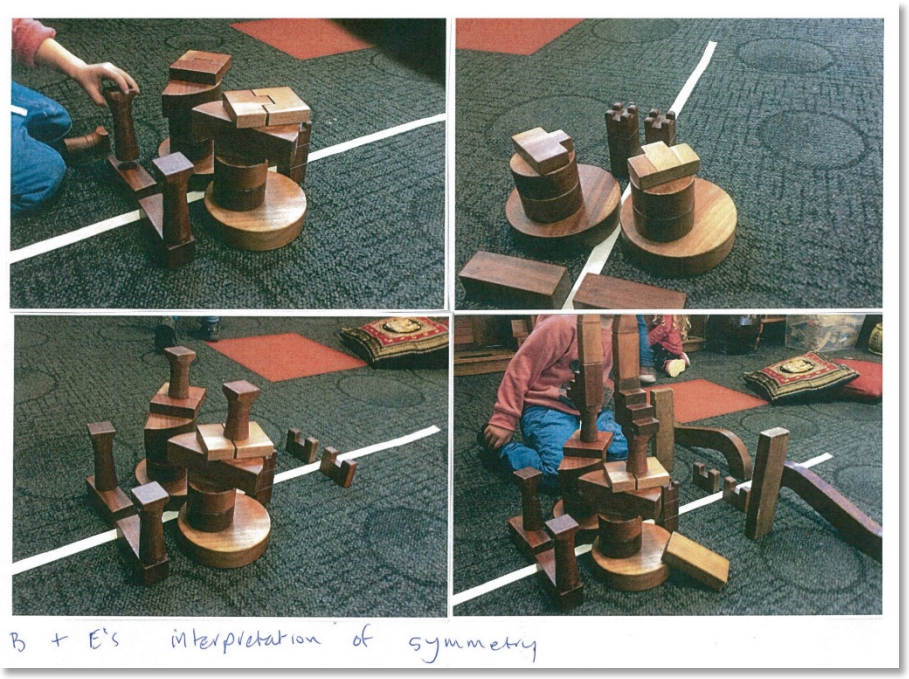


Figure 42. "Interpretation of symmetry", 3-year-old group (IY, 2/9/16).

These outcomes demonstrated how the children explored their spatial reasoning capabilities and understandings of symmetry, demonstrating perseverance, problem-solving skills, perspective taking, and the ability to engage in the creation of complex and detailed symmetrical designs. These outcomes contribute to the knowledge that very young children explore these concepts and can develop their knowledge with the intentional support of others (Uttal et al., 2013; Uttal & Sheehan, 2014).

During the implementation, participants reported planning outcomes for children aged 3 to 5 years, which included making butterfly prints, looking for symmetry in the natural environment (plants, leaves, trees, bodies), making folded masks with animal faces printed on one half for children to complete, taking photographs of children's faces and printing one half so children could complete their portrait, large-scale block play that included radial, horizontal, and vertical symmetry, complex matching games, and detailed symmetrical designs across large spaces. However, these outcomes were contingent on the quality of teaching practice and the assessment strategies used to enact the activities with children. IY wrote,

> The assessment activities have influenced all areas of curriculum and children demonstrate conceptual understandings across domains, for example: "I am painting a window using symmetry with triangles". With all the experiences, I feel the impact on my planning has been really positive and it has created more depth when exploring children's understanding of maths in everyday life. (IY, 24/11/16)

Data indicated the interrelatedness of the mathematics strands (VCAA, 2017) across curriculum domains, highlighting how children's explorations of mathematics were at times complex and wide ranging. Data suggested that children were recalling their mathematics knowledge and applying it in different contexts. For example, "L" explored attributes of shape, shape composition (reminiscent of Tangram: "What Makes a Square?"), symmetry, size, order, and repeating pattern in art, as seen in Figures 43 and 44. IY discusses this further below:



Figure 43. Symmetry across domains (IY, 23/11/16).

When we discuss shapes, children will often recall information from other experiences such as making toast. L did a painting and used this experience to discuss the shapes at the top. She said that they could be a repeating pattern if they were all the same size but they were going smallest to biggest instead. The window she is painting, using triangles; her intention is to make the shapes symmetrical. L also did a drawing. A dinosaur eating a tree. Her intent once again was to make the tree symmetrical. The dinosaur's legs follow the rules of a repeating pattern. (IY, 23/11/16)



Figure 44. Symmetry across domains (IY, 23/11/16).

These examples demonstrate that the training, skill, experience, efficacy, and beliefs of the educator contributed to the quantity and quality of mathematics assessment and teaching practice enacted in the early childhood program. The following section turns to focus on the implementation outcomes for 3D Shape: "Look, Think, Make!"

7.4.5 3D Shape: "Look, Think, Make!"

3D Shape: "Look, Think, Make!" (see Section 5.5) was reported as one of the most difficult mathematical concepts to introduce to children, and the assessment activity was implemented 20 times in total. Participants (75%) reported not "connecting" to the 3D Shape: "Look, think, Make!" activity themselves; however, a further 25% persisted with the implementation. BH reported not being confident about her knowledge of 3D shapes, however implemented the activity because she had committed to completing the research project. In doing so, BH discovered she was "very good" at 3D shape, linking children's understandings to the environment and real-life contexts. Further, when a child looked at a

sphere and said “ball”, BH asked if they knew “another name for the shape”, using intentional strategies to assess the upper limits of the children’s knowledge. Children collected and identified objects in the setting and were invited to bring 3D objects from home for categorisation. BH wrote,

> I tried out the 3D shapes activity with the children this week. I was quite surprised with the results! [pause] Doing this assessment with a small group of children, I found that they did not have much knowledge of the names of 3D shapes [pause]. I found the children were learning when we could find objects in our own environment which were 3D shapes—i.e. one child saw the picture of the triangular prism and said it looked like a pyramid—we then looked up the pyramids in Egypt on the iPad. We noticed the cube looked like a die and counted the six sides. (BH, 6/9/16)

There was evidence of participants (11%) linking the assessment of 3D shape with children’s play in the block corner; for example, children identified cubes when constructing train carriages and linked the concepts to everyday routines such as discovering “spheres” and “cones” during snack time. An increase in the language associated with 3D shape in the setting and home environments was reported by the participants enacting the activities:

> A mother came up to me yesterday and told me that her daughter [in my class] was helping her older brother when he was trying to work out 3D shapes! The children continue to use it in their everyday language now. (KC, 14/10/16)

The following example demonstrates how KC introduced 3D shape using a song and movement for children to embody the concepts. She planned a “shape walk” in the setting to find and match 3D shapes from the environment. Children categorised these shapes on large pieces of paper and engaged in music and movement games to identify the shapes (see Figure 45). This activity was repeated so each child had an opportunity to “identify” different shapes, and the other class was invited to watch the game and take a turn, supporting peer learning as children watched and prompted each other in the process.

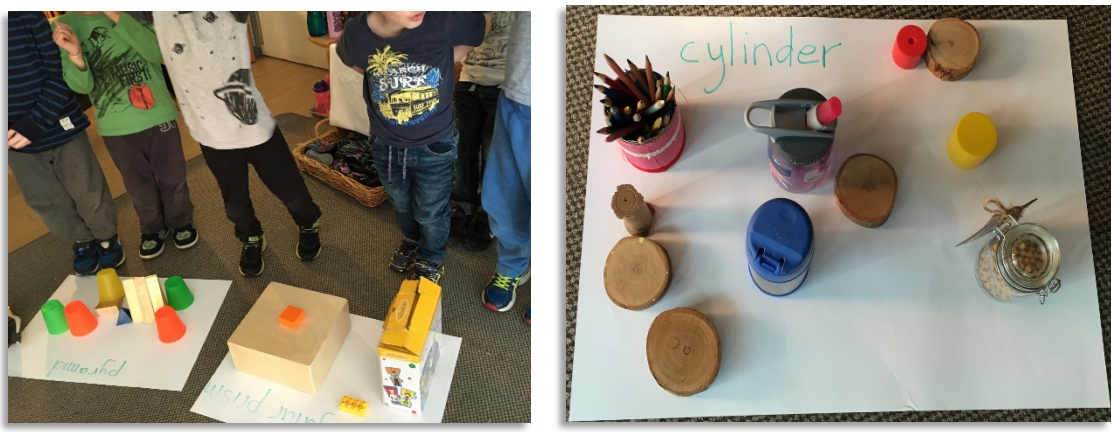


Figure 45. 3D Shape: "Look, Think, Make!", assessment artefacts (KC, 1/9/16).

This artefact demonstrated the participant's creativity when linking children's interests (music and movement) with the assessment activity and further, creating links between the abstract names of 3D shape and objects from their everyday and home environments.

It was believed that a finer focus on fewer, but more specific, spatial reasoning concepts would support participants in their knowledge of what children knew and therefore, how to plan to support children's learning. The following artefact (see Figure 46) demonstrated how, in early childhood, children's knowledge is varied, and educators can often teach groups of children that have a developmental range spanning 3 to 5 years in one room (DET, 2016). This highlights the level of proficiency and professional knowledge early childhood educators are expected to have when observing, assessing, and planning to support children's individual learning outcomes.

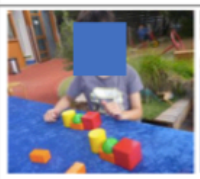
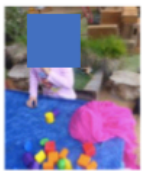
Date/Time	Photo Observation	Anecdotal Observation & Conversation
07.09.2016 9:45am (4.11)		was able to remember building when I used three and four shapes
07.09.2016 9:55am (5.10)	 	was confident with this game, he completed buildings with three and four shapes, but was unable to complete a building with five. He peaked under the material so he could remember.
07.09.2016 10:05am (5.5)	 	was unable to complete the task. She selected one shape correctly and then was unsure how to proceed. To give her a sense of achievement and aim the task more at her level I removed the cloth and asked her to copy my buildings by looking at them. She was able to achieve this, although still found it challenging.

Figure 46. 3D Shape: "Look, Think, Make!" observation (TB, 7/9/16).

TB combined the kits to provide more choice for the children, and she reinforced real-world connections to 3D shape, which as a concept on its own can be abstract and difficult to understand unless it has real-world applications that relate to the child's context. The participant adopted explicit teaching strategies, following the child's interests throughout the assessment and making incidental adjustments to her teaching strategies to support successful assessment outcomes for children. TB had evidence to contingently plan for children's individual learning needs. TB was aware of the teachable moments during play, and because TB did this as a small-group experience, the potential for peer learning was evident. At the end of the implementation, data revealed that primary school teachers, who were supporting children's transitions from early childhood into the primary environment, reported observing a kindergarten group working with tubs of shapes during a "free play" activity, composing complex shapes, describing and naming shapes and attributes, and using positional and directional language.

Figures 47 and 48 demonstrate how the assessment outcomes linked to ideas for planning, including links to the home environment as children were encouraged to identify 3D shapes in their setting and at home and create a 3D plan for a playground.



Figure 47. Identifying 3D shape in the environment (MP, 15/9/16).

> I also asked the children to go home and look for any 3D shapes they could find around their house. Naturally they started bringing items into school. The exploration of these shapes has been exciting and they keep on coming. Wherever we go they are looking for these shapes. I took a small group of children and asked them to work as a group using the 3D shapes. They came up with a plan to design a playground. The planning, design and execution was delightful to record. (MP, 15/9/16)



Figure 48. A 3D plan to design a playground (MP, 15/9/16).

Although this activity was reported as one of the most difficult mathematical concepts to introduce to children, data indicated there were many ideas and applications for planning that supported children's individual learning and emergent interests, suggesting that the activity had positive outcomes for both teaching and learning. The focus now turns to the implementation outcomes for Mapping Pathways, the last assessment activity to be discussed in this section.

7.4.6 Mapping Pathways

Although implemented the least amount of times (18 counts), Mapping Pathways (see Section 5.7) had the most significant impact on links between assessment and planning. Participants followed children's interests, which included mapping the route from home to kinder, reading and decoding maps of local areas, planning journeys using schedules for public transport, using symbolic representation, robotics, coding, programming, 2D representations of 3D objects (and the opposite), story books based on mapping, songs incorporating positional and directional language and gesture, explorations of compass points, left and right, and aerial perspectives with children. Participants (37%) who implemented Mapping Pathways initially did not perceive the activity as mathematical, providing a significant shift in thinking for participants with mathematics anxiety and challenging traditional perceptions of what constitutes mathematics in early childhood. The following examples have been chosen as they demonstrate how the assessment outcomes informed planning and explicit teaching strategies.

MN reported that over time, children's outcomes reflected deeper and more detailed understandings of positional and directional concepts and language. In Figure 49, MN noted "directions within directions" as a child mapped the pathway of a dragon "around" her bed (14/11/16), providing further planning ideas for dramatic play and mapping.

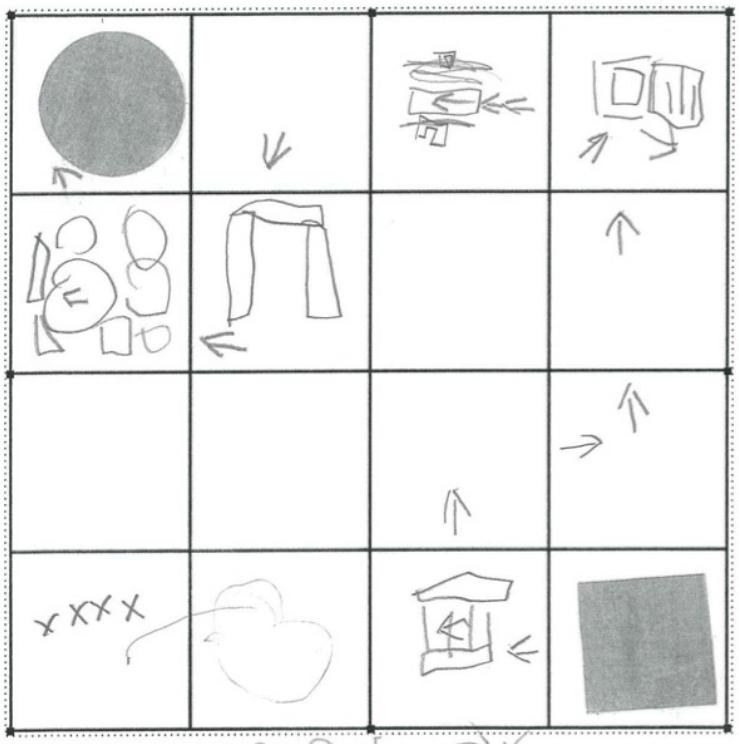


Figure 49. Mapping Pathways assessment artefact (MN, 14/11/16).

NU also introduced left and right (see Figure 50), which children explored when documenting, testing their maps, and communicating directions verbally and nonverbally through gesture.

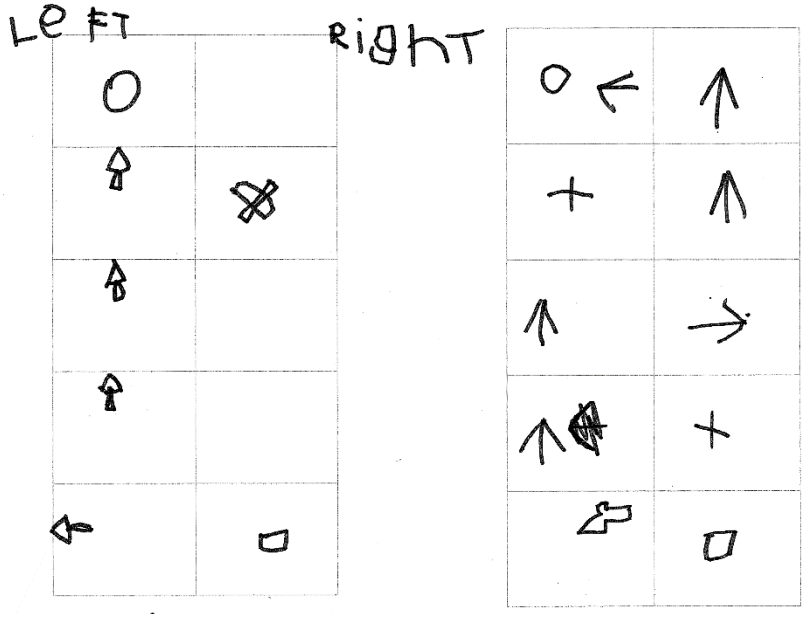


Figure 50. Mapping Pathways assessment artefact (NU, 28/10/16).

IY wrote about Mapping Pathways within the context of her program planning, highlighting recognition of "incidental" teachable moments in practice, providing children with opportunities to consolidate new knowledge about left, right, compass points, and symbolic representation (see Figure 51). Assessment outcomes were also linked to children's interests in navigating the route from home to the kindergarten, providing real opportunities to create and use a map, therefore understanding the intention and purpose of mapping. This led to children mapping in their local community and using compasses to plan increasingly complex excursions that they then executed, for example, a trip to the zoo.

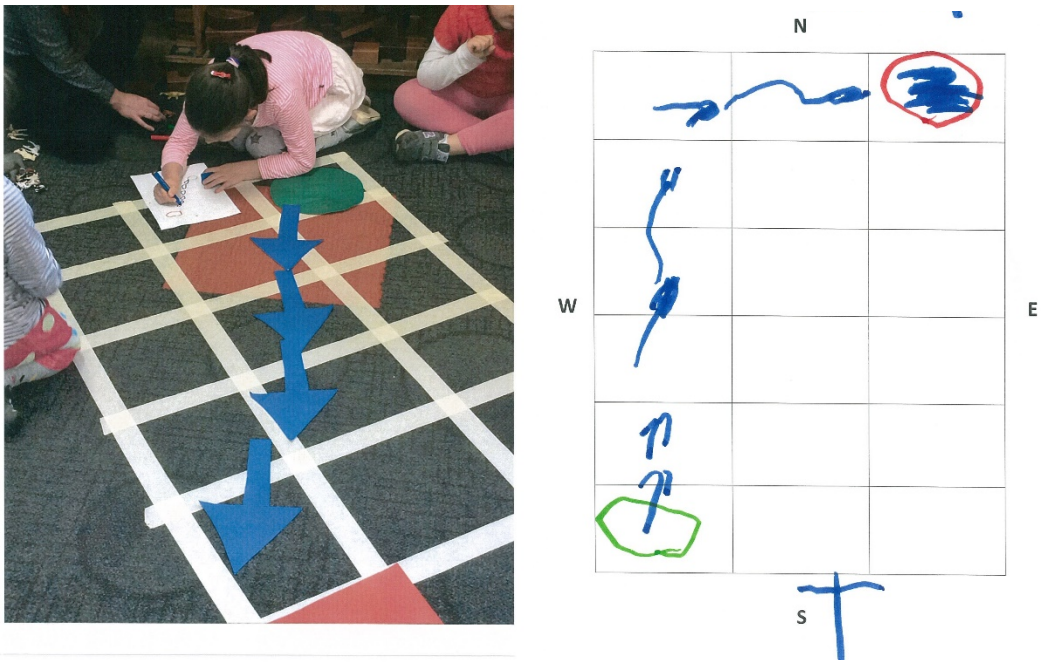


Figure 51. Mapping Pathways compass points (IY, 28/10/16).

In the following example, the assessment activity was implemented according to the guidelines, with clear links between the children's interests and the assessment objectives. Assessment outcomes clearly informed planning, and evidence of children's progress was keenly monitored and documented. MN modified her planning to provide a larger floor grid to facilitate children's interests in creating a cityscape with buildings, a car park, and "green space". In Figure 52, children mapped routes for their cars, documenting 2D symbolic representations of their 3D cityscape. MN sourced and read *As the Crow Flies: A First Book of Maps* (Hartman & Stevenson, 1993), providing children with insights into aerial perspective. The maps were then used to provide directions for each other to drive around the "city". Their map demonstrated understandings of aerial perspective, as represented in the drawing of the car park and buildings.

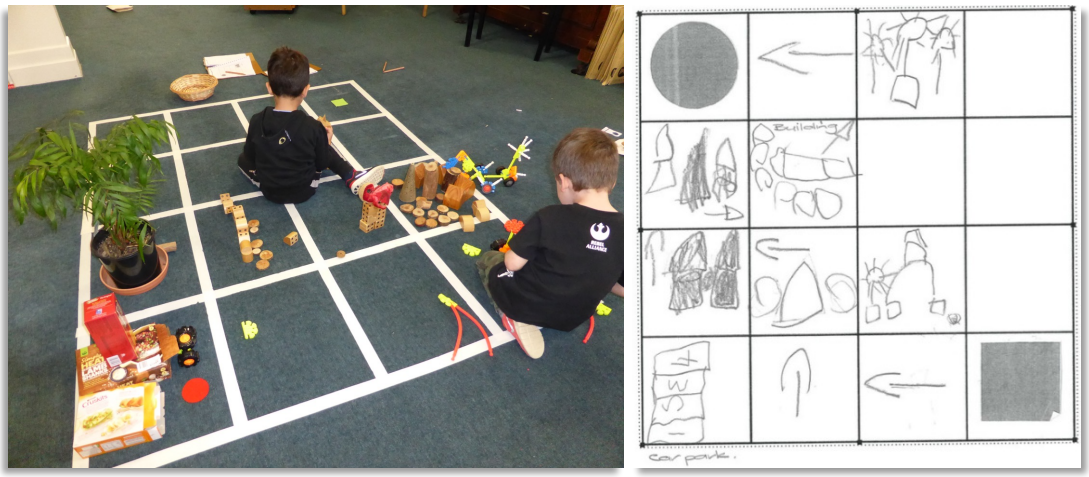


Figure 52. Mapping Pathways city scape (MN, 14/11/2016).

MN's planning included reading books that involved journeys or travel, watching examples of how to make a map (YouTube), and in Figure 53, mapping *Rosie's Walk* (Hutchins, 1971), providing opportunities for children to sequence the story using a visual story cards MN made for the activity. MN wrote,

> Invited a small group of children to use playroom materials and story pictures to recreate farm scene. Children gave directions to a friend who moved a Rosie puppet around the farm. Children then drew the scene and created a map of Rosie's journey. (11/11/16)

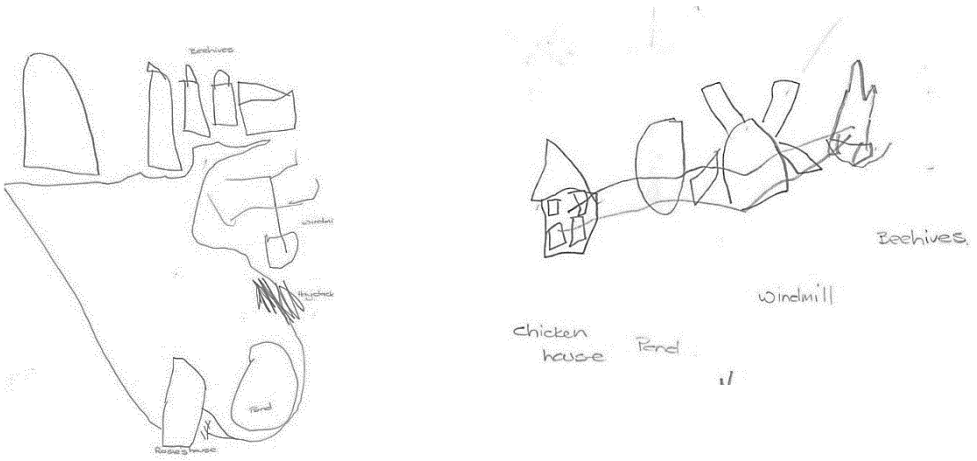


Figure 53. Mapping *Rosie's Walk* by children 4 to 5 years old (MN, 11/11/16).

Mapping was combined with imaginative play, including puppets, ICT, and sequencing using the grid to map and navigate routes. Children were supported to explore concepts of scale, document their maps on a small-scale version of the grid, and further, use the "code"

from their maps to "direct" other children and/or move an object along the pathway. This further supported children with EAL to participate and communicate their mapping pathways. MN noted, "By placing arrows first or without verbal directions, children with little English or a developing understanding of direction were able to demonstrate their understandings of mapping" (11/11/16). This extract highlights the significance of being able to assess children's nonverbal communication, indicating implications for planning. The capacity to assess children's nonverbal understandings of positional and directional language led to a shift in understandings of EAL children's knowledge in this area.

Based on initial assessment outcomes, participants modified the floor grid to increase its size and provide further learning extensions for children, for example, increasing the number of obstacles for children to navigate. Data indicated that the assessment activity evolved to include large floor grids which were up to 5 squares wide by 9 squares long and elaborate constructions that developed into a cityscape with "vertical" directions as children went "up" and "over" objects.

Figure 54 demonstrates a coding extension with links to planning for robotics and the use of ICT. In this way, NU extended children's learning beyond the aims of the assessment activities by creating code for children to decode based on the arrows from the floor grid. NU also invited children to code a picture, explaining that "0" represented a blank square and "1" represented a green square. These coding templates provided an engaging resource for educators to use with children when supporting understandings of how code can communicate information. For example, using a blank grid and following the code, a child could replicate the tree. In another extension, children were invited to create their own picture in the squares and then code their picture. A child decided to code her name and was encouraged to fill in the squares to make it easier to code using 0s and 1s.

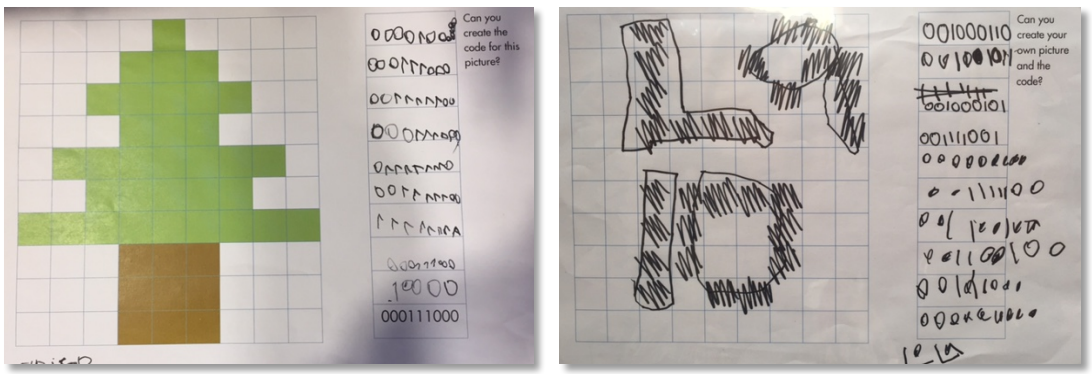


Figure 54. Mapping coding learning extensions (NU, 28/10/16).

NU extended the grid template further and incorporated the use of robotics—BeeBots—and coding in her planning. NU placed a large grid on top of a table and children created accurate sequences of code to move the BeeBot from one location to another without falling. The development of children's precoding skills was important to include in Mapping Pathways, as not every early childhood centre or educator has access to robotics or ICT (Yelland & Gilbert, 2016), however data indicates that children's fundamental understandings of coding can still be assessed and taught.

Figure 21 highlights these outcomes further, as 61% of the time, ICT was "*never or almost never*" used to support children's mathematical understandings (pre-implementation study survey). These outcomes were informed by the availability of ICT resources; however, outcomes were also informed by participant beliefs about the appropriateness of using ICT in early childhood education (Blackwell, Lauricella, & Wartella, 2014; Parette, Quesenberry, & Blum, 2010). Mistaken beliefs about ICT and early childhood pedagogy appeared to present a barrier toward the ways ICT could be used to support children's spatial reasoning and geometry leaning. Given the rise and recognition of STEM as a necessary curriculum area for young children's learning (Fox, Diezmann, Lamb, & Mathematics Education Research Group of Australasia, 2016; NAEYC, 2012; NCTM, 2010b; OECD, 2012; Yelland, 2016), it was important to address strategies to include ICT in the assessment activities. Taking this into consideration, Mapping Pathways was an assessment activity that did not use ICT; however, it addressed the coding skills necessary for children to develop when engaged in programming and coding activities. For example, children were encouraged to draw and plot their route on a grid, including the directions necessary to avoid and navigate obstacles to achieve an objective. The "maps" were representations of a sequence of symbols that were documented and used between peers to code and decode information and follow a sequence of spatial instructions. Although implemented the least amount of times, the largest volume of planning ideas enacted in practice were reported for Mapping Pathways. Mapping around obstacles on the grid led to the development of precoding skills that included ICT and robotics, increasing in complexity as children's learning outcomes evolved.

In summary, the implementation rate for each activity varied widely; however, this variation did not always compare with the quality of the assessment outcomes and subsequent ideas for planning. Mapping Pathways was reported as having the greatest impact on observations, assessment, and planning, perhaps as it was implemented last, toward the end of the project when participant understandings of the activities had developed over the four-

month implementation phase. The implementation rate for each activity was influenced by many factors, including participant training, skills, and beliefs about mathematics and assessment in early childhood. The following section presents the impacts of the implementation on participant beliefs about their own mathematics ability and the place of mathematics in early childhood education, indicating the reciprocal influence between participant beliefs about mathematics and the enactment of the implementation.

7.5 Educator Beliefs About Mathematics in Early Childhood Education

Research Question 2 focused on participant beliefs about mathematics in early childhood education and participant beliefs about their own mathematics abilities. This section presents the results for the first part of this question, focusing on educator beliefs about mathematics in early childhood education before, during, and after the implementation. The pre- and post-implementation survey outcomes are presented and the impact of the implementation on participant beliefs is compared.

Figure 55 presents the difference between participant beliefs about mathematics in early childhood education before, during, and after the implementation.

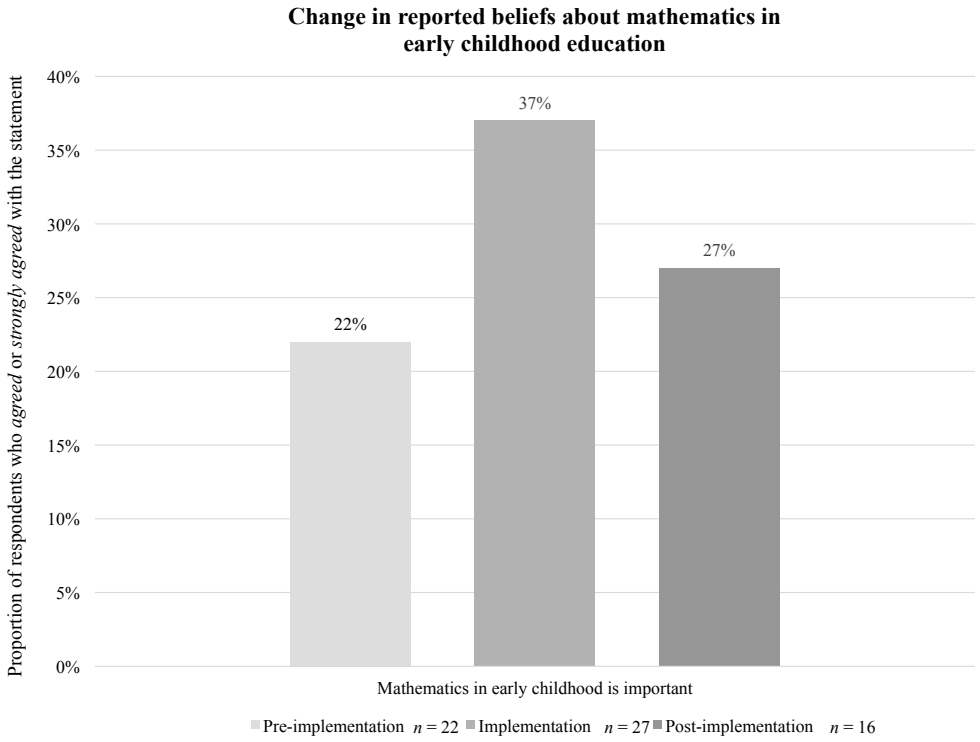


Figure 55. Educator beliefs about mathematics in early childhood education.

Notably, positive beliefs about mathematics in early childhood increased during the implementation. Pre-implementation survey data indicated that 22% of participants shared the belief that mathematics was important in early childhood education. This increased to 37% during the implementation and reflected outcomes in the data that indicated participants had an increased awareness of the mathematics they were enacting in practice during the implementation. Meeting the demands of the research project created a focus on spatial reasoning and geometry, and mentoring and support during the implementation provided opportunities for participants to experience how the activities could align with play-based philosophies of learning. Post-implementation survey outcomes indicated that participant beliefs about the importance of mathematics in early childhood education decreased from 37% to 27%. This reflected participant reports of being "time poor" during Terms 3 and 4 of the school year, and this shift was also informed by the withdrawal of the research project requirements, mentoring, and support due to the end of data collection. Therefore, mathematics was afforded a lower priority at the end of the research project.

The following examples indicate the range of participant views about mathematics education for young children informing the implementation. Views include a preference for supporting children's language and literacy skills over mathematics, the need for more mathematics resources in early childhood, and prioritising families' requests for their child's education:

> What is the definition of "Maths"—I believe that children should start school with adequate pre literacy skills. (PK, 6/7/16)

> Many teachers/educators don't have the resources/play-based ideas at hand to incorporate into their curriculum. There are many misconceptions about maths/readiness for school. There are not enough readily available maths experiences for early childhood educators. (OP, 12/8/16)

> My families don't have email, they don't own computers, all they want is for their children to learn how to read and write. (LJ, 23/11/16)

Over half the participants (65%) reported that mathematics did not have a place in early childhood education. However, this belief shifted during the implementation, indicating that beliefs are changeable. Sections 7.5.1, 7.5.2, and 7.5.3 discuss this further, drawing on examples from the data that highlight how educator beliefs about mathematics in early childhood education can impact the inclusion of mathematics in teaching practice.

7.5.1 Evidence of Children's Learning Outcomes: Motivation for Change

During the implementation, participants (15%) reported observing children's sustained engagement with the activities and increased learning outcomes, which motivated the enactment of the assessment activities in practice. These outcomes are supported by research evidence that suggests children's learning outcomes motivate and influence educator engagement in mathematics (Brown & Inglis, 2013). For example, NU reported on Tangram: "What Makes a Square?":

> I didn't want to do it, I don't do formal assessments, I don't do check lists and this was like a check list [pause]. I just sat on the mat and said, "OK we are doing maths" because I felt I had to get it done, to get something out of it [pause]. Anyway, the children got really excited. In the end, I had the experience set up at the table with the little book and a lot of them would reference the book and create the shapes that were in the book, and some of them were doing it from memory and they were doing it a lot quicker too, you could tell they were proud about that [pause]. It was exciting. (29/11/16)

Another key outcome was evidence of participants following children's interests when enacting the activities. This approach aligned with existing teaching practices and linked to early childhood philosophies of learning, which shifted perceptions of what mathematics is and can be in play-based, early childhood education.

7.5.2 Educator Beliefs About Free Play and Assessment

Notably, three participants with primary school training were familiar with frequently assessing children's learning and reported the value of supporting children's foundational mathematics skills. These participants had experience of teaching a primary school mathematics curriculum, understood and were familiar with children's learning trajectories. Further, five participants were situated in early learning centres within the grounds of primary school settings and had experience of the expected levels of children's mathematics proficiencies when transitioning into primary school. The preschool children spent time throughout the year "visiting" the primary school to prepare for transition. These participants had knowledge of the Victorian Curriculum F–10: Mathematics (VCAA, 2017) and reported the value of mathematics in early childhood education when linked to play-based philosophies of learning. Data indicated that the participants had clear insights into children's expected levels of mathematics proficiencies in the first few years of primary school. These participants were also familiar with children's learning trajectories because of their

knowledge of the curriculum. This supported participant understandings of the mathematics children need to learn in early childhood education and the explicit teaching strategies necessary to support mathematics learning.

Conversely, almost a third of participants (32%) reported challenges stemming from their negative beliefs about mathematics in early childhood education and the use of explicit teaching strategies in early childhood pedagogies. Beliefs about the importance of free play for children significantly outweighed beliefs about the importance of mathematics and assessment in early childhood education. For example, TL said,

> Sometimes I think "how do we assess" and this is what I am really getting my head around as a teacher, um [pause]. But if you really look at the curriculum you don't really have to tell the parents that they can do all these things, because [pause] it [mathematics] is too complicated or um [pause] like, I don't know [pause] they should just be left, I mean just left alone, you know, to play [pause], to be kids [pause]. We do free play here. (18/11/16)

TL questioned the purpose of assessment in early childhood education, the relevance of documenting learning, and the use of explicit teaching strategies in her setting. These participants (32%) also found it challenging to link children's interests to the assessment activities. Beliefs about free play did not align with explicit teaching, mathematics, and play-based philosophies of learning. These outcomes raised questions about how participants were assessing and planning for children's mathematics learning, as outlined in the National Quality Standard (ACECQA, n.d.) and early years frameworks.

7.5.3 Mathematics, Free Play and Program Planning

Participants who reported hating mathematics also believed in the benefits associated with children being able to follow their interests without adult intervention and explicit teaching (32%). These outcomes align with previous research into play-based learning and the prioritising of children's free play above intentional teaching strategies (Fleer, Tonyan, Mantilla, & Rivalland, 2009). However, it is well known that without intervention and explicit teaching strategies to support children's mathematics learning, significant learning opportunities are missed and can remain a neglected priority (Clements & Sarama, 2014; Cohrssen et al., 2016; Hachey, 2013a; Lake & Kelly, 2014; Pollitt et al., 2017). Further research is necessary to understand if participant beliefs about their own mathematics abilities are linked to their beliefs about the teaching of mathematics in early childhood education and

the impact this has on the provision of mathematics in program planning. The following section now turns to focus on educator beliefs about their own mathematics abilities, and presents key findings from the enactment of the implementation.

7.6 Educator Beliefs About Their Own Mathematics Abilities

Educator beliefs about their own mathematics abilities have an impact on the amount of mathematics they teach (Lake & Kelly, 2014). However, the outcomes from this research project indicated that the enactment of the implementation had a positive impact on participant beliefs, the benefits of which continued after its conclusion. The results indicated that participant beliefs about their mathematics abilities did not always align with the mathematics they were required to teach. This section presents outcomes relating to the key themes arising from the study based on participant beliefs about their own mathematics ability and conversely, the impact the implementation had on these beliefs. Figure 56 demonstrates this further.

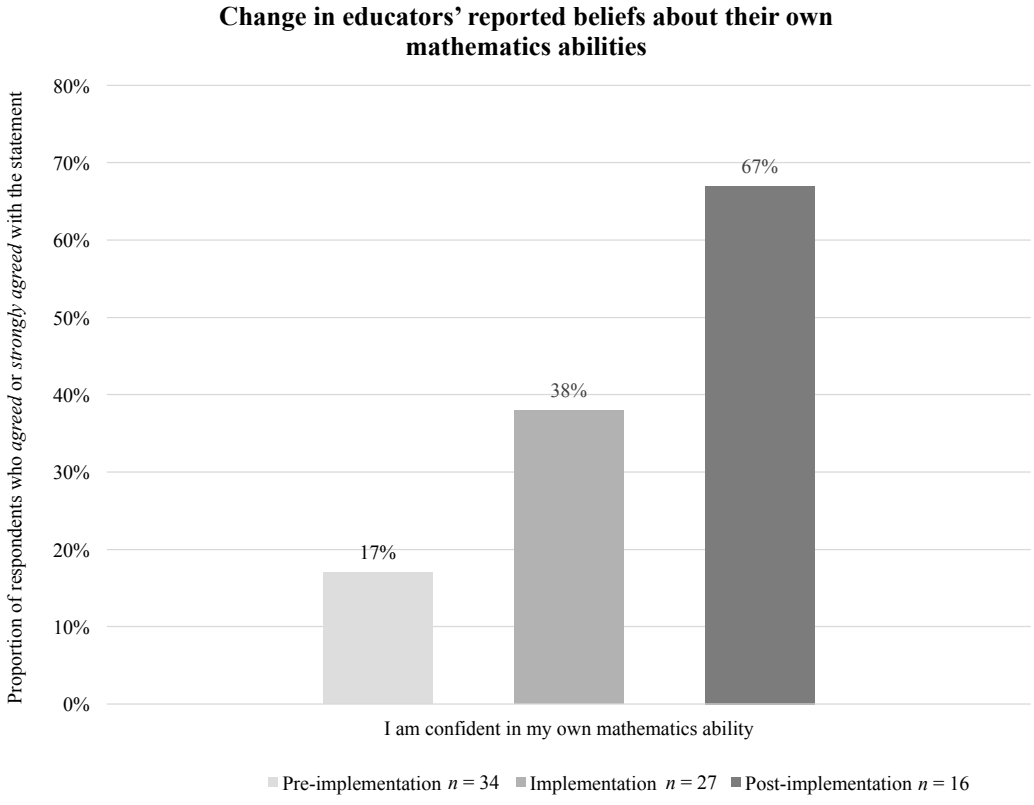


Figure 56. Educator beliefs about their mathematics abilities.

Participant confidence in their mathematics abilities was low pre-implementation (17%). For example, participants reported, “never been good at maths” (OQ, 18/07/16), “not a math person” (CB, 20/07/16), “not good with numbers” (KC, 18/07/16), and “hating maths” (LS, 13/07/16). Further, at the pre-implementation survey, participants (85%) agreed that children should “be helped to learn maths during play-based activities”; however, only 17% of participants believed in their ability to plan for and support children’s mathematics learning. These outcomes indicated a significant gap between what participants believed children needed to support their mathematics learning and what they believed they were capable of teaching. During the implementation, participant confidence in their ability to enact mathematics in practice continued to increase, and four months later, post-implementation, participant confidence had increased by 29%. Participants reported positive changes in their beliefs about teaching mathematics, stating, “I can do maths” (KC, 23/10/16), “I never thought I could do maths and I can” (DC, 10/10/16), “This has changed the way I think about maths” (LS, 15/11/16), and “I was never a maths person, but I can do this and I am good at it!” (OP, 9/9/16). This shift is significant, as pre-implementation, participants reported beliefs about their own mathematics abilities were low; for example, a large percentage of participants (58%) disagreed with the statement “Maths was one of my favourite subjects in school”, 26% agreed that the word “maths” made them feel nervous, and a further 36% stated that they were not a “maths person”. Further research is necessary to understand if these shifts in participant beliefs about their mathematics abilities alone had a lasting impact on the quantity and quality of mathematics enacted in practice and included in program planning. The discussion now turns to focus on section 7.6.1 and how early mathematics experiences can have a lasting impact on beliefs about mathematics capabilities.

7.6.1 Beliefs About Mathematics Abilities Are Formed in the Early Years

During the semistructured interviews, mathematics-anxious participants (18%) recalled their experiences of being taught mathematics at school. Participants’ early mathematics experiences were retold emotionally, at times recalling their teacher’s name and manner of teaching, using heightened language (expletives) to describe their experience of learning mathematics, including the use of exaggerated gestures and expressions of frustration at their perceived lack of mathematics ability.

At times, participants were lost for words when recalling early mathematics experiences. These outcomes indicated that participant beliefs about mathematics, formed during the early years of education, are influenced by how they were taught mathematics at

school (Hattie, 2008; McNeal & Simon, 2000), and that these experiences have had a significant and long-lasting impact on participant beliefs about their ability to teach the subject today.

These findings indicated that educators' attitudes toward the teaching of mathematics can explicitly and implicitly have an impact on young children's beliefs about their own emergent capabilities, which can continue throughout adulthood (see Section 2.5.3). The semistructured interview outcomes highlighted the significance and long-lasting impact educators can have on children's (and adults') beliefs about their own mathematics abilities (Anders & Rossbach, 2015). The survey and interview data indicated that participants' negative *and* positive beliefs about mathematics were founded in early experiences of learning mathematics at school. Participants (15%) who reported a "love" of mathematics, had positive experiences of teaching and learning the subject at school.

Interview data indicated that participants' negative beliefs were usually compounded during times of performing mathematics tasks socially or in front of peers. The origins of these beliefs stemmed from experiences at school, for example, being "made to" (QL, 11/11/16) stand and recite times tables or reciting responses to mathematics questions under the pressure of being "time tested" (OP, 23/11/16). It was interesting to note that participants with mathematics anxiety had a fear of "getting the answer wrong", suggesting that further research is necessary to understand how to support educators when addressing their anxiety. For some participants (18%), these long-held beliefs about their existing mathematics abilities had not been questioned or challenged for over thirty years. In Section 7.6.2, the discussion turns to focus on participants' (12%) negative experiences of mathematics at school and how this motivated the implementation of the assessment activities, how what is taught in early childhood education is often informed by educators' beliefs and the value of an early childhood mathematics curriculum.

7.6.2 Positive Impacts on Children's Mathematics Learning

Participants (18%) cited "bad math experiences at school" as the origin of their mathematics anxiety. However, 12% of these participants were motivated to enact the activities in practice to ensure children's positive experiences of mathematics. Reasons for these beliefs were complex and impacted the implementation in different ways. For example, KC reported "hating math", however implemented the activities for the "benefit of the children" (23/11/16). Participants reported negative mathematics experiences during childhood motivated them to have a positive impact on children's learning outcomes:

> I found the study very beneficial because I am not very strong in maths; since primary school I have had a fear of it because I was never at the same level as my peers and I was always struggling and we would have these mental maths lessons every week and I would be like [pause] oh! I don't know! So, I have never been very confident. So, it was a good refresher for me to say, well actually, I do know maths and I want children to know it too, to be confident about it! (OQ, 18/11/16)

> I gave up on maths in Year 10; I was hopeless at it, and I just know how important it is and I have obviously been reading a lot about how kids today just do not have enough of a maths background and we need more of it. (KC, 15/11/16)

This highlighted how participants were influenced by their own experience of mathematics during the early years of their education and how early mathematics experiences impacted the shaping of their beliefs. For example, data from the interviews indicated that children perceive when educators are disinterested in a subject area, and the example below describes children's ability to "sense" this:

> The only thing I had problems with were 3D shapes and I think as a teacher too children can sense when you are not passionate about something; they pick it up [pause] the children knew I was not really committed to the 3D shapes, and I think it would have been different if the children had a teacher that loved 3D shape, who was passionate and committed to them—perhaps their outcomes would be different [pause]. If you forget about the shapes and just get me working in the block corner I don't have a problem but for me I had to get away from just naming the shapes, and to see it wasn't about that so I had to get away from that type of thinking. (LS, 22/11/16)

These outcomes suggested that the participant was accustomed to separating mathematical concepts from "play"; for example, she did not have a problem with "working in the block corner", and playing with these concepts as long as she could "get away from just naming shapes" and "get away from that type of thinking", which was associated with traditional perceptions about mathematics teaching and learning. It is evident that when educators are excited about their teaching, children are also more likely to be engaged and inspired.

The participant recognised that her "commitment" to 3D shape may have impacted children's learning outcomes, which highlighted how (without a clear mathematics curricula)

mathematics teaching and learning in early childhood education may only include what participants know and feel comfortable teaching. Furthermore, the pre-implementation survey outcomes demonstrated that, at times, the mathematics participants were teaching to children was limited and was *limiting* children's mathematics learning, separating the "learning" from the ways children naturally and creatively explore mathematics in play. This demonstrated how educator bias can favour areas of mathematics over others based on beliefs, knowledge, confidence, experience, and willingness to adopt new ideas in practice.

During the implementation, LS shifted away from "that type of thinking", and her data submissions began to include examples of children using 3D magnetic construction blocks to create trains in the "block corner", which evolved to include imaginative play, symmetry, and mapping. LS implemented the activities with two other educators in her centre, one of whom was the centre director. The participants provided coaching for each other, which enabled them to discuss assessment outcomes and new ideas for play-based approaches to mathematics practice, pedagogy, and planning. Section 7.6.3 discusses how beliefs can change rapidly.

7.6.3 Changes in Beliefs Can Occur Rapidly

Although participants (18%) had negative beliefs about their mathematics ability, these beliefs did not always impact the inclusion of mathematics in curriculum. Despite negative beliefs, participants endeavoured to enact new knowledge in practice as their positive beliefs about the importance of supporting children's mathematics learning outweighed their negative beliefs about their abilities. Guerra and Wubbena (2017) described this as "cognitive dissonance", whereby there is discord between what is known and what is believed, which causes a state of cognitive discomfort and a need to find equilibrium between the two conflicting states of knowledge and beliefs. To achieve this equilibrium, something must change (Guerra & Wubbena, 2017). Implementation data indicated that changes in beliefs can occur rapidly. Data also indicated that a change in beliefs is necessary to lead change in practice, and that an increase in mathematics content knowledge alone did not impact participant beliefs about their ability to teach mathematics. Data from this study indicated that a change in beliefs occurred during the *enactment* of new ideas in practice. The research outcomes indicated that in this instance, participant beliefs about their own mathematics ability increased by 29% over four months, signifying that unlike values, beliefs are not fixed and can shift rapidly (Guerra & Wubbena, 2017). Section 7.6.4 discusses how rates of implementation had varying impacts on participant beliefs.

7.6.4 Rates of Implementation Impact Changes in Beliefs

Participants reported children's "engagement" with and "excitement" about the activities influenced their confidence and motivation to complete the project. The enactment of the assessment activities provided evidence that influenced beliefs, which in turn influenced teaching practice and children's learning outcomes, forming an ongoing cycle of change. A higher rate of implementation demonstrated a higher rate of change in teaching practice and beliefs:

> I have the confidence; I just did not have the skills to do it [pause]. I didn't recognise that some of the concepts we look at through everyday play are maths. (OP, 22/11/16)

> I was too focused on the names of the shapes. It took me back to my Year 8 maths and getting the answers right! I had to get away from that type of thinking. Before starting the project, I thought about maths in a very different way. I thought maths was very concrete: numbers, volume, shape, measurement [pause]. I didn't recognise mapping as a maths assessment, or the language. (LS, 25/11/16)

> I was just really excited to be involved in something that I thought I was completely incapable of and that it turns out I am [capable of it] so thank you for that opportunity for a bit of self-gratification [pause] a bit of an awakening moment. (KJ, 14/11/16)

Participants who did not enact the assessment activities did so for the following reasons: self-doubt about mathematics content knowledge, knowledge of appropriate teaching strategies, and misunderstandings about what constitutes mathematics in play-based curricula (31%). These outcomes align with the research findings of Zhang and Wong (2015), which suggested that knowledge and beliefs are intrinsically linked and have a reciprocal impact on each other. For example, they suggested that increasing educator knowledge alone would not necessarily impact beliefs. The outcomes of this research project suggest that a shift in beliefs can occur through the *enactment* of new ideas in practice. However, outcomes highlight the importance of the provision of mentoring and support for educators when facing long-held negative beliefs about their mathematics ability, enacting new ideas, and developing skills in practice. The focus turns to 7.6.5, and discussion about support for the enactment of the implementation.

7.6.5 Collegial Support and Impacts on Changes to Beliefs

Participants who implemented the activities with colleagues reported it was useful to have collegiate support when enacting new concepts in practice and overcoming mathematics anxiety. Across the 15 settings, six groups of participants implemented the activities together. Five groups reported sharing positive outcomes and ideas for planning in their settings that supported engagement with the implementation. The sixth group reported sharing negative beliefs and attitudes toward the assessment activities and the inclusion of mathematics in early childhood programs. It is important to expand on these findings briefly as they provide an example of how participant beliefs impact the provision and quality of mathematics in program planning.

Five participants grouped in one setting found the mathematics assessment activities to be incongruent with their centres' emergent curriculum and play-based philosophies of learning. The assessment activities were reported as not being applicable to the children's interests. One of the participants reported the assessment activities were not used in her setting as they were "against" the centre's philosophy of following the child's interests, yet she remained in the study and did not submit any data. Across the implementation phase, the centre disengaged with the project and two participants withdrew. The remaining participants described the assessment activities as "check lists", "tests", "too strict", and the need to "push" against mathematics in early childhood:

> I don't push this [mathematics] a lot, as this is their last chance to be children, and I don't want to be the one who says, no you can't play or let's learn numbers. I thought, why am I doing this, I am just going to stop [pause]. I hate maths [pause] so I am going to step out and let them be [pause]. They will learn it at school when they are ready [pause]. The push down of information to younger and younger children; I really fight that. (OR, 18/11/16)

The activities were predominantly set up at standalone tables and children could engage with the materials during free play without adult intervention or assessment. The link between play-based approaches to mathematics and assessment were incongruent with the centre philosophy, which only supported free play, and the predominant belief that mathematics was for primary school (see Anders & Rossbach, 2015). Interview outcomes indicated that children in this centre were generally not interested in the mathematical concepts being explored.

Of the nine participants who implemented the activities on their own, four found the project challenging. They stated that at times, their philosophy about the inclusion of mathematics in their early childhood program conflicted with their colleagues' philosophies or beliefs about mathematics, the centre philosophy, or ideas for curriculum planning. These brief examples from the implementation outcomes demonstrate the variability of mathematics education children received across 15 Melbourne-based early childhood settings at the time of the research project. The following section discusses the implementation outcomes and implications for EAL children's learning.

7.6.6 Evidence of What Children Know and Are Ready to Learn Next

The assessment activities supported children's nonverbal communication of their existing mathematics knowledge. This was significant, as pre-implementation participants mostly viewed evidence of children's mathematics knowledge as verbal (69%). This outcome was important, as 51% of the children taking part in the implementation were reported to have EAL. It was discovered that "children knew a lot about maths" (MP, 12/11/16), and the activities brought children's knowledge to the fore.

EAL children demonstrated mathematics proficiencies that were otherwise undetected and at times exceeded participants' assumed understandings of the child's mathematics knowledge (31%). Participants also reported making assumptions about children's knowledge and proficiencies based on their language and literacy skills, having assumed that children who were adept at language and literacy were "above average" in all curriculum areas. Four educators noted their "surprise" at the amount of mathematics knowledge EAL children demonstrated during the assessments and at children's capacity to learn new mathematical concepts quickly (LS, 2/9/2016; 24/8/2016; BH, 6/9/2016; IY, 15/9/2016; MN, 12/10/2016). Participants also identified gaps in children's mathematics learning (MN, 12/10/2016; LS, 24/8/2016; IY, 19/9/2016; QL, 23/10/2016), which were addressed in planning. The assessment activities enabled children to demonstrate what they knew and what they were ready to learn next:

> B in particular surprised me with her visual knowledge by knowing very quickly which pieces had gone missing. After removing two pieces from a complex ABCD pattern she very quickly was able to inform me which pieces were missing. (LS, 2/9/16)

In this way, participants had evidence to plan for children's ongoing learning, meaning that the assessment activities could be used to support and scaffold EAL learners and address gaps in children's learning that may have otherwise remained undetected. The following section turns to focus on attrition and the factors impacting completion of the implementation.

7.6.7 Attrition

Of the 27 participants, 16 educators completed the final survey. Attrition was attributed to implementation "fade out" (Bailey et al., 2016), and participants reported time constraints and teaching commitments as factors impacting completion of the implementation. However, where participants reported child engagement, there was an increase in the level of educator engagement, rate, and rigor of implementation. Comparisons were made between responses to the first and final surveys based on average outcomes. Of the 27 participants, one completed eight rounds of data and implemented the six assessment activities, 16 completed the final survey, 13 attended Workshop 2, and 11 participants took part in the semistructured interviews. As the fortnights progressed, increased links between assessment and planning for learning were evident (Round 4: 22%, $n = 27$). For others, the link between assessment outcomes, analysis, and planning remained unclear and were not documented or reported (17%).

7.7 Summary

In summary, data indicated shifts in participant beliefs, teaching practice, and planning, ranging from significant changes to none at all. The greatest shift in teaching practice and educator beliefs about mathematics occurred when the implementation was enacted frequently and rigorously, and mentoring was provided to support the enactment of the activities. Post-implementation survey outcomes indicated that participant beliefs about their own mathematics ability increased by 29%, supporting the inclusion of mathematics across play-based curriculum areas. The results highlighted the need to provide educators with ongoing mentorship when enacting new ideas about play-based mathematics assessment in their programs. Supporting and mentoring the uptake of new ideas—until they become routine practice—can deter the fadeout that often occurs over time, when educators are unsure of how to enact the next stage in their learning (Bailey et al., 2016). Further research is necessary to determine what informs changes in beliefs about the place of mathematics in early childhood education and beliefs about mathematics ability in teaching practice. Chapter 8 discusses the implications of educator beliefs on the inclusion of mathematics in early

childhood education and the impacts of the implementation on participants' beliefs about their own mathematics ability and their teaching practice: observations, assessment, and planning. This discussion responds to each research question.

CHAPTER 8: DISCUSSION

8.1 Introduction

This chapter discusses the impacts of the implementation on teaching practice and educator beliefs in response to the research questions:

1. How did the implementation of a suite of play-based mathematics assessment activities impact early childhood teaching practices, including observations, assessment, and curriculum planning?
2. How did the implementation affect educator beliefs regarding mathematics education in their early childhood programs?

Framed by the research questions, key themes began to emerge from the analysed data. Each theme was chosen because of the frequency with which it emerged from the data, and because of its relationship to the research questions. In this chapter, the key themes that will be discussed in the following sections are teaching practice, including observations, assessment, and planning; educator beliefs about early childhood mathematics; the impact of beliefs on mathematics in early childhood education; the role of curriculum in early childhood education; and the role of the mentor. The discussion is framed by the underlying theoretical rationale which aligns with a social constructivist approach (Vygotsky, 1978; Wood, 1998). First, Section 8.2 focuses attention on teaching practice, including participants' observations, assessment, and planning for children's learning.

8.2 Teaching Practice: Observations, Assessment, and Planning

In this study, teaching practice consisted of three key areas: observations, assessment, and planning for mathematics learning. This is aligned with the early childhood education profession in Australia, where educators are required to provide evidence-based planning to support children's numeracy learning (DEEWR, 2009). Such planning requires purposeful observations, analysis that is guided by knowledge of typical early childhood developmental progressions, and links to further curriculum planning for ongoing learning (ACECQA, n.d.) (see Section 1.2.1).

Analysed data in this study highlights the tenuous links that exist in the observations–assessment–planning process (see Section 7.2). This echoes existing research that has highlighted how educators can improve their understandings of knowing what to observe as evidence of children's mathematics learning, how to analyse observations, and further, how

to link analysis with evidence-based planning for learning and in so doing, expose the need for support in their documentation of children's learning (Anders & Rossbach, 2015; Anthony et al., 2015; Bradford, 2012; Bromley, 2009; Chiatovich & Stipek, 2016; Lake & Kelly, 2014; Ramirez et al., 2013; Rosenfeld, 2010; Stonehouse, 2015).

The outcomes of this research project reveal a gap between what is known in the research literature about the value of explicitly teaching mathematics in early childhood programs and what is currently being enacted in daily teaching practice. Historically, the adoption of intentional teaching strategies in early childhood mathematics education has been challenging (Ginsburg et al., 2014; Ginsburg et al., 2008). This is mainly because views about what constitutes mathematics in early childhood play-based contexts vary widely. The necessity of assessing children's mathematics knowledge is often debated (Barblett, 2010; Clements et al., 2017; Hachey, 2013b; Lee & Ginsburg, 2009; Sandberg & Pramling Samuelsson, 2003; Starkey et al., 2004) and, as indicated in the study outcomes, continues to be misunderstood as "testing" and applies unnecessary pressure on children during childhood (see Section 2.4.1).

The gaps between assessment and explicit teaching strategies need to be addressed to support children's mathematics learning. This is an area of ongoing debate in early childhood education and evokes diverse responses from both researchers and educators in the field (Duncan et al., 2007; Fleer, 2012; Hachey, 2013b; Lake & Kelly, 2014). The gaps between observations, assessment, and planning are important to address, as the outcomes from this study indicate that large individual differences in the provision of planning for children's mathematics learning exist, impacting the individual differences in children's mathematics knowledge prior to commencing formal schooling (Jordan & Levine, 2009; Starkey et al., 2004), which can have ongoing implications for later mathematics achievement (Baroody, Lai, & Mix, 2006; Claessens & Engel, 2013).

The data indicate variability in participants' responses to the implementation of the assessment activities. While educator beliefs are discussed in more detail later in this chapter (see Section 8.3), beliefs and practice are closely related, and it is thus necessary to refer to educator beliefs while focusing primarily on observations, assessment, planning, and the constructs of teaching practice. Specifically, some participants in this study were challenged to re-evaluate their understanding of play-based learning to accommodate the inclusion of intentionally assessing children's mathematical thinking *in the context of play*.

Participants reported challenges when merging their understandings of play-based philosophies of learning with children's mathematics education. Discussion from the semistructured interviews was representative of the attitudes of six participants who held strong beliefs about a divide between play-based learning and the place of mathematics in early childhood. This highlights the difficulties educators face when knowing how to assess children's mathematics knowledge, what to plan next to support children's learning, and how to "merge" the explicit teaching strategies necessary to support children's mathematics learning with free play. These outcomes highlight the divide that still exists between understandings of play-based learning and mathematics in early childhood education, as within this sample population, mathematics was generally perceived to be an academic subject incompatible with play and challenging to incorporate within a play-based learning context.

The comments made by six participants during semistructured interviews reflect a resistance to following an assessment of child knowledge with the development of contingent learning experiences that support the consolidation and extension of learning. This is indicative of the challenges educators face when thinking about the place of mathematics in a play-based program and aligns with findings in other studies (Aubrey, 2013; Kilderry, 2015; Klibanoff et al., 2006; Lehrl et al., 2016). The data reflect educator uncertainty about what to do with assessment outcomes, what the best teaching strategies are for supporting children's mathematics learning, and how to implement these strategies in an early learning context. During the semistructured interview, OR explicitly expressed her views about "fighting" against a perceived "push down of information" (18/11/16) in early childhood education despite assessment outcomes indicating evidence of children's mathematics knowledge. OR was also aware of how her views linked with her own negative experiences of and beliefs about mathematics in school. This was typical of participants, who reported that their beliefs about what children were ready to learn did not align with evidence of children's demonstrated knowledge and understandings of what early childhood mathematics could be in practice.

Finally, although all participants shared similar pedagogical contexts and philosophies of play-based learning, subject to the same National Quality Standard (ACECQA, n.d.) and early years learning frameworks (DEEWR, 2009; DET, 2016), interpretations of play-based philosophies and how they were enacted in practice varied widely in the data outcomes (Ohi, 2008). The data outcomes suggest that each participant had brought their own individual

beliefs and values about explicit teaching and play to the enactment of the implementation. The following section focuses discussion on observations.

8.2.1 Observations

Observations are integral to teaching practice and form a necessary part of the Early Years Planning Cycle (DEEWR, 2015). Educators working with young children are required to gather observational evidence of children's learning and document learning outcomes across time. This is not always straightforward, as young children demonstrate and communicate their knowledge in multimodal ways, through both verbal and nonverbal means (Pollitt et al., 2015; Pollitt et al., 2017; Wright, 2010). Educators observe children, gather evidence of their learning, and analyse and evaluate these observations with a view to informing evidence-based planning. The Early Years Planning Cycle (DEEWR, 2015) is significant, as children require explicit teaching strategies to learn the foundations of mathematics (Clements & Sarama, 2014). Purposeful teaching requires planning based on evidence of what children know. The Early Years Planning Cycle (DEEWR, 2015) begins with observations of children, which build understandings of their current knowledge, interests, learning, and development (Hodgeman, 2011). Therefore, observations that are purposeful and provide accurate snapshots of children's mathematics understandings are imperative to support development in this area.

Development in the early years can be rapid and unpredictable (Sheridan, Sharma, & Cockerill, 2008); therefore, regular and ongoing observations are necessary to avoid gaps occurring in children's mathematics learning. If undetected, gaps in children's learning can widen, impacting their future learning outcomes (Lehrl et al., 2016; NCTM, 2000b). Addressing the gaps in the planning cycle also aligns with broader research that has called for purposeful links between observations, assessment, program planning, and pedagogy in early childhood settings (Ginsburg, Kaplan, et al., 2006; Stonehouse, 2015). Therefore, observations are key to supporting successful planning and positive learning outcomes for children.

During the semistructured interviews, five participants discussed the pressure they felt to observe and document children's learning and the amount of time consumed searching this documentation to justify program planning. For example, participants reported being burdened by the responsibility of having to document "what children were doing" (DC, 11/11/16), "filling" children's portfolios (QL, 23/11/16; OR, 12/10/16; KC, 23/11/16), and the need for program planning to encompass "everything" (TL, 10/10/16). This seems to

align with the challenge of knowing what to observe and document as evidence of children's learning, as current methods of documenting children's learning were reported as being ineffective when supporting program planning.

The pre-implementation survey outcomes similarly demonstrate that during daily practice, participants felt pressured to capture evidence of children's learning and were frustrated by daily, ongoing demands for documentation in practice and the time taken away from teaching. This was reported as encroaching upon planning time, time "away from the children" and the pressure of "always catching up" on documentation (BR, 23/11/16). Documentation predominantly took the form of learning stories, reflections, and artefacts of children's work in an effort to capture "everything" (TL, 5/11/16); however, close perusal of the data submitted provided little evidence of analysis and links to planning. The data further demonstrate that despite the high volume of documentation, its usefulness in supporting planning was limited and reflects that participants were at times unsure of what was important to document as evidence of children's learning and therefore, instead of purposeful observations, documented broadly.

Purposeful observations, analysis, evidence-based planning, and learning outcomes that indicate what the child knows and is ready to learn next form the key tenets of the Early Years Planning Cycle (DEEWR, 2015). Data indicate that documentation of children's learning was also used in children's portfolios to provide families with a "keepsake" of their child's early years education and "learning journey" (TL, 15/11/16) throughout the year. This proves problematic when children's portfolios are mistaken for evidence of children's learning, as reflections, learning stories, and artefacts do not necessarily provide evidence of children's learning outcomes (Stonehouse, 2015). For example, three participants reported that although they were documenting broadly to capture "everything" (TL, 5/11/16; LJ, 12/11/16; OR, 15/11/16), their documentation was seldom used as evidence for program planning, raising further questions about the purpose and intention of the documentation (Kennedy & Stonehouse, 2012). As discussed in Section 1.2.2, the National Quality Standard requires educators to "observe purposefully" (ACECQA, n.d.), using the Early Years Planning Cycle (DEEWR, 2015) and frameworks to support assessment for learning, "which is designed to discover what children know and understand, based on what they make, write, draw, say and do" (DET, 2016, p. 13). This appears to explain the volume of documentation collected by the participants in this study; however, the intent behind the National Quality Standard is to "purposefully" gather evidence of children's learning to inform ongoing

evidence-based planning, which—when intentional—would have a purpose beyond filling portfolios.

Data from the pre-implementation survey and Workshop 1 indicated that one of the key challenges of this study would be to focus participant observations through a spatial reasoning and geometry lens. The intention of the implementation was to encourage participants to see, hear, and identify the spatial reasoning and geometry occurring during play. As the implementation phase of this project advanced, shifts in teaching practice began to emerge as participants observed and assessed evidence of children's spatial reasoning and geometry learning and reported linking this evidence to ideas for planning. The data reveal that as participants began to recognise the impact of their teaching practice and planning on children's learning and engagement, this in turn resulted in more frequent implementation of the assessment activities. These outcomes typically reflect how children's learning outcomes can provide motivation to enact change in practice (Brown & Inglis, 2013), as the reciprocal effects of children's engagement with learning on educator behaviour has been well documented over the years (Han, Yin, & Boylan, 2016; Skinner & Belmont, 1993). Participants reported that a combination of recognising the impacts of their planning on children's learning outcomes and an increased awareness of *how* to identify, observe, and name the mathematics occurring in their settings were the key contributing factors when identifying what to observe and document as evidence of children's mathematics learning during play.

In summary, the assessment activities equipped participants to observe and document evidence of children's spatial reasoning and geometry understandings with greater specificity. With improved observation, assessment began to inform cycles of evidence-based planning that were targeted at the child's ZPD (Vygotsky, 1978) and were, arguably, more engaging and specific to each child's learning needs. Data from the implementation and assessment records demonstrate that one of the most significant influences motivating the uptake of the assessment activities was participant observations of mathematical thinking during play and evidence of children's increased learning outcomes. Participants also reported knowing more about children's individual mathematical understandings and therefore planning next steps for learning became clearer. The discussion now turns to focus on the next key area of teaching practice: assessment.

8.2.2 Assessment

Data collected during Weeks 1 to 16 of the implementation phase highlight the challenges faced by educators when assessing children's learning in play-based environments. Emergent data reveal a disconnection between assessment and planning. Assessment is what takes place during the analysis of observations and, as Wiggins (1998) stated, should aim "to educate and improve student performance, not merely to audit it" (p. 7). Assessment is reliant on the professional knowledge and skills of the educator. The purpose of providing educators with the play-based assessment activities and records was to create a specific mathematics lens that would focus participant attention on observations of children's spatial reasoning and geometry learning as explored by children during play. As discussed in detail in the latter part of Section 3.4.7, the assessment activities and records provided participants with fewer mathematical concepts to focus on and in this way highlighted the potential links between observations, assessment, and planning. The assessment activities were not definitive; however, they included a core sample of what to look and listen for when observing children's spatial reasoning and geometry during play, the intention being to focus participant attention on the key aspects of spatial reasoning and geometry and how to identify and assess children's knowledge of these concepts in play-based contexts.

During the implementation, participants were asked to identify and document observations of children's mathematics knowledge, analyse the observations, and link the analysis with ideas for evidence-based planning. The intention was to explicitly link observations and assessment of children's spatial reasoning and geometry knowledge with the Early Years Planning Cycle (DEEWR, 2015) and support educators in knowing how to plan for children's ongoing mathematics learning in play-based contexts. The study focused participant attention on observations, assessment, and links to planning in daily practice in an effort to address the gaps identified in the extant literature between what was currently occurring in teaching practice and what needed to occur to make these links more explicit (Ginsburg et al., 2014; Kennedy & Stonehouse, 2012; Klibanoff et al., 2006; Lake & Kelly, 2014; Lehrl et al., 2016; Stonehouse, 2015) (see Section 1.2.3).

These findings were similarly reflected in data from this study: pre-implementation survey outcomes demonstrate that participants who were spending five minutes or less on mathematics observations, assessment, and planning per week reported that links between observations, assessment, and planning were not occurring (see Section 7.2.3), indicating that

the Early Years Planning Cycle (DEEWR, 2015) was not being effectively enacted in practice. Participants submitting data that did not demonstrate effective analysis of observations were emailed and asked to clarify the links between observations, analysis, and ideas for planning and whether support was needed to analyse the observations or generate ideas for and links to planning.

After Week 4 of the implementation, although the rate of enacted implementations declined, changes to teaching practice became evident (see Section 7.3.4). Eleven participants reported that the observations they had made were beginning to inform assessment and links to evidence-based planning. Data also indicate that children's positive learning outcomes increased participant confidence in teaching spatial reasoning and geometry because participants could see the positive impact of their teaching practice and planning on children's learning. These outcomes sustained participant engagement in the implementation. Post-implementation survey data demonstrate a 50% increase in participant confidence about their own mathematics abilities (see Section 7.5). By Week 8 of the research project, changes to mathematics practice and planning had shifted significantly. Data from the semistructured interviews demonstrate that 37% of participants were confident with the planning decisions they were making because their decisions were based on observations and evidence of children's demonstrated knowledge and their increased ability to assess the observations and link the assessment to planning.

Participants reported knowing what to look and listen for as evidence of children's mathematics understandings and began to include observations of mathematics in other areas of their program planning, including art, dance, geography, science, and imaginative play (see Section 7.4). This was significant because the pre-implementation survey outcomes had indicated that mathematics was perceived as a standalone subject, and that participants were looking for evidence of children's mathematical understandings predominantly when they were engaged in mathematics tasks. For a core group of six participants, observations and analysis of children's existing mathematics knowledge generated ideas for planning, which became more varied, linked to evidence of children's knowledge, and aligned with children's interests and creative explorations of mathematics during play. These participants shared mathematics anxieties; however, they overcame them during the implementation, being motivated by the belief that children's learning outcomes would benefit from explicit mathematics teaching.

It was hypothesised that assessment would be pivotal to educator engagement with the planning cycle, as assessment would highlight evidence of the existence of children's mathematics knowledge and further, highlight the planning necessary to support children's ongoing learning (see Section 7.2.2). Once an assessment activity had been implemented, it was anticipated that participants would make a direct link between assessment and planning, addressing the gap between assessment and planning identified in the extant literature (see Section 2.4.2). This was not the case. The initial rounds of implementation data demonstrate that participants found it challenging knowing *how* to identify and observe children's spatial reasoning and geometry understandings during play. Knowing what constituted evidence of children's spatial reasoning and geometry understandings during play was an important first step when assessing children's existing knowledge, and the assessment activities provided this first step. The outcomes indicate that when implemented fortnightly—and at the minimum rate—the activities provided a focus on what to look and listen for as evidence of children's knowledge; the activities prioritised mathematics and assessment *during* play and supported participant confidence in their own ability to identify and contingently plan for children's mathematics learning during daily practice (see Section 7.6.4).

In summary, assessment of learning informs planning for mathematics learning. Without evidence of what children know, it is not possible to assess and plan effectively. The assessment activities supported educator understandings of which aspects of spatial reasoning and geometry were relevant to early childhood programs and how to identify these concepts during play with a view to supporting links between observations, assessment, and planning. This highlights how identifying and assessing children's demonstrated mathematics capabilities are necessary to support children's mathematics learning. The discussion now turns to curriculum planning.

8.2.3 Curriculum Planning

In this study, the assessment activities placed a specific focus on observations as the key to assessment and evidence-based planning. The study highlights that planning does not occur in isolation, forming part of an ongoing cycle of observations and assessment, which—to advance children's learning—needs to be informed by observations and evidence of what children know and are ready to learn next (Ginsburg & Golbeck, 2004).

However, the study outcomes also indicate that in play-based contexts, children's demonstrated interests in mathematics were not always recognised or identified during play. Therefore, children's ideas in and interests about mathematics may not necessarily be

represented in program planning. This is perhaps not surprising. Identifying children's mathematics knowledge can be challenging, as children demonstrate their mathematics thinking in unique, creative, and often complex ways (Pollitt et al., 2015). The study outcomes highlight that the educator's ability to observe, assess, and plan for children's learning is contingent upon many variables, including qualifications, experience, skills, and beliefs about mathematics. For example, the pre-implementation survey outcomes demonstrate that participants were unsure of what constitutes mathematics in early childhood, how to observe and identify mathematics during play, which areas of mathematics were important for children to learn, and what types of mathematics were relevant to curriculum planning in play-based philosophies of learning (see Section 7.2.3).

Participants were unsure how to link assessment outcomes with ideas for play-based spatial reasoning and geometry planning. The reasons for the gaps in evidence-based planning for learning are informed by the many varied ways participants interpret and enact curriculum planning, further influenced by their qualifications, skills, and beliefs about early childhood mathematics and the broad range of understandings about how to link evidence of children's knowledge to planning (see Section 7.3.5). The study focused educator attention on evidence of what children know now in an effort to link observations, assessment, and planning. Significantly, the implementation data show that it *is* possible to conduct assessments of children's spatial reasoning and geometry knowledge in play-based contexts, providing evidence that children explore these concepts during play and that educators are identifying them. However, despite evidence to support children's interests in mathematics, data from the study indicate that planning for children's spatial reasoning and geometry learning is still not occurring.

Implementation data from this study reveal disparity and variability in participants' approaches to planning and further, disparity between the amount of mathematics planning and learning being afforded to children across the 15 participating services. This means that some children are receiving rich mathematics experiences, while some children are receiving very little or none at all. These outcomes are of concern given recent research outcomes highlighting the importance of children's foundational mathematics learning occurring in early years education (OECD, 2006).

In summary, educators require specific training and ongoing mentoring to observe, assess, and plan for children's mathematics learning in play-based contexts to address the gap between assessment and planning (Bruns et al., 2017). This gap continues to have a

significant impact on the quantity and quality of mathematics being taught in early childhood education (Chapman, 2005). Introducing participants to the spatial reasoning and geometric concepts underlying children's mathematics learning provides a way to address beliefs about what mathematics is and can be in early childhood curriculum and furthermore, each participant's ability to assess, teach, and plan for children's learning in this area. The following section discusses the implications of educators' beliefs about their own mathematics abilities and their beliefs about the place of mathematics in early childhood curriculum. As discussed in the section to follow, educator beliefs have a significant impact on the inclusion of mathematics in play-based curriculum.

8.3 Educator Beliefs About Early Childhood Mathematics

Mathematics teaching practice is informed by teachers' beliefs about mathematics, and these beliefs about mathematics are highly variable and frequently complex (Cohrssen et al., 2013; Cohrssen et al., 2015; Cohrssen et al., 2016; Seah, Andersson, Bishop, & Clarkson, 2016). The inclusion of mathematics curriculum in early childhood programs is largely reliant on individual teachers to plan and enact (Lee & Ginsburg, 2009). Many factors impact the quality and frequency of mathematics education enacted by early childhood educators: the educator's own formal mathematics education, and their personal beliefs, skills, and ability to teach mathematics in practice (Gould, 2012; Lee & Ginsburg, 2009; Todd-Brown, 2005). As stated in section 8.2.3, variability of mathematics teaching was evident across the 15 early childhood settings participating in this study.

As complex as they are, beliefs are important to address, as belief systems can significantly impact how and what we teach, informing the quality and quantity of mathematics children receive (Lake & Kelly, 2014). Data contribute toward understandings of how participant beliefs about teaching mathematics affected the implementation rate, as participants who reported mathematics anxiety held negative beliefs toward teaching mathematics in early childhood, lacked confidence in their mathematics teaching abilities, and had lower implementation rates (see Section 7.6.4). It is important to understand educator beliefs about mathematics because children's beliefs and emergent mathematics capabilities can be influenced by negative attitudes toward mathematics, having lasting impacts on children's capacity for mathematics learning and the next generation of mathematicians (Ginsburg, Hyson & Woods, 2014).

Over the past decade, research has examined how secondary teacher beliefs about mathematics contribute to pedagogical decision-making and impacts on teaching practice and behaviour (Aguirre & Speer, 2000; Schoenfeld, 1998, 2002, 2010, 2011; Zhang & Wong, 2015). Research into early childhood educator beliefs is emerging (Ginsburg, Kaplan, et al., 2006; Lake & Kelly, 2014), particularly with the increased recognition of the importance of teaching spatial reasoning and geometry learning in early years education (Clements & Sarama, 2014; Davis & SRSG, 2015; Moss et al., Pollitt et al., 2017; 2016; Uttal et al., 2013, Uttal & Sheehan, 2014). Educator beliefs (conscious or otherwise) inform behaviour and pedagogical choices, which ultimately impact teaching practice and the inclusion of mathematics in early childhood programs (Lake & Kelly, 2014; Lee, 2010). This is problematic in Victoria where there is no early childhood curriculum, and therefore, children's mathematics learning is reliant on the educator. It is therefore important to find practical ways and resources to address educators' negative beliefs and barriers toward the inclusion of mathematics in early childhood education to support necessary and lasting change in this area (Cohrssen et al., 2016), as sometimes beliefs can change through the successful enactment of a new idea or skill in practice, which breaks the cycle of negative belief and informs change by highlighting possibility. The following section discusses beliefs as barriers to change in more detail.

8.3.1 Beliefs as Barriers to Change

Participants' negative beliefs about their mathematics abilities were a common theme throughout the study, which at times presented barriers to implementing the assessment activities and effecting change. Participants reported that their beliefs about mathematics were mostly formed during early experiences of mathematics at school. Subsequent experiences of mathematics throughout school and during adulthood had contributed toward steadfast beliefs about their mathematics abilities and subsequently informed beliefs about the place of mathematics in early childhood (see Section 7.6.1). This was important to consider, as the implementation comprised new ideas about early childhood mathematics teaching practice and theory, and overcoming these barriers to change required a shift in thinking to support the uptake of the implementation in practice.

Shifts in thinking can present challenges, particularly when beliefs are steadfast and have been reinforced over time (Schoenfeld, 1998). Shifts in thinking require critical reflective practice (Kolb, 1984), a willingness to change, and the motivation to consistently enact change in practice if habits are to evolve. For some participants, this was challenging

and at times confronting, as data from the implementation and semistructured interviews indicate that during the implementation, six participants experienced mathematics anxiety and reported feeling stressed when anticipating the task ahead (Lyons & Beilock, 2012a). The following section discusses in detail how anxiety, associated with the anticipation of having to attend to mathematics tasks, can create barriers to change.

8.3.2 Mathematics Anxiety and the Enactment of Change

Anxiety is complex and can create barriers toward change (Hembree, 1990; Herron, 2010). Participants experienced anxiety at the thought of assessing and teaching mathematics, which led to memories of fears of being "tested" and "failing" mathematics at school. This at times led to task-avoidant behaviours (see the latter part of Section 7.3.4). During the implementation, and during the enactment of the assessment activities, six participants became aware of longstanding negative beliefs about their mathematics abilities. The six participants reported how, for a long time, these beliefs had created barriers to the inclusion of mathematics in teaching practice.

These findings align with Lyons and Beilock (2012b), who found that for people with high levels of mathematics anxiety, the thought of doing mathematics can be painful, evoking feelings of fear. They also found that the pain and fear associated with the anticipation of doing a mathematics task was not evident when the mathematics task was performed. They suggested that it is the anticipation of the mathematics task that evokes feelings of fear and pain and not the mathematics itself. Their findings align with the study outcomes, which highlight the importance of coaching mathematics-anxious educators when enacting mathematics tasks and to address anticipation before it leads to feelings of anxiety and barriers to change (see Section 7.3.2).

It was the *enactment* of the suite of assessment activities that began to impact beliefs and shift teaching habits. This as times required mentoring and coaching to support participants to focus on the task at hand, rather than on the anticipation and anxiety associated with "doing" mathematics. Data indicate that participants who learnt about spatial reasoning and geometry during the workshop, who did not enact the assessment activities in practice, did not demonstrate a shift in beliefs, indicating that beliefs were affected by the enactment of the implementation rather than an increase in spatial reasoning and geometry content knowledge alone. It is important to address the gap between educators' beliefs about mathematics and what they are capable of achieving in practice; as the study outcomes demonstrate, educators can hold on to mistaken beliefs for long periods of time, which can

influence task-avoidant behaviour. The following section discusses how disrupting cycles of belief can impact change.

8.3.3 Disrupting Cycles of Inherited Beliefs About Mathematics

Participants' beliefs about mathematics influenced their behaviour toward the teaching and prioritising of mathematics in program planning. This can have a significant impact on children's learning outcomes and, furthermore, children's emergent beliefs about their own mathematics capabilities (Stipek, Givvin, Salmon, & MacGyver, 2001; Tschannen-Moran & Hoy, 2001). This is significant and relevant to early childhood settings where children are reliant on educators to identify and support their emergent mathematics skills. Furthermore, children are influenced by educators' beliefs about and attitudes toward teaching mathematics, as educators' nonverbal communication, including gestures and task-avoidant behaviours, may influence children's beliefs and mathematics abilities (Tschannen-Moran & Hoy, 2001), particularly girls who can inherit negative dispositions toward mathematics prior to actually experiencing mathematics teaching and learning (Beilock, 2010; Beilock & DeCaro, 2007).

The participants in this study were women, and half the participants were of a generation where their experiences of mathematics teaching and learning at school would have been subject to gender bias (Bander & Betz, 1981; Dowker, Sarkar, & Looi, 2016). A majority of these women reported experiencing mathematics anxiety and, given the transmission of mathematics anxiety can be gender related, it is important to address and disrupt the cycle of negative impact this anxiety has on young children's emergent beliefs about their own mathematics abilities. It is well known that mathematics anxiety can inform later academic decisions (Brown, 2005; Devine, Fawcett, Szûcs, & Dowker, 2012) and limits occupational choices for women (Halpern et al., 2007). Therefore, addressing mathematics anxiety can disrupt this self-fulfilling prophesy, which over the years has resulted in an underrepresentation of women in mathematics-based careers (National Science Foundation, 2002). The assessment activities presented a way to address participants' mathematics anxiety through the enactment of resources that were not typically associated with traditional perceptions of "doing" mathematics and therefore bypassed anxiety associated with number and "calculations" that had previously presented barriers to the teaching of mathematics in early child education. The following section discusses beliefs about what children are ready to learn when compared to assessment and evidence of children's capabilities.

8.3.4 Beliefs About What Children Are Ready to Learn

A further barrier arising from the data is based on enduring beliefs about the child's level of maturation and capacity for cognitive reasoning at a young age. Beliefs about how children learn mathematics in early childhood education are grounded in developmental theory (Piaget, 1952), which continues to inform and at times limit beliefs about what children are ready to learn and what is appropriate to teach (Hachey, 2013a). Beliefs about developmentally appropriate practice have had a lasting impact on the inclusion of mathematics in early childhood programs today, as evidenced throughout the implementation (see Section 2.2.1). Participant (32%) beliefs about assessment and mathematics in early childhood education were based on theoretical constructs about children's maturation, cognitive ability, and readiness to learn, which have since been critiqued (Clements & Sarama, 2014; Hachey, 2013b; Lake & Kelly, 2014). Data indicate that participants were surprised at what children knew and were ready to learn, presenting opportunities to address beliefs about the place of mathematics in early childhood education. Mathematics can play a significant role in early childhood education since children are ready to learn, and ready to learn more than we probably think. The following section discusses how evidence of children's mathematics learning supported changes in participant beliefs about their mathematics teaching abilities.

8.3.5 Evidence Presents Opportunities for Change

Barriers to the implementation also presented opportunities for change. A synthesis of the data indicates that participant commitment to including mathematics in program planning challenged a lack of confidence about their own abilities in this area. Motivation to engage with the implementation was reported as a willingness to improve children's mathematics learning outcomes. In this way, participants who enacted the activities overcame negative beliefs about their mathematics ability.

Children's engagement in the activities and evidence of their ongoing learning outcomes had a significant impact on participant beliefs about their own ability to teach mathematics in a short period of time (between Weeks 2 and 12 of the implementation). The children's achievements provided motivation for change (Brown & Inglis, 2013; Jenßen, Dunekacke, Eid, & Blömeke, 2015; Lake & Kelly, 2014). Children's learning outcomes provided the evidence required to sustain participant engagement in the assessment activities and further, validate participant beliefs about their ability to teach early childhood mathematics. Participants who persisted with the project reported children's engagement with

the activities and children's learning outcomes as two of the key motivational factors for continuing to invest in the implementation, even when faced with challenges, such as gaps in their own learning or lack of interest in an activity. Despite these challenges, a core group of six participants persisted with the implementation, as evidence demonstrate that it was beneficial for their practice and children's mathematics learning (see Chapter 5).

In summary, both barriers toward and opportunities for change significantly impacted the range of implementation outcomes. Participant beliefs about mathematics impacted the provision of mathematics teaching and learning in early childhood. This was important to address, as negative beliefs about mathematics directly influence children's attitudes toward the subject and perpetuate cycles of negative beliefs about mathematics. Further, young children can inherit negative beliefs about mathematics from the adults around them, and form negative beliefs about their own mathematics capabilities prior to experiencing mathematics teaching and learning (Hadley & Dorward, 2011). Furthermore, an increase in spatial reasoning and geometry content knowledge alone did not impact educator beliefs; it was the *enactment* of new knowledge in practice, evidence of children's learning, and the provision of ongoing mentorship that had a positive impact on change. The enactment of the assessment activities throughout the implementation supported a sense of self-efficacy, and in most cases, participation in the implementation provided momentum for change. The following section addresses these complex relationships among educator beliefs in further detail.

8.4 Impact of Beliefs on Mathematics in Early Childhood Education

In this section, educator beliefs about the place of mathematics in early childhood education and educator beliefs about their own ability to teach mathematics are discussed in detail. Data outcomes demonstrate that these two areas of beliefs are often interrelated, complex, and difficult to separate and discuss in isolation. Beliefs about what constitutes mathematics in early childhood, the need for a mathematics curriculum and guidelines, and impacts of educator beliefs on mathematics teaching abilities are discussed. A model is proposed to demonstrate how the enactment of the implementation can disrupt negative cycles of belief and effect change.

A majority of the participants began the implementation with a range of beliefs toward mathematics and the teaching of mathematics in early childhood. These included not liking mathematics, being fearful of it, being unsure about what mathematics is in early childhood

education, not wanting to teach it, and wanting to teach it but not knowing how. These findings reflect the research of Ginsburg and colleagues (2014), who found similar traits in preservice and preschool educators, suggesting that preschool educators are drawn to the early childhood profession with the mistaken belief that they will not have to teach mathematics. As Ginsburg and colleagues (2008) wrote,

> Our personal experience suggests that many prospective and current preschool teachers do not like mathematics, are afraid of it, and do not want to teach it. The available research does not put the issue so bluntly, but provides evidence consistent with our observations. (p. 10)

When educators are fearful of mathematics and do not teach it, opportunities to critically reflect on their beliefs and fears about teaching mathematics may not occur—particularly if mathematics does not form part of daily teaching practice nor a structured curriculum. Furthermore, if educators' beliefs about their ability to teach mathematics remain unchallenged, these beliefs may not shift or evolve (Copley, 2004; Lee & Ginsburg, 2009; Maloney & Beilock, 2012). The following section discusses links between educator qualifications, beliefs about mathematics, and the inclusion of mathematics in program planning.

8.4.1 Educator Beliefs and Qualifications Inform Program Planning

Participants' early experiences of mathematics learning have played a significant role in shaping their beliefs about their own mathematics abilities and the place of mathematics in early childhood education. Data indicate that educator beliefs about their ability to teach mathematics were linked to the type and amount of mathematics included in their program planning, and the quality of mathematics included in program planning was further informed by participants' level of mathematics qualification. Participants with a background in primary education were more confident in their mathematics teaching and planning abilities. It was apparent that participants who were qualified primary school teachers valued the place of mathematics in early childhood education, reporting mathematics was important for establishing children's foundational learning prior to entering primary school. Experience teaching a primary mathematics curriculum contributed to participant understandings of the mathematics strands, developmental trajectories, indicative goals, and milestones for children's ongoing learning. Data also indicate that participants with primary experience

reported the importance of assessment and planning when supporting children's learning trajectories across curriculum domains.

By comparison, participants who were anxious about mathematics and believed they had limited mathematics abilities did not have a formal mathematics education. Reported reasons for not pursuing mathematics education were based on negative experiences of learning mathematics at school. This outcome aligns with research suggesting negative mathematics beliefs inform subject and career choices (Lake & Kelly, 2014). It is interesting to note that the reported reasons for not having a background in mathematics were based on early experiences of mathematics at school and related to beliefs about not being a "math person" (OQ, 12/11/16), which led to "dropping" (KC, 23/11/16) the subject. Participants reported wanting to have a positive effect on children's learning outcomes as they understood the influence negative beliefs could have on children's mathematics learning. These participants believed in the importance of teaching mathematics; however, perceptions of what mathematics could be in early childhood and the strategies for teaching it were at times limited.

During the implementation, shifts in beliefs and confidence occurred as participants identified mathematical concepts in their daily teaching practice. This included seeing pattern, symmetry, positional and directional language, and mapping as mathematical. Therefore, a background in mathematics did inform the amount and type of mathematics included in curriculum; however, at times, participants' negative beliefs about their own mathematics abilities were countered by the potential benefits of teaching mathematics in preschool education and a willingness to adopt new ideas in practice. These outcomes highlight the complexities inherent in the relationship between educator beliefs about mathematics and how they impact practice and planning. The following section discusses a proposed model that demonstrates how the enactment of the implementation can disrupt cycles of change.

8.4.2 Beliefs and Implementation Model

This model has been conceptualised to demonstrate cycles of negative and positive beliefs to illustrate how beliefs present both barriers and opportunities for change (see Figure 57). The model demonstrates how the implementation of the assessment activities had the capacity to disrupt negative beliefs and support the enactment of new knowledge about mathematics in practice. This is important as educators' pedagogical content knowledge is predictive of children's learning outcomes (Shulman, 2013), and educators' beliefs about

mathematics, opinions and personal memories about their own mathematics learning may influence the prioritising of mathematics in early childhood programs. The model proposes that through the enactment of the implementation, negative cycles of belief will be disrupted, resulting in change.

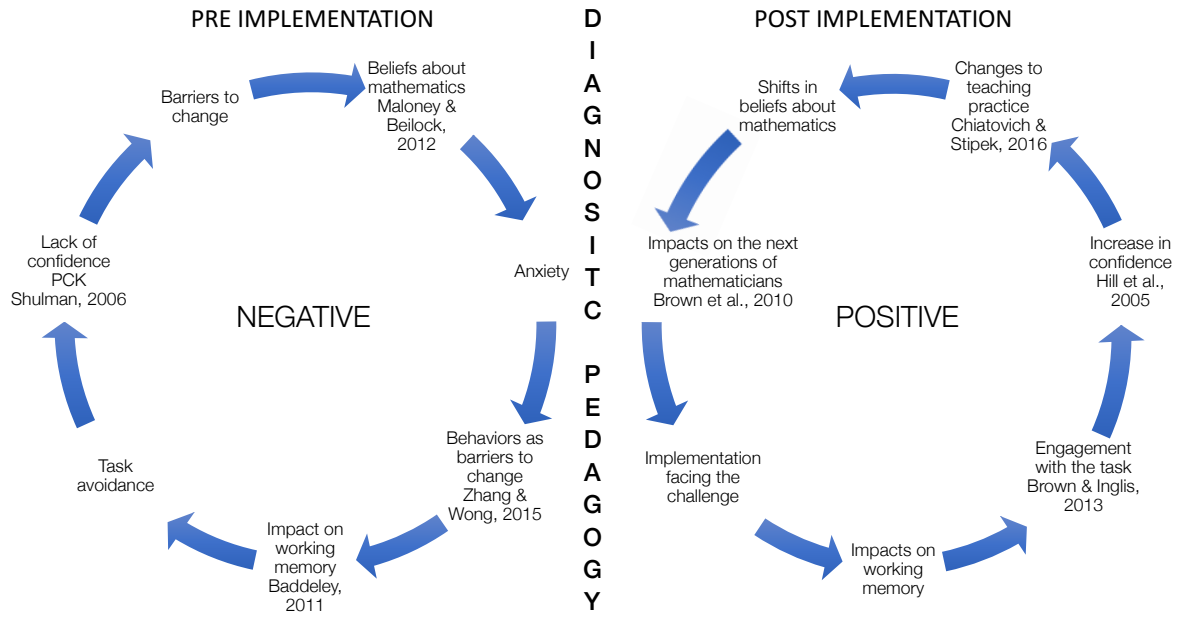


Figure 57. Diagnostic pedagogy model.

8.4.2.1 Cycle of negative beliefs

Cycle 1 of the model demonstrates how negative beliefs about mathematics abilities lead to feelings of anxiety when thinking about doing mathematics tasks. This anxiety is likened to a feeling of "cognitive disequilibrium", whereby beliefs about the task are incongruent with the task at hand (Guerra & Wubbena, 2017). This was important to consider as—for many reasons—participant beliefs about mathematics were often nonspecific and did not align with the requirements of the assessment activities or the play-based spatial reasoning and geometry tasks at hand. Participants' negative beliefs and anxiety were also associated with unpleasant memories of how they were taught mathematics (Ma & Xu, 2004; Rubinsten & Tannock, 2010). This is important to note, as often educators' beliefs about mathematics are influenced by experiences and personal memories of how they were taught mathematics, which has informed their teaching practice in some way (Brown, 2005). This anxiety created a range of physiological reactions toward the thought of doing mathematics, regardless of the task, for example, increased heart rate, sweaty palms, negative runaway

thoughts resulting in wanting to avoid mathematics, and choosing a profession where there is little demand for the teaching of it (Ashcraft, 2002; Lee & Ginsburg, 2008). As evident in other studies, the anxiety participants were experiencing was disproportionate to the type of mathematics tasks participants were asked to engage with in early childhood education (Hopko, Hunt, & Armento, 2005), suggesting that their anxiety toward the expectations of the task were incongruent with what was required by the task at hand.

Anxiety is known to impact reasoning abilities and cognition in children and adults. The reasons for this are complex, as often, reactions to anxiety are informed by conscious and unconscious beliefs (Ashcraft & Kirk, 2001; Ashcraft & Krause, 2007; Lyons & Beilock, 2012a; Owens, Stevenson, Hadwin, & Norgate, 2012; Young et al., 2012). Put simply, to establish equilibrium—a state without anxiety—an individual makes decisions that are informed by complex belief systems, conscious or otherwise, ranging, for example, from task-avoidant behaviour to a conscious shift in beliefs about the positive potential outcomes of their actions (Guerra & Wubbena, 2017). Anxiety is important to address as it affects working memory (Baddeley, 2011, Haavisto & Lehto, 2005), the very process needed to problem-solve and attend to mathematics tasks. Anxiety toward mathematics exacerbates the problem as anxiety is the very thing that inhibits mathematics reasoning, by impacting working memory, attention control, and the ability to achieve mathematics tasks (Eysenck, Derakshan, Santos, & Calvo, 2007). This can therefore lead to task-avoidant behaviour, as the thought of doing mathematics is stressful. Furthermore, if mathematics tasks are attempted under stress, it is difficult to complete the task, reinforcing the cycle of anxiety, poor performance, and beliefs about the inability to do mathematics (Lyons & Beilock, 2012a). This in turn leads to a lack of confidence as the more mathematics avoidant behaviour continues, the less mathematics content knowledge is learned or enacted in practice. These beliefs create barriers to change, and furthermore, this cycle of behaviour continues to reinforce participants' negative beliefs about their existing mathematics abilities.

This is significant in early childhood education because these negative beliefs have a lasting impact on the amount and quality of children's mathematics learning, and further, participants' negative beliefs and anxiety about mathematics can inadvertently be adopted by the children they teach (Lake & Kelly, 2014). Educator beliefs can innately impact children's beliefs about their own mathematics ability, as educators reactions and behaviours toward mathematics impact how children feel about their own emergent mathematics abilities. Research has suggested that by addressing the anxiety, the capacity to perform mathematics

tasks is increased and beliefs can shift (Artemenko, Daroczy, & Nuerk, 2015; Lake & Kelly, 2014). The following section adds to discussion about the enactment of the implementation and changes to cycles of belief.

8.4.2.2 Cycle of positive beliefs

Cycle 1 and Cycle 2 (see Figure 57) demonstrates how the implementation supported participants when addressing their mathematics anxiety by focusing attention on the assessment activity, evidence of children's mathematics knowledge, and links to play-based learning.

The suite of six assessment activities had a core focus on spatial reasoning and geometry skills that provided participants with specific mathematical concepts to explore in depth. They included clear links to play-based methods for assessment and ideas for planning. This helped to address anxiety by limiting mathematics to a sample of core spatial reasoning and geometric concepts necessary to support children's learning in a play-based context, concepts that were not traditionally associated with participants' perceptions of what constitutes mathematics learning, such as academic lessons, one-on-one tasks, worksheets, and testing. Participants also reported not realising that spatial concepts were mathematical. In this way, the focus on spatial reasoning and geometry—not typically included in early childhood education programs (Clements & Sarama, 2017; Davis & SRSG, 2015; Moss et al., 2016)—distinguished the suite of assessment activities from the participants' preconceived expectations about mathematics and thus resolved (to some extent) their mathematics anxiety. Figure 57 illustrates the cycles of belief, demonstrating how the enacted implementation could disrupt negative beliefs by providing educators with a tool to assess their pedagogy.

In summary, the implementation disrupted cycles of beliefs that had, in some instances, remained unchallenged since childhood. This highlights the long-lasting impact of early mathematics experiences on the perceptions participants still held of themselves as a "maths person", perceptions that some participants had held for as long as 30 years. The implementation provided a way to disrupt beliefs with a view to supporting the enactment of change in practice. Section 8.5 discusses the role of curriculum and the need to clarify what a mathematics curriculum is in early childhood education.

8.5 Role of Curriculum in Early Childhood Education

A theme that repeatedly emerged from the data demonstrates that participants had felt overwhelmed by the thought of teaching mathematics and knowing what to include in

practice, as mathematics alone covers a vast curriculum area. Participants who were trained in primary education used the Victorian Curriculum F–10: Mathematics (VCAA, 2017) in their practice and planning, stating that it provided ideas for what to plan next with a view to where children were heading. The need for greater clarity about the mathematics learning continuum, strand by strand, emerged more than once. Reports about the VEYLDF (DET, 2016) and EYLF (DEEWR, 2009) stated that the frameworks did not help participants to understand how best to support children's mathematics learning outcomes, and the expected goals for children's mathematics learning in early childhood education were unclear.

8.5.1 Role of Mathematics and Play-Based Learning

For a core group of participants, mathematics did not have a role in play-based curriculum, which impacted the prioritising of mathematics in program planning. While the rationales for these beliefs varied, it emerged that for six participants (22%), knowing how to enact mathematics playfully in practice was challenging. Children explore mathematical concepts creatively from a very young age, particularly during play (Cohrssen et al., 2013; Moss et al., 2015; Pollitt et al., 2015), highlighting the necessary adoption of play-based assessment strategies when planning for young children's mathematics learning.

By contrast, participants (22%) described teaching mathematics as a standalone, one-on-one task, which required instructional formats, was teacher led, and overly teacher directed. The six participants were resistant toward the inclusion of mathematics in early childhood education based on their negative beliefs and traditional perceptions of what mathematics is. In addition, these participants aligned their experiences of how mathematics was taught to them in school with expectations of how mathematics was taught in early childhood, as mathematics "teaching" was perceived as the imparting of arithmetical skills in the form of didactic lessons, which were reported as better suited to primary school. Participants' historic beliefs about mathematics as a formal academic subject and how it should be taught were at times seemingly unchangeable. These outcomes point toward the significant role educators' beliefs (about their own mathematics ability, the place of mathematics in early childhood, and mathematics assessment) play in the prioritising of mathematics in program planning.

Fundamental questions were raised during the implementation about the role of mathematics within play, for example, the role of spatial reasoning, geometry, and assessment in early childhood education, the role beliefs play in pedagogical decision-making, and how mathematics forms part of daily play-based programs. These contributors to

variability in the quantity and quality of mathematics that children have access to in their daily programs support the argument for an equitable approach to the inclusion of mathematics in early childhood education. It is well documented that support for children's mathematics learning in the early years is important and impacts the development of mathematical understandings now and in the future (Clements & Sarama, 2014; Davis & SRSG, 2015; Duncan et al., 2007; Farmer et al., 2013). However, outcomes indicate that participant beliefs about their own mathematics ability, what constitutes mathematics and assessment in early childhood, the compatibility of the assessment activities, and play-based philosophies of learning and how they align with a play-based curriculum have a significant impact on the provision of mathematics in early childhood (see Section 7.5.3).

8.5.2 Need for Early Childhood Mathematics Curriculum

The early years frameworks for Australia are guiding documents that are best described by what they are not. The frameworks are not a syllabus, program, curriculum, model, assessment tool, or comprehensive list of children's learning (DEEWR, 2009). The *Educators' Guide to the Early Years Learning Framework* (DEEWR, 2009) states that it is a framework of "principles, practices and outcomes with which to build your curriculum" (p. 3). Unlike a school or formal curriculum, the frameworks are open ended and provide a base from which early childhood professionals plan, promote, and assess learning (DEEWR, 2009). However, early childhood educators are not always sure how to plan for, promote, assess, or build mathematics curriculum in practice (Klibanoff et al., 2006; Lehrl et al., 2016). In addition, participants reported finding time to incorporate mathematics in curriculum challenging. These challenges were associated with uncertainty of what mathematics should be in early childhood and what to identify as evidence of children's learning during play, and at times, perceptions of early childhood mathematics were limited to counting, number, and shape (Clements & Sarama, 2014). Participants also reported feeling uncertain about how the frameworks supported understandings of what to enact in practice and further, how to align their practice and planning with "current thinking and expectations" (DEEWR, 2009, p. 3) as outlined in the frameworks.

Within a broad content area like mathematics, the assessment activities provided a core focus and starting point. The provision of a suite of assessment activities provided resources and structure for educators, making the process of knowing what to include in program planning clearer and more meaningful for participants and the children they teach. The interplay between in-the-moment assessment and facilitation of learning was evident as

participants commented on the way the assessment activities supported their observations of these concepts, their planning, and ability to contingently respond to teachable moments during play. Participants reported being able to access the upper reaches of children's spatial reasoning and geometry knowledge, and in doing so, planning became more meaningful and contingently responded to next steps on children's learning continuum, as evidenced in children's engagement in the task (Section 7.6.4). The clarity of the assessment activities' objectives and focus on what to identify as evidence of children's knowledge supported participants to see what children were demonstrating more clearly. Disrupting this cycle can address each child's right to a mathematics education (Cohrssen & Page, 2016).

In summary, there is a need for sustained professional learning that addresses the variability in the quality and quantity of children's mathematics learning and supports educators in knowing how and what to include in a play-based mathematics curriculum. To support the inclusion of mathematics in play-based curriculum and bridge the gap between explicit teaching and play-based learning strategies, mentorship and coaching are necessary. However, for change to occur, clear guidelines about what constitutes mathematics curriculum in early childhood—including play-based approaches to assessment and teaching mathematics—are necessary. It is proposed that with clearer frameworks to support understandings of what constitutes mathematics in early childhood, educators can begin to address their beliefs about the role of mathematics in program planning. With mentorship and support, educators could then begin to address beliefs about their ability to teach and enact an early childhood mathematics curriculum in practice, as data indicate that educator beliefs about their own mathematics abilities did not align with the mathematics that educators are required to teach in early childhood play-based programs. Section 8.6 focuses attention on the significance of mentorship, contingently responding to feedback, and sustaining change in practice over time.

8.6 Role of the Mentor

As discussed in Chapter 7, a broad range of participant responses were observed, ranging from significant and sustained changes in teaching practice to no change at all. Why this process was more straightforward for some participants than others is complex. While there were multiple variables—such as participant qualifications, experience, training, beliefs about mathematics abilities, and the place of mathematics in early childhood education—here the necessity of mentoring to sustain change is discussed.

8.6.1 Contingent Feedback Supports Change

It was necessary to respond to participant questions and data submissions with suggestions of how to analyse observations, make links between assessment and planning, and provide ongoing support and ideas for planning through coaching and supervision. During the semistructured interviews, participants who initially reported that they could not "do maths" discussed being more competent and confident about their mathematics skills and teaching practice after the implementation. To make this shift, educators had to *decide* to change and, through processes of critical reflective practice, determine what to change to accommodate new ideas and to integrate them in practice in a purposeful manner. It was evident that these decision-making processes were complicated for participants as they were not always informed by conscious beliefs and not always straightforward.

While enacting change in practice, participants require support, which in this instance took the form of workshops, coaching, feedback, mentoring and supervision during the implementation and played an important role in supporting the integration of new, evidence-based ideas in practice (Artman-Meeker, Hemmeter, & Snyder, 2014; Kam, Greenberg, & Walls, 2003; Matsumura, Garnier, & Resnick, 2010; Sarama, Clements, Starkey, Klein, & Wakeley, 2008). Enactment of new ideas about spatial reasoning and geometry are central to the uptake of recent research findings into routine practice, as data demonstrate that links between recent findings about spatial reasoning, geometry, and teaching practice were not occurring (see Section 8.2). The following section discusses the challenges inherent in sustaining change and beneficial outcomes in practice.

8.6.2 Sustaining the Benefits of the Implementation

Shifts in participant confidence and beliefs about their mathematics abilities alone are not enough to ensure sustained inclusion of mathematics in planning and curricula. Implementing new ideas in practice takes time, consistent practice, and support for the ongoing development of new skills and the formation of new habits (Schoenfeld, 2011). For many of the participants, shifts in beliefs were not enough to sustain inclusion of mathematics in their program planning. In line with other research, it is apparent that ongoing professional learning and mentoring is necessary to shift well-practiced behaviours, learn new habits and skills in practice, and support lasting effects (Lake & Kelly, 2014; Schoenfeld, 2000, 2008).

Once the implementation phase of the project had concluded, this rate of change was not sustained. As soon as one month after the implementation had finished, the survey data indicate that positive participant beliefs about the place of mathematics in early childhood

began to decline. This points to the fact that unless educators are mentored and the place of mathematics is clearly defined within curriculum planning, provision for the teaching, assessment, and planning of mathematics learning takes a lower priority and in many instances is just "too hard" (TL, 12/11/16). A majority of the participants reported (post-implementation survey) that mathematics was not included or was still considered a separate subject area and therefore not incorporated into routines across program planning or seldom identified as spontaneous teachable moments during play. Ongoing mentorship is necessary to support the link between spatial reasoning, geometry, and play across all curriculum areas.

8.6.3 Leadership and Collegiate Support

Six centres had more than one educator taking part in the implementation, and groups of participants from these centres reported sharing assessment outcomes and ideas for planning with each other. This highlights the importance of leadership and collegiate support when adopting new concepts in practice, as professional learning may not always be practical and provide an ongoing solution when adopting new skills in practice. Without ongoing support, research has suggested that implementation fadeout will happen over time (Bailey et al., 2016), and the benefits for participants who received the implementation diminish when participants are unsure about how to enact new knowledge in practice or do not know what comes next in the continuum of children's mathematics learning. This points to the importance of ongoing support for participants beyond the implementation to ensure the uptake of new ideas becomes part of routine practice and the benefits are ongoing (Bailey et al., 2016). This outcome provides further evidence of the benefits of ongoing mentoring and coaching when implementing change in practice to support lasting change. Outcomes indicate that in most cases, mentoring is necessary to facilitate this change. The following section provides a summary of the key findings of this discussion chapter.

8.7 Summary

This section is a summary of the key findings in this discussion chapter, focusing on teaching practice—observations, assessment, and planning—and educator beliefs about mathematics in play-based programs and mathematics teaching abilities. This section addresses mentoring and sustaining changes in practice over time and the potential for spatial reasoning and geometry to contribute toward an early childhood curriculum.

8.7.1 Teaching Practice: Observations, Assessment, and Planning

In summary, the data demonstrate that with a higher rate of implementation and degree of rigor when enacting the assessment activities in practice, impacts on participant beliefs about the place of assessment and mathematics teaching practice in play-based programs shifted, informing changes across observations, assessment, and planning. One of the key outcomes of the implementation indicates that participants were identifying mathematics in play and documenting evidence of children's demonstrated knowledge in the assessment records. These outcomes were visible, demonstrating that with support and mentoring, links between observations, assessment, and planning were being made, addressing the gaps identified in the Early Years Planning Cycle (DEEWR, 2015). Further, children's engagement with and interest in spatial reasoning and geometry tasks reinforced the place of mathematics in play-based programs. Furthermore, participants could see the impact of their teaching practice in children's learning outcomes, which motivated investment in the implementation and greater rates of change.

8.7.2 Beliefs About Mathematics in Early Childhood Education

A synthesis of the data reveals that participant beliefs are complex and at times fixed, influencing how mathematics is enacted in practice and further, influencing the inclusion of mathematics in program planning. However, evidence also indicates that beliefs can change rapidly. The suite of assessment activities provided participants with tangible resources and clear guidelines for the enactment of mathematics assessment, planning, and teaching practice in play-based programs, which for some participants, disrupted negative beliefs about their mathematics capabilities. A focus on play-based assessment of children's spatial reasoning skills can address educator beliefs about mathematics, as the tenets of spatial reasoning are not associated with traditional ideas of teaching and learning mathematics in early childhood. Assessment records provided evidence of children's mathematics abilities, indicating what children were ready to learn. Therefore, educators' beliefs about mathematics in early childhood education were challenged and in some cases prompted critical reflection and change. For a core group of participants, the enactment of the implementation created an ongoing cycle of positive impact on their beliefs about their own mathematics abilities and the place of mathematics in early childhood.

8.7.3 Mentoring and Sustaining Change

Adopting new ideas in practice requires ongoing support and mentorship to sustain the benefits of the implementation over time. The study outcomes indicate that collegiate support

for the implementation of new ideas in practice can support change. The data demonstrate that beliefs can change rapidly; however, new habits are formed slowly (Schoenfeld, 1983). Therefore, the provision of ongoing professional learning and mentoring can sustain these changes and the formation of new habits in practice over time. During the implementation, mentoring was necessary to support some participants when enacting change in practice. Mentoring and support were provided with a view to the potential long-term benefits the implementation outcomes could have on teaching practice and educator beliefs. The decline in the rate of mathematics teaching, assessment, and planning at the end of the study indicate that mentoring is necessary to sustain change in practice.

8.7.4 Contribution of Spatial Reasoning and Geometry Toward a Mathematics Curriculum

Spatial reasoning is a key concept that underpins mathematics learning (Davis & SRSG, 2015; Moss et al., 2015) and provides a way to support the provision of high-quality mathematics education programs (Uttal et al., 2013). It was established that spatial reasoning and geometry provides the foundation for mathematics learning in early childhood education. In this way, spatial reasoning and geometry can contribute toward an early childhood mathematics curriculum, providing a focus for educators in knowing how to support children's mathematics interests and learning, and further, knowing what to include in practice and planning. In Victorian early childhood programs, there is no set curriculum for the teaching of mathematics. Curriculum is child centred, informed by the Early Years Planning Cycle, and based on the interests of the child (DEEWR, 2015). It became evident that an early childhood mathematics curriculum could clarify uncertainty of what constitutes mathematics in play-based programs. Spatial reasoning and geometry align with the key tenets of a play-based curriculum. The suite of activities and guidelines provided a clear framework for the enactment of mathematics assessment, planning, and teaching practice. The guidelines provided a focus for what to look and listen for as evidence of children's demonstrated mathematics knowledge during play, further broadening educator expectations for mathematics learning beyond counting, number, and shape. A mathematics curriculum would also address the quality and quantity of mathematics learning afforded to children, addressing equity and the provision of mathematics teaching and learning for every child (Munn, 2006). Having discussed the five identified themes—namely, teaching practice, educator beliefs about early childhood mathematics, the impact of beliefs on mathematics in

early childhood education, the role of curriculum in early childhood education, and the role of the mentor—Chapter 9 turns attention to the study conclusions and implications.

CHAPTER 9: CONCLUSIONS

This study examined the impacts of the educators' implementation of a suite of mathematics assessment activities on their teaching practice, including observations, assessment, and planning for mathematics learning in early childhood settings. Using a social constructivist approach - which focused on how individuals create knowledge influenced by multiple belief systems and "lived experiences" (Guba & Lincoln, 2005, p. 196) - the study also examined the impact of the implementation on educator beliefs regarding mathematics education in early childhood programs and determined how beliefs informed the inclusion of mathematics in curriculum. It was established that when enacted in practice, the implementation supported educators to identify spatial reasoning and geometry in play-based contexts, and links between observations, assessment, and evidence-based planning for children's learning increased. The implementation also impacted educator beliefs about their mathematics teaching ability and the place of mathematics in play-based programs.

The following sections in this chapter present the conclusions and implications arising from this study. The first section revisits the research questions and outlines four key findings that contribute to the field of early childhood mathematics practice, research, and policymaking.

9.1 Revisiting the Research Questions

This research examined the impact of the implementation of a suite of play-based assessment activities on teaching practice and educator beliefs about mathematics. The research questions are listed below, this time accompanied by responses that are informed by the findings of this research study.

1. How did the implementation of a suite of play-based mathematics assessment activities impact early childhood teaching practices, including observations, assessment, and curriculum planning?

The implementation of the assessment activities, when implemented frequently and enacted with rigor, had an impact on early childhood teaching practice. Knowing how and what to observe as evidence of children's demonstrated mathematical understandings during play became clearer. Mentoring supported educators to make explicit links between assessment and curriculum planning.

2. How did the implementation affect educator beliefs regarding mathematics education in their early childhood programs?

The implementation and the enactment of the assessment activities in daily teaching practice affected educator beliefs regarding the inclusion of mathematics in their early childhood programs, by providing evidence of children's existing mathematics knowledge and capabilities. The reciprocal influence of seeing the impacts of their planning for children's mathematics learning reflected in children's learning outcomes increased educator confidence and beliefs about their own mathematics teaching abilities. Beliefs are malleable. Attending professional learning workshops alone can have little impact on barriers to change, as it was the enactment of new knowledge about early childhood mathematics in practice and the provision of mentorship that had a positive influence on educator beliefs about mathematics in their early childhood programs.

9.2 Key Findings

In responding to the two research questions, the data that were collected and analysed also highlighted the following key findings: that beliefs are changeable, that there is a need for an early childhood mathematics curriculum, that the provision of professional learning and mentorship in the early childhood profession is essential, and that it is necessary to address the gaps in the enactment of the Early Years Planning Cycle (DEEWR, 2015). The following section addresses educator beliefs.

9.2.1 Beliefs Are Changeable

In early childhood programs, educators' beliefs about mathematics have a lasting impact on the prioritising of mathematics in early childhood education (Clements & Sarama, 2014; Hachey, 2013a; Lee & Ginsburg, 2009; Maloney & Beilock, 2012). In this study, educator beliefs about mathematics informed what was included in and excluded from curriculum planning. Educator beliefs about mathematics created barriers to the adoption of emerging ideas about the teaching of mathematics in early childhood education (Lee & Ginsburg, 2009). These barriers were informed by negative beliefs and anxiety, which did not align with the requirements of the implementation (see Section 8.4.1). The implications of this finding are significant, as most often, beliefs about mathematics are informed by teachers, peers, and family, indicating that children's emergent beliefs about their own mathematics abilities are subject to the influences of others. Disrupting educators' negative beliefs about mathematics was therefore important to address.

When the assessment activities were enacted frequently and with rigor, educator beliefs changed rapidly. The study findings demonstrate that their beliefs were not fixed (see Guerra & Wubbena, 2017). Educator beliefs had a significant impact on the quantity and quality of mathematics children received in their early childhood programs. These outcomes had significant implications for the provision of mathematics in early childhood curriculum and therefore significant implications for children's ongoing learning and emergent beliefs about their own mathematics capabilities.

9.2.2 Need for an Early Childhood Mathematics Curriculum

In this study, the need for an early childhood mathematics curriculum to support high-quality mathematics education for young children in Victoria was identified. Data across the study demonstrate that the provision of mathematics learning for young children varied widely in quality, was generally infrequent, and at times non-existent. It was limited to fixed ideas about what constitutes mathematics in early childhood programs, which limited the way in which opportunities were provided for children to explore mathematics during play (Clements & Sarama, 2014; Moss et al., 2015), therefore limiting children's learning opportunities. These outcomes were influenced by educator beliefs about mathematics and play-based programs that exclusively follow the interests of the child. Educator bias, based on negative beliefs about mathematics, informed program planning. In practical terms, spatial reasoning and geometry contributed to the foundations for mathematics curriculum, providing a focus on the key concepts underpinning children's mathematics learning and establishing foundations for children's future mathematical understandings (Davis & SRSG, 2015; Moss et al., 2015; Uttal & Sheehan, 2014, Uttal et al., 2013), which are not contingent on educator beliefs.

The notion of an early childhood mathematics curriculum is not a new idea, as multiple successful examples of preschool curricula already exist (see Department for Education (UK), 2017; Lillard, 2007; Department of Education (Northern Territory), 2017; NAEYC, 2010). An early childhood mathematics curriculum could address every child's right to mathematics education in play-based programs (Cohrssen & Page, 2016).

9.2.3 Ongoing Mentorship Supports Gains in Professional Learning

Evidence from this study supports the need for ongoing mentorship to fully and effectively realise the positive benefits of professional learning in daily practice. Professional learning alone has little impact on practice when it is a one-off event. Without ongoing mentorship, the positive effects of implementation research dissipate over time (Bailey et al.,

2016). Observing, assessing, and planning for children's mathematics learning require specific training and skills (Bentzen, 2009). To sustain the benefits of professional learning over time, it is necessary to build on the provision of mentoring available to educators and educational leaders in this area. Professional learning that has provision for ongoing mentoring and coaching is optimal when sustaining change—ongoing support is necessary when enacting change in practice.

Mentoring and coaching is an important aspect of linking theory to practice, as well as providing educators with the skills required to—in this instance—make links between observations, assessment, and planning for children's mathematics learning in daily practice. In this study, evidence demonstrates that an increase in content knowledge alone did not inform changes in teaching practice, as it emerged in this study that educators who received ongoing mentorship demonstrated gains when integrating new ideas into their daily practice and programs. Effective and regular mentoring has the capacity to support and sustain positive changes in routine practice and program planning.

9.2.4 Enactment of the Early Years Planning Cycle

Gaps were observed in the effective enactment of the Early Years Planning Cycle (DEEWR, 2015). This study identified that gaps between assessment and planning in play-based contexts impact the quantity and quality of mathematics included in early childhood education. This remains an ongoing issue in early childhood teaching practice (Clements & Sarama, 2014; Davis & SRSG, 2015; Lake & Kelly, 2014; Moss et al., 2016). This study addressed the key obstacles to the effective enactment of the Early Years Planning Cycle (DEEWR, 2015), identified as time constraints, the prioritising of mathematics in planning play-based activities, participants' lack of confidence when knowing how to identify children's demonstrated mathematics knowledge during play, and the integration of mathematics with play-based philosophies of learning. Knowledge of what constitutes mathematics in early childhood education, including what constitutes observational evidence, assessment, and planning, was highly variable. This study addressed this variability by focusing educator attention on what to identify and observe as evidence of children's mathematics knowledge, informing assessment, and links to evidence-based planning. The following section presents the four key findings arising from this study and how they informed implications for further research, policy, and practice.

9.3 Limitations

The key findings discussed above should be understood in the context of the limitations inherent in the research design.

9.3.1 Generalisability of the Data

The generalisability of the data is constrained by the fact that the data was collected in the Melbourne Metropolitan area. Therefore, we need to exercise caution when considering the applicability of the research outcomes to regional and remote areas of Australia. In addition, if the research design was replicated in these remote areas, budgets and resources would need to be up scaled to provide the necessary workshops and contingent mentoring.

9.3.2 The Major Concepts Underpinning Spatial Reasoning

The six assessment activities were designed to cover the major concepts underpinning spatial reasoning, which were applicable to a play-based context. There is scope for these resources to be expanded, however it was necessary to limit these in order to prevent the research from becoming too onerous for educators.

9.3.3 A Focus on Educator Outcomes

The scope of this doctoral research project prioritised the impact on educator outcomes, rather than children's learning outcomes. The design of the study did not provide for the assessment of individual gains in child outcomes. An up scaled longitudinal study could provide further data on the impact on children's learning outcomes.

9.4 Implications

The four key findings arising from this study were

1. the need to address early childhood educator beliefs about the inclusion of mathematics teaching practice and planning;
2. the need for an early childhood mathematics curriculum;
3. the importance of professional learning and ongoing mentorship for educators to sustain change when enacting new ideas in teaching practice; and
4. the importance of focusing educator attention on play-based spatial reasoning and geometry assessment activities to address gaps in the planning cycle.

The implications of these findings in the context of the further research, policymaking, and practice are discussed in the following sections.

9.4.1 Implications for Further Research

Implications for further research include a focus on how educator beliefs and anxiety about mathematics inform the inclusion of mathematics in teaching practice and planning in 3- to 5-year-old settings. Research into tools and resources for educators to implement in practice that reframe beliefs about traditional perceptions of mathematics assessment are necessary. Further investigation into spatial reasoning and geometry as a platform for early childhood mathematics curriculum is necessary to validate spatial reasoning and geometry as a foundation for children's mathematics learning.

The implications of supporting young children's spatial reasoning and geometry learning (0–3 years) would benefit from further investigation, as data demonstrate high levels of proficiency in this age range. There is a significant need for practical resources and materials that support educator understandings of what and how to assess and plan for very young children's mathematics learning during play.

Research on how to support early childhood educators when assessing and planning for EAL children's mathematics learning is also necessary, given the high proportion of EAL children in the 15 settings represented in the study (51%). Given the cultural diversity of children in Australia, understanding how to support children's mathematics learning is essential and has further implications for research into first language maintenance.

The implementation model, although not new, became an original perspective on ways to conduct implementation research in early childhood education. This model contingently responded to data analysis from each stage of the research project, and the outcomes from each stage of the study informed the next. This model has practical implications for implementation research and further, the design and delivery of professional learning to early childhood professionals. The effectiveness of the implementation model and the potential for such models to impact professional learning is tangible. Further research into the effectiveness of such models is necessary to determine if the implementation model can support a professional learning framework.

9.4.2 Implications for Policy

The implications for policy, arising from the findings of this study include

1. the need for preservice play-based mathematics education and training for early childhood educators;

2. ongoing professional learning and mentorship when making links between emergent early childhood mathematics theory and research findings in practice; and
3. ongoing mentoring for graduate educators to support and sustain the enactment of new ideas in professional practice.

The Department of Education and Training in Victoria has an Effective Mentoring Program (DET, 2016), which provides training for experienced teachers in mentorship. However, there is an overwhelming demand for mentorship in early childhood, and existing mentors are unable to keep up with current demands in Victoria (DET, 2018). Implications for the provision of funding to address this demand is evident.

A further implication for policymaking is the need to address access to and equity of the provision of play-based mathematics education for young children through an early years mathematics curriculum based on the key tenets of spatial reasoning and geometry and therefore the foundations of mathematics learning.

9.4.3 Implications for Practice

The development of an early childhood mathematics curriculum is necessary to help focus educator attention on what is important to include in early childhood program planning. In this study, it was evident that clear guidelines for identifying mathematics during play, clear assessment objectives, and further, ideas to support educators when planning next steps along each child's mathematics learning continuum were necessary to support teaching practice. The following section provides a final summary of the key outcomes of this study.

9.5 Final Words

This study contributes toward a growing body of research that has examined educator beliefs about the place of mathematics in early childhood education, educator beliefs about their mathematics teaching abilities, beliefs about the explicit teaching of mathematics in play-based contexts, beliefs about the age at which children demonstrate their mathematics knowledge, and the potential impacts educator beliefs can have on children's mathematics learning now and in the future.

This study demonstrates the divide that exists between educator beliefs about mathematics, and the contribution of early mathematics learning to child outcomes that research demonstrates. Educator beliefs influence what is included and enacted in practice when supporting children's mathematics learning, the quality and quantity of mathematics education children receive continues to be variable and inequitable. Some participants

experienced dramatic changes in beliefs, which aligned with the rate of the enactment of the assessment activities. However, effecting belief change did not always lead to practice change, due to the constraints brought about by variables such as being time-poor, and experiencing mathematics anxiety. In some instances, no belief change was observed, and consequently enactment was low or non-existent.

This study has focused our attention on the impacts of educators' implementation of a suite of play-based assessment activities that addressed gaps in their enactment of the Early Years Planning Cycle (DEEWR, 2015). Assessing what children knew in order to plan to consolidate or extend learning was the missing link when participants identified mathematics in play. The assessment activities aligned with the philosophies of play-based learning and equipped participants to address the gaps effectively and consequently to enact the Early Years Planning Cycle (DEEWR, 2015) in teaching practice. This demonstrated how the enactment of an intervention can support the identification of mathematics during play and be a vehicle for change in teaching practice.

The study established that in a short time—but with support—educators were able to identify children's mathematics learning during play and enact evidence-based planning to support children in reaching their mathematics potential. When educators identified evidence of children's demonstrated mathematics knowledge, this evidence had an impact on their beliefs about the relevance of mathematics education in early childhood education and further, provided direct links to evidence-based planning for children's learning.

It is timely to address mathematics in early childhood education and to find a place for it in play-based curricula, as children are highly mathematical (Clements & Sarama, 2014) and have a right to mathematics learning (Cohrssen & Page, 2016). It is well documented that early numeracy knowledge, above literacy, is a better predictor of children's future success in school (Chen et al., 2017; Duncan et al., 2007; Hill, Rowan, & Loewenberg Ball, 2005). However, despite the importance of this persuasive body of research, evidence of change over the past ten years is minimal (Chen et al., 2017). Increasingly, we are observing a momentum to incorporate STEM in early childhood education, yet the building blocks of STEM, that is, science, technology, engineering, and mathematics, have yet to be established in early childhood teaching practice and curriculum.

Finally, this study provides further evidence of the variability in the provision of early childhood mathematics education across Melbourne, demonstrating the importance of play-

based assessment resources, frameworks, explicit teaching strategies, and the need for an early childhood mathematics curricula to support educators in knowing how best to assess, teach, and plan play-based mathematics programs for every child.

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APPENDICES

Appendix 1: Guideline to the Assessment Activities

Guideline to the Assessment Activities

Project: Examining the impact of six play-based assessment activities on teaching practice, planning and beliefs regarding mathematics in early childhood

Rachel Pollitt PhD Candidate, Graduate School of Education
University of Melbourne 2016

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Assessment Activities at a Glance

Assessment Activity	Activity	Assessment
1. What Makes a Square?	Making a square by combining two shapes or more.	Makes square using two or more shapes, names 2D shapes, uses directional language, uses geometric language eg. triangle.
2. Symmetry	2D shape composer and decomposer, making a symmetrical design.	Identifies line of symmetry, matches shapes, uses positional/directional language. Demonstrates understandings of symmetry, eg. two sides match, two halves are the same.
3. Pattern: What Comes Next?	Repeating pattern, making a pattern and knowing what comes next, or what is missing.	Makes a pattern, extends the pattern, understands the rules of the pattern structure, eg. ababab. May count elements, recognise number/sequence. Identifies what is missing.
4. 3D Shape: Look, Think, Make!	3D shape: repeats design from memory.	Names some 3D shapes and their attributes, uses positional/directional language or gesture, composes and decomposes shape. Repeats design from memory.
5. From Here to There	Describing and showing the movement of animals/objects from one location to another.	Describes object in relation to other objects. Uses positional, directional language or gesture.
6. Mapping Pathways	Pathway grid for mapping using 2D symbols Orientation, coding and sequencing.	Uses positional directional words/gestures. Uses grid to map directions from start to finish. May use 2D symbols to document directions as a sequence of code. May guide others through pathway.

1. Assessment Activity: What Makes a Square?







For educators to observe children:

1. Making a square using two or more shapes.
2. Recognising smaller shapes can combine to make larger shapes.
3. Saying "turn, flip, slide, rotate" when arranging shapes.
4. Using geometric language: triangle, square, parallelogram, angle, corner, face, long side, short side, large, small.
5. Identifying the attributes (rules) of shapes, for example a triangle always has three sides.

What you will need:

- Tangram (one set is for three participants)
- Refer to pages 4 – 10 of the assessment guideline.

Rationale and Purpose

The tangram is a square, made up of seven small shapes. The square can be decomposed into seven smaller shapes and recomposed to create the square. Children begin to see how smaller shapes can combine to make larger shapes, with many different ways to achieve a goal. For example: two triangles can make a square, as can different combinations of shape. This informs later maths learning, for example, how different combinations of number can add together to "equal" ten, part/whole relationships and fractions. Children see there are many creative ways to solve mathematical problems. Children may say "turn, flip, slide, rotate" as they move the tans. Exploration of the tangram encourages children to identify, match and compose new shapes which may relate to familiar forms. for example, children may say: "It looks like a bird". This assessment is conducted with a small group of children to support peer talk and joint problem-solving skills to achieve a goal (Ramani et al., 2014).

Links to the EYLF

Outcome 4: Children are confident and involved learners

Children develop a range of skills and processes such as problem solving, inquiry, experimentation, hypothesizing, researching and investigating. This is evident, for example, when children:

- make predictions and generalisations about their daily activities, aspects of the natural world and environments, using patterns they generate or identify and communicate these using mathematical language or symbols
- contribute constructively to mathematical discussions and arguments (2009, p.35).

Links to the Australian Curriculum

Measurement and Geometry

Shape

Foundation Year: Sort, describe and name familiar two-dimensional shapes and three-dimensional objects in the environment.

Year 1: Recognise and classify familiar two-dimensional shapes and three-dimensional objects using obvious features.

Location and transformation

Foundation Year: Describe position and movement.

Fractions and decimals

Year 1: Recognise and describe one-half as one of two equal parts of a whole.

(ACARA, 2016)

5

Introduction and background to assessment of shape



Why is shape important? Why do we assess children's understandings of shape? Children's geometric development increases as children are able to "construct and duplicate units of units (shapes made from other shapes) intentionally, and understands each as being both multiple small shapes and one larger shape" (Clements and Sarama, 2012, p.265). Opportunities to explore shape and part - whole relationships are linked to understandings of number and later algebraic reasoning. This is important as children develop their mathematical skills by manipulating shapes, discussing part-whole relationships, identifying the attributes, and exploring the relationships between them (Clements and Sarama, 2012). For example, identifying two triangles make a square, and describing one triangle as representing one half of the two equal parts of the square supports later knowledge of fractions (VCAA, 2016). When grouped together, shapes may be associated with a familiar form, which engages visualisation skills essential for problem solving and mathematics learning (Moss et al., 2016). This activity helps us to assess children's existing knowledge, supporting the ongoing development of these skills.

Step one: thinking mathematically about shape and tangrams



1. Exploration: working with a small group of children, provide each child with a tangram. It could be useful to read *Grandfather Tang's Story* to introduce how smaller shapes can combine to make larger shapes or designs.

2. Discuss the shapes in the pictures. Talk about the different shapes that make up the whole design. For example:
   "Do you recognise any shapes in this picture?"
   "What are some of the shapes you can see?"
   "Which shapes make up the body of the bird?"



3. Invite children to explore the tans and create their own designs. Discuss the shapes used to make the designs. Use the words "flip, slide, turn, rotate" to describe children's actions.

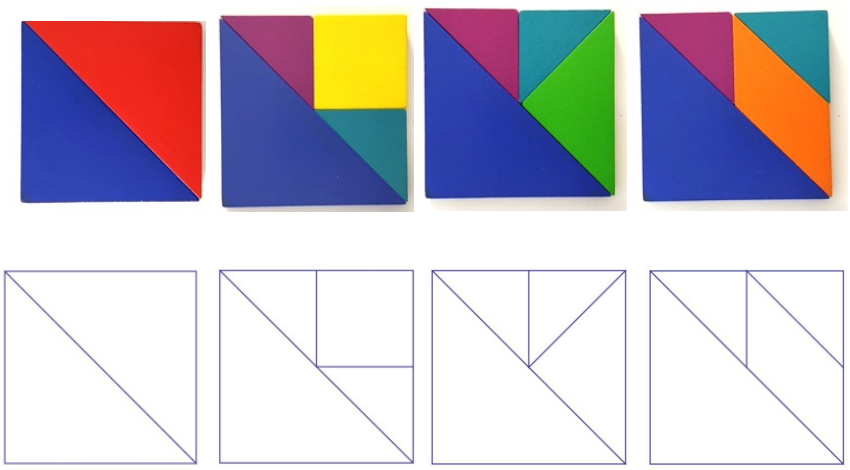
4. Invite children to describe their design. Highlight how smaller shapes combine to make larger shapes, for example: "You've made a large rectangle by combining these smaller shapes, can you tell me more about it?"

Assessment Activity: What Makes a Square?

1. Use shapes from your tangram to make a square, for example, two triangles. With a small group of children, talk about what you are doing as you make the square, using the words "flip, slide, turn, rotate".

2. Invite children to find the triangles in their sets and make the square, just like yours. Describe children's designs using mathematical language, for example: "These two triangles make a square." Talk about why it is a square (four sides of equal length, flat sides, four right angles).

3. Invite children to see if other combinations of shape will make a square. Ask children: "How many shapes make up your square?" Count the pieces, discuss the shapes and why they were chosen. Ask children what they did first? Children see there are many different ways to achieve the goal.



Assessment: What to look and listen for

The child:

- makes the square using two or more shapes.
- recognises smaller shapes can combine to make larger shapes.
- says flip, slide, turn and rotate when moving shapes to create the square (directional language).
- uses geometric language: triangle, square, parallelogram, angle, corner, face, long side, short side, large, small.
- identifies the attributes (rules) of shapes, may say: "a triangle always has three sides".
- uses trial and error to make the square.

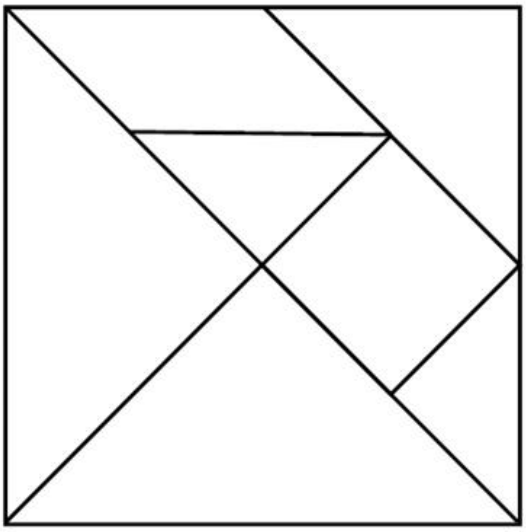
Fill in the assessment record as you go. What did you notice? How did the outcomes of this assessment inform your planning?

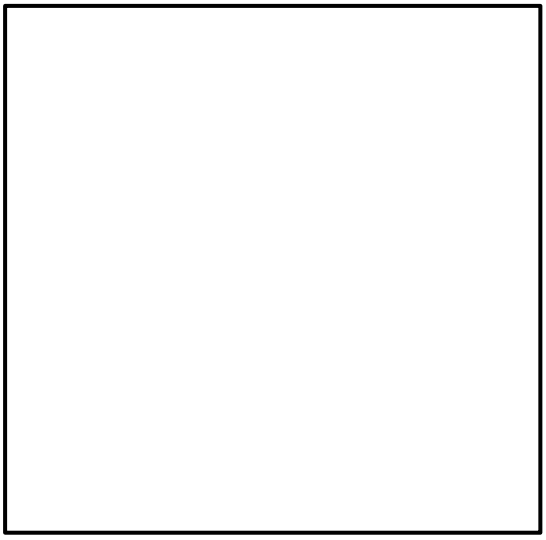
Implementation and Assessment Record

The implementation and assessment record are provided as a guide for you to document the assessment outcomes. Copies of these records are provided with each of the activities. Please date, check the appropriate boxes and fill in the record each time you use this assessment. Please use one row per child for each assessment and note any impact this assessment activity has on your practice or planning in the comment box provided. If you make any variations or adaptations to the assessment activity, please document the changes and outcomes. The implementation and assessment records will be collected each fortnight, and new copies provided as required. You may choose to keep a journal for further comments.

Implementation and Assessment Record Tangram: What Makes a Square?																	
Date & Child's Initial								Composes/ decomposes shape			Identifies shape and attributes				Makes square uses trial and error	
	flip	slide	turn	rotate	half turn 180° whole turn 360°	around	matching	triangle	square	parallelogram	angle	corner	side	face	part (half)	whole
Comments:																	
Did the outcomes of this assessment impact upon your planning? Please make a note:																	

Tangram Template





2. Assessment Activity: Symmetry



For educators to observe children:

1. Using words or actions to identify the line of symmetry.
2. Using shapes to match the design on either side of the line.
3. Using words or actions to describe symmetry, for example: both sides are the same when folded in half.
4. Using words: the same, side, face, corner, angle.
5. Using words or gestures: flip, slide, turn, rotate, across, over, beside, on top, behind, near, under.

What you will need:

- Assessment record
- Tape or ruler
- Shapes: hexagon, square, triangle, parallelogram, rhombus, trapezoid.
- Refer to pages 11 – 18 of the assessment guideline.

Rationale and Purpose

Symmetry is one aspect of geometry that can connect children's mathematical thinking to everyday objects, patterns and play (Davies et al., 2015). Children intuitively understand symmetry and often detect symmetrical patterns in everyday contexts like the wings of a butterfly, the shape of a leaf, or architecture. It is important to highlight the links between children's mathematical thinking and their interests in everyday objects around them (Seo & Ginsburg, 2004). Symmetry encourages spatial visualisation as children mentally rotate, transform and imagine positioning shapes to mirror a pattern. Symmetry provides opportunities to look at equal halves, to discriminate between shape and pattern and to "simplify complex information" (Moss et al., 2016, p.68). For example, being able to 'chunk' information into recognisable parts; important for subitising, number patterns, processing speed, algebra and problem solving. Symmetry is creative and a link between the beauty of mathematics and the everyday (Eberle, 2014). Through play, children begin to explore these concepts. This assessment is used in play-based settings with small groups of children.

Links to the EYLF

Outcome 4: Children are confident and involved learners.

Children develop a range of skills and processes such as problem solving, inquiry, experimentation, hypothesizing, researching and investigating. This is evident, for example, when children:
create and use representation to organize, record and communicate mathematical ideas and concepts (DEEWR, 2009, p.35).

Links to the Australian Curriculum

Foundation Year:

Shape

Sort, describe and name familiar two-dimensional shapes and three-dimensional objects in the environment (ACMMG009).

Elaborations: sorting and describing squares, circles, triangles, rectangles, spheres and cubes.

Year 1: Recognise and classify familiar two-dimensional shapes and three-dimensional objects using obvious features (ACMMG022)

Elaborations: focusing on geometric features and describing shapes and objects using everyday words such as 'corners', 'edges' and 'faces'

Folding and Symmetry

Level 1: Indicator of progress - Success depends on students recognising that certain shapes are made up of parts that repeat in some way. For example, they see that a shape may have two halves that are 'the same' in the sense that one half is a back-to-front version of the other. They understand that this property can be checked by folding the shape in half. This is the beginning of understanding about line (or mirror) symmetry.

Students may also recognise that certain shapes look the same after being turned less than a full turn. This is the beginning of understanding about rotational symmetry.

At this stage, it is not expected that students be able to describe what makes a shape symmetrical, but they may 'know it when they see it'. They may describe the two halves of a symmetrical shape as being the same (when technically speaking, they are not). The recognition of rotational symmetry is more difficult than line symmetry.

http://www.education.vic.gov.au/school/teachers/teachingresources/discipline/maths/continuum/Pages/symmetry15.aspx

Introduction to Symmetry



What is symmetry? How do educators assess children's knowledge of symmetry? There are many types of symmetry; this assessment activity focuses on reflection symmetry, (also known as mirror symmetry) where there is one line of symmetry which is vertical. Any pattern, shape or object folded along a vertical line of symmetry will have equal parts. Symmetry provides opportunities to introduce children to mathematical language and mathematical thinking at an early age. Understanding symmetry supports children's ability to recognise and contextualize shape, pattern and number (Uttal, 2015).



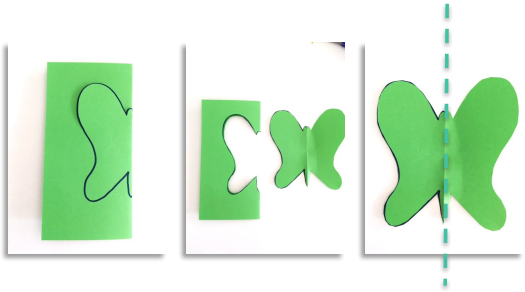
Children have an innate sense of symmetry and are naturally curious and interested in the beauty of mathematical representations; symmetrical patterns can evoke a sense of completion and harmony (Ha, 1989). We intuitively recognise patterns in our everyday lives, from symmetry in nature, architecture, art, food, language, mathematics, music and ourselves! Assessing children's existing knowledge of symmetry and planning next steps can make important connections between maths and everyday concepts.

Notes:

Step one: Let's talk symmetry!

Before using the assessment activity, you may choose to introduce children to symmetry and some of the mathematical language used to describe it: **half, equal, symmetrical, line, reflection, flip, slide, turn.** To introduce these ideas, it is useful to have some shapes drawn on folded paper. Show children the outline and ask them to predict what the shape will be once it is cut out and unfolded. Cut along the line and unfold to reveal the shape. Talk about the fold line as the line of symmetry, discuss how the two sides are equal, are symmetrical or the same.

Line of symmetry: butterfly (fold line)



You may ask children:

"What do you notice about the two sides?"

"What do you think the shape will be when it is unfolded?"

"Why do you think that?"

"I wonder if the two sides are the same (equal)?"

"How can we test this to find out?"

"Would you like to show me if these two sides match?"

Line of symmetry: triangle (fold line)



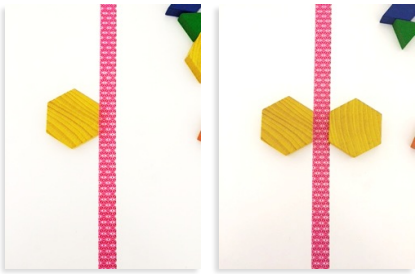
Assessment Activity: Symmetry

1. Make a vertical line on the floor or table using tape. Make sure there is enough space for children to be beside you.
   Show children the line of symmetry and invite children to make a symmetrical design (pattern) with you.

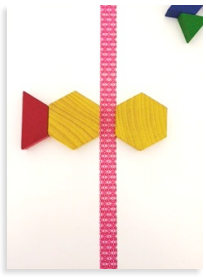


2. Empty out the bag of 2D shapes and as you work, talk about the shapes and their attributes.

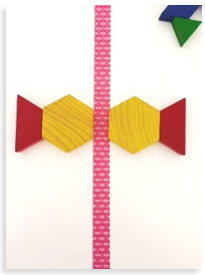
3. Demonstrate the game, using the language flip, slide, turn, rotate, beside… Model where to put the side of the first shape (hexagon), close to the "line of symmetry".
   "I am going to slide the hexagon across to the line of symmetry, so the side is touching the line".
   "Would you like to find a shape that matches mine?"
   "For our design to be symmetrical each side must match."
   Ask children if they think the design is symmetrical and why.



4. Ask children if they would like to add to the design.
   "Which shape will you choose? [Trapezoid] …"
   "You are sliding the trapezoid across to the hexagon…"



5. And now copy the child, using words to describe the shape and your actions:
   "I am going to choose a trapezoid as well, see it matches yours".
   "I am going to slide the trapezoid across to the hexagon".
   "Look it is opposite yours, it is like a reflection of your design".
   Keep building the design using positional and directional language, describing your actions, the attributes and names of each shape.



Children can play this game in pairs, taking turns and contributing to one side of the design. When finished, ask children to tell you about their design, what they notice and why it is symmetrical.

Assessment: What to Look and Listen For

The child:

- uses words or actions to identify the line of symmetry.
- identifies shapes using geometric language: triangle, square, hexagon, rhombus, parallelogram, trapezoid.
- uses positional and directional language and gesture: flip, slide, turn, rotate, across, over, beside, on top, near.
- uses shapes to match the design on the other side of the line of symmetry.
- says/shows a pattern is symmetrical because both sides are the same.
- talks about the attributes of shape, using words: the same, side, face, corner, angle.
- may use gesture to show the movement of a piece, for example "flipping" with their hand.

Fill in the assessment record as you go. What did you notice? How did the outcomes of this assessment inform your planning?

Implementation and Assessment Record

The implementation and assessment record are provided as a guide for you to document the assessment outcomes. Copies of these records are provided with each of the activities. Please date, check the appropriate boxes and fill in the record each time you use this assessment. Please use one row per child for each assessment and note any impact this assessment activity has on your practice or planning in the comment box provided. If you make any variations or adaptations to the assessment activity, please document the changes and outcomes. The implementation and assessment records will be collected each fortnight, and new copies provided as required. You may choose to keep a journal for further comments.

Implementation and Assessment Record: Symmetry

	Symmetry						Identifies and creates symmetrical patterns		
Date & Child's Initial	flip slide turn rotate	across over beside on top near	line of symmetry	the same matching equal	triangle square hexagon rhombus parallelogram trapezoid	side face corner angle	Identifies and talks about lines of symmetry (fold)	Makes symmetrical design, says/shows why it is symmetrical (two sides matching)	Copies and understands the rules of symmetry

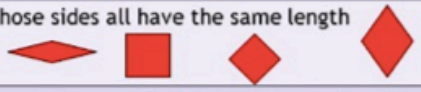
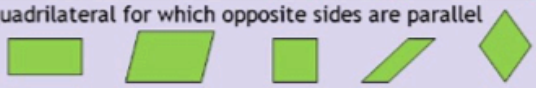
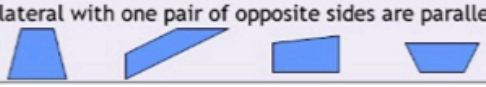
Comments:

Did these assessment activities impact upon your planning? If so, please note:

17

Quadrilaterals

https://www.mathsisfun.com/quadrilaterals.html

Polygon	Definition
QUADRILATERALS	
square	quadrilateral with 4 right angles whose sides all have the same length 
rectangle	quadrilateral with 4 right angles 
rhombus	quadrilateral whose sides all have the same length 
parallelogram	quadrilateral for which opposite sides are parallel 
trapezium	quadrilateral with one pair of opposite sides are parallel 

18

3. Assessment Activity Pattern: What Comes Next?







For educators to observe children:

1. Making a repeating pattern and using words or actions to describe why it is a pattern.
2. Copying patterns and extending them further, responding to the question: "What comes next?"
3. Identifying the structure of the pattern, eg. yellow, green, yellow, green, yellow, green…
4. Counting the elements of the pattern.
5. Recognising a sequence of repetition eg. every 3nd counter is a square.
6. Completing the pattern when one piece is missing.

What you will need:

- Assessment record
- Materials
- Refer to pages 19 – 25 of the assessment guide.

Rationale and Purpose

Intentional teaching is essential in revealing the connections between pattern and mathematics to young children (Fox, 2005, p. 318). When exploring pattern children may begin to make connections about information within their world, to predict and generalise further beyond what is in front of them (Clements & Sarama, 2011). For example, children may repeat 'clap, tap, clap, tap…' and with intentional guidance, recognise this pattern as having an ABABAB structure. Identifying the structure of patterns helps children to identify the structure of numerical and mathematical sequences. 'Having one thing stand for another is the beginning of algebraic representation' (Clements & Sarama, 2009, p. 191). Completing pattern sequences may rely on spatial processes like visualisation and orientation. Through play, children begin to explore these concepts. This assessment is for use in play-based settings, with small groups of children.

Links to the VEYLDF

Outcome 4: Children develop a range of skills and processes such as problem solving, inquiry, experimentation, hypothesizing, researching and investigating.
This is evident, for example, when children:

- apply a wide variety of thinking strategies to engage with situations and solve problems, and adapt these strategies to new situations.
- create and use representation to organise, record and communicate mathematical ideas and concepts.
- make predictions and generalisations about their daily activities, aspects of the natural world and environments, using patterns they generate or identify, and communicate these using mathematical language and symbols.
- contribute constructively to mathematical discussions and arguments.

Outcome 5: Children begin to understand how symbols and pattern systems work.

- use symbols in play to represent and make meaning.
- develop an understanding that symbols are a powerful means of communication and that ideas, thoughts and concepts can be represented through them.
- begin to be aware of the relationships between oral, written and visual representations.
- begin to recognise patterns and relationships and the connections between them.
- listen and respond to sounds and patterns in speech, stories and rhyme.
- draw on memory of a sequence to complete a task.
- draw on their experiences in constructing meaning using symbols.

Links to the Victorian Curriculum

Levels F – 2: This develops, for example, when students:

Sort and classify familiar objects and explain the basis for these classifications, and copy, continue and create patterns with objects and drawings. Mathematics: Number and Algebra (F)
VCMNA076

Investigate and describe number patterns formed by skip counting and patterns with objects. Mathematics: Number and Algebra (L1)
VCMNA093

Introduction to repeating pattern

How do educators assess children's knowledge of pattern? Why is this important? Patterns are sequences, determined by a rule. When children recognise the rule of a pattern, it supports visualisation and prediction (Uttal et al., 2015). Children begin to understand what will come next and why, for example, repeating patterns in counting and skip counting. This is a useful skill to develop for mathematical learning as "virtually all mathematics is based on pattern and structure" (Erikson Institute, 2014, p. 83).

As an introduction to repeating patterns, you may choose to invite children on a pattern walk and observe repeating patterns in the environment. Patterns connect our mathematical understandings to the everyday. This is important as associations between mathematics and our environment establishes maths as relevant and useful for communicating ideas and understanding our world (Erikson Institute, 2014). Ask children what they notice. Why is it a pattern and what is the rule? Is it a repeating pattern or a design? If it is a repeating pattern what might come next?

Repeating patterns in rhyme and music also provide opportunities for children to explore and predict what will come next. Assessment of these understandings can inform planning for next steps.

Assessment Activity Pattern: What Comes Next?

1. To begin with, create an ABABAB pattern with the materials. You can assess children's knowledge by inviting children to show you: "What comes next?"
2. You can assess children's understandings of the rule by removing one element from the pattern. Ask children:
   "How do you know what is missing? Why?"
   "How can we fix the pattern?"
3. Invite children to make a pattern for you to extend.

Assessment: What to look and listen for

The child:

- makes a repeating pattern and uses words or actions to describe why it is a pattern.
- copies patterns and extends them further, responds to the question: "What comes next?"
- identifies the structure of the pattern, eg. ABABAB.
- counts the elements of the pattern.
- recognises a sequence of repetition eg. every 2nd counter is blue.
- completes pattern sequences when one piece is missing.

Fill in the assessment record as you go. What did you notice? How do the outcomes of this assessment inform your planning?

Implementation and Assessment Record

The implementation and assessment record are provided as a guide for you to document the assessment outcomes. Copies of these records are provided with each of the activities. Please date, check the appropriate boxes and fill in the record each time you use this assessment. Please use one row per child for each assessment and note any impact this assessment activity has on your practice or planning in the comment box provided. If you make any variations or adaptations to the assessment activity, please document the changes and outcomes. The implementation and assessment records will be collected each fortnight, and new copies provided as required. You may choose to keep a journal for further comments.

Implementation and Assessment Record Pattern: What Comes Next?												
	Pattern and words									Identifies and Creates Patterns		
Date & Child's Initial	after	before	again	repeat	add	next	pattern	counts 1, 2, 3…	1st, 2nd, 3rd…	Copies a pattern and extends this further when asked what comes next?	Makes a repeating pattern, demonstrates understanding of the pattern rule.	Replaces the missing part of the pattern.

Comments:

Did the outcomes of this assessment activity inform your planning? If so, please note:

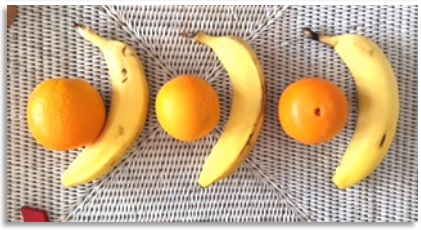
Assessment elaborations

1. Pattern can also be explored through movement and music. Establish a movement pattern with children, freeze and ask children what might come next.

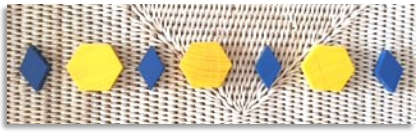
2. Use the rule of one pattern to create another. This further supports the beginnings of algebraic reasoning and children's ability to transfer their knowledge of pattern to other forms (Clements and Sarama, 2012).



For example, stomp one foot for shell, clap for the starfish = stomp, clap, stomp, clap, stomp, clap… Using symbols to represent meaing.



Tapping sticks for orange, shakers for banana: tap, shake, tap, shake, tap, shake… Children may compose a pattern together, which you play.



Step forwards for blue and backwards for yellow = forwards, backwards, forwards…Children may like to choreograph a pattern, which you move to.

Assessment elaborations may include:

a. This problem has a core pattern – identification of this pattern is a visual process:



b. This problem has a core pattern and a pattern of rotation – identification of the pattern of rotation is a spatial process:



Asking children "what could come next?" opens up discussion about the possible outcomes depending on the attributes of the patterns. What do children already know? In this instance the attribute of the core pattern in problem a. is colour. In problem b. and c. the attributes are both the core pattern (colour) and pattern of rotation (orientation).

Further assessment extensions may include:

c. This problem has a core pattern and a pattern of rotation – identification of the pattern of rotation is a spatial process:



Discussions could include degrees of rotation: half turn, quarter turn, full turn (and later the introduction of 45° and 90° and 180° rotations).

4. Assessment Activity 3D Shape: Look, Think, Make!





For educators to observe children:

1. Identifying and describing one or more 3D shapes. For example: cube, cylinder, sphere, cone, rectangular prism, triangular prism, hexagonal prism, square pyramid, hemisphere, pentagonal prism.
2. Using words and actions when combining shapes. For example: flip, slide, turn, rotate.
3. Using words to describe position: beside, on, under, below, above, between, over.
4. Repeating the design from memory.
5. Identifying corner, edge, side, face, angle, curve, straight edge.

What you will need:

- Assessment record
- 3D shapes and a cloth
- Refer to pages 26 – 33 in the assessment guidelines.

Rationale and Purpose

Exploring 3D shape during play is a dynamic way to understand geometry in action (Uttal et al., 2015). Children benefit from engaging in activities that encourage geometric composition (Moss et al., 2016; Davies et al., 2015). Children manipulate and explore shape, and imagine or visualise combinations of shape. This is an important skill and "essential to the development of [children's] geometric intuition about shapes and to their geometric sense of their surroundings" (NCTM, 2001). Mathematics can explain the world we live in and can help us to communicate our ideas. Providing opportunities for children to make geometric sense of their world connects mathematical concepts with the everyday, giving maths relevance and a purpose. Through play, children explore these concepts, providing many opportunities for assessment. This assessment is to be used in play-based settings with small groups of children.

Links to the EYLF

Outcome 4:
Children are confident and involved learners – children develop a range of skills and processes such as problem solving, inquiry, experimentation, hypothesizing, researching and investigating. This is evident, for example, when children:

- create and use representation to organize, record and communicate mathematical ideas and concepts.

Links to the Australian Curriculum

Shape
Foundation Year: Sort, describe and name familiar two-dimensional shapes and three-dimensional objects in the environment (ACMMG009)

Elaborations: sorting and describing squares, circles, triangles, rectangles, spheres and cubes.

Year 1: Recognise and classify familiar two-dimensional shapes and three-dimensional objects using obvious features (ACMMG022)

Elaborations: focusing on geometric features and describing shapes and objects using everyday words such as 'corners', 'edges' and 'faces'.

Introduction to 3D shape



Why is it important for children to explore 3D shape? Why is it relevant to assess children's knowledge of 3D shape? As adults it is challenging to imagine what a shape may look like when it is rotated, or to understand how an object is still the same object regardless of its orientation. Many forms of mathematics require this visualisation skill. Children begin to develop the ability to visualise shape and combinations of shape, understanding that the orientation of a shape does not change its properties. For example, a triangle standing on one point is still a triangle. Research tells us that the capacity to visualise and hold images in the minds-eye is an important skill that supports mathematical reasoning (Uttal, 2015; Davies, 2015; Moss et al., 2016). This importance is underscored by research that also suggests children are more likely to find mathematics easier when they are able to remember and mentally manipulate visual-spatial information (Davis et al., 2015; Kyttala & Lehto, 2008; Thompson et al., 2013).

Step one: Let's talk 3D shape!



1. Before playing with the assessment activity, it may be useful to introduce children to the idea of 3D shapes and mathematical language to describe their designs.

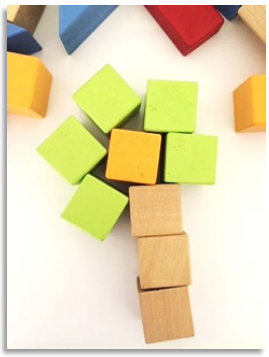
   Names of 3D shapes: cube, cylinder, rectangular prism, sphere, hexagonal prism, triangular prism, square pyramid, hemisphere, cone, pentagonal prism and hexagonal prism.

   Directional language: flips (reflections), slides (translations), turns (rotations).

   Positional language: beside, on, under, below, above, between, over.

   Attributes (rules) of shape: corner, edge, side, (faces), angle, curve, straight.

2. With a small group of children use the 3D shapes to build a design. This provides opportunities for you to talk about shape and attribute. If it is useful, integrate the 3D shapes into block play. You may invite children to close their eyes and imagine what they will make, or encourage "thinking time." Invite children to imagine their design, think about it and talk about it before they make it. Ask children to tell you about their design and what they imagine.



3. Invite children to imagine rotating a shape and seeing it with their "minds-eye" (Verdine et al., 2008), describing how it looks before using a block to show you. Discuss if a triangle is still a triangle if it is flipped onto its side. "I wonder…" statements help to engage children's thinking, making it visible and assessable.

4. Ask children if their design reminds them of anything. Children may say: "It looks like a tree", connecting shapes to everyday objects. Associating the whole shape with a known object can free the mind to focus on learning new information.

Assessment Activity 3D Shape: Look, Think, Make!

1. With a small group of children, model combining two or more 3D shapes together to make a design. Talk about the shapes, their position and orientation.

2. Ask children to look carefully at your design and discuss what they see. (Sit beside children, so you share the same perspective).

3. Invite children to copy your design. Ask children to share the strategies they used to recreate it. For example, children may say: "It looks like a house" associating the whole shape with a familiar object before choosing the relevant smaller shapes to make it.

4. Now, make a design and show it to children for a short time. Invite children to look at it carefully and talk about what they see. Cover the design over and ask children to remember what the design looks like before they make it. You may invite children to cover or close their eyes to see the design in their mind.



5. When the children are finished, reveal your design and discuss using spatial language (position, direction and orientation). "Your cube is beside the cylinder just like mine!" Talk about what was the same, what was different and why.

6. Ask children to share their strategies for remembering the design, for example children may say "it looks like a robot" or start with the biggest shape first. Children can take turns being the "designer".



Assessment: What to look and listen for

The child:

- may use one or two words to identify and describe 3D shapes. For example: cube, cylinder, sphere, cone, rectangular prism, triangular prism, hexagonal prism, square pyramid, hemisphere, pentagonal prism.
- uses directional language when making the design. For example, flip, slide, rotate, turn.
- uses positional language to describe placement of blocks: beside, on, under, below, above, between, over.
- may associate combinations of shapes with objects in the environment: "It looks like the chair".
- demonstrates an understanding of the attributes of shape: corners, edges, sides, (faces), angles.
- repeats the design from memory.

Fill in the assessment record as you go. What did you notice? How did the outcomes of this assessment inform your planning?

Implementation and Assessment Record

The implementation and assessment record are provided as a guide for you to document the assessment outcomes. Copies of these records are provided with each of the activities. Please date, check the appropriate boxes and fill in the record each time you use this assessment. Please use one row per child for each assessment and note any impact this assessment activity has on your practice or planning in the comment box provided. If you make any variations or adaptations to the assessment activity, please document the changes and outcomes. The implementation and assessment records will be collected each fortnight, and new copies provided as required. You may choose to keep a journal for further comments.

Assessment Record 3D Shape: Look, Think, Make!													
	Identifies shape and attributes, describes position and direction, repeats design.												
Date & Child's Initial	cube	cylinder, cone	sphere, hemisphere	rectangular prism	triangular prism	hexagonal prism	pentagonal prism	flip	slide	turn, rotate	Says/shows: beside, on, under, below, above, between, over.	Repeats design from memory.	Identifies corners, edges, sides, angles.

Comments:

Did these assessment outcomes have any impact on your planning? If so, please note:

32

3D Geometric Shapes



Cube



Cylinder



Cone



Hexagonal prism



Hemisphere



Large rectangular prism



Triangular pyramid



Triangular prism



Square pyramid



Pentagonal prism



Square rectangular prism



Sphere

5. Assessment Activity: From Here to There





For educators to observe children:

1. Using positional language when describing location of objects in relation to other objects: beside, on, under, below, above, between, over, beneath, in front of, behind, inside, outside.

2. Using directional language or gesture when moving objects. For example, the koala is climbing "up" the tree, the platypus is swimming "across" the water: over, down, around, through, in, out, turning left, right.

What you will need:

- Assessment record.
- Animals and objects.
- Refer to pages 34 – 39 in the assessment guide.

Rationale and Purpose

Communicating position and direction during play provides opportunities for children to demonstrate relationships between themselves, objects and others in space. When engaged in this activity, children may use positional and directional language to describe their actions. For example: "I am putting the platypus in the water, first it has to swim around the rock." Or: "The koala is climbing up the tree so it is on top." Children are naturally aware of spatial relationships, noticing and describing movement, location, orientation and shape (Tepylo, Moss and Stephenson, 2015). This assessment activity highlights children's existing knowledge of "both numerical and spatial geometrical concepts" (NRC, 2009, p. 184). Developing these concepts supports the necessary skills for mapping, coding, sequencing, visualisation and problem solving. Young children require intentional teaching to develop these skills (Uttal et al., 2015). This assessment is conducted with a small group of children in play-based settings.

Links to the VEYLDF

Outcome 5: Communication

Children interact verbally and non-verbally with others for a range of purposes: This is evident, for example when children:

- interact with others to explore ideas and concepts, clarify and challenge thinking, negotiate and share new understandings
- exchange ideas, feelings and understandings using language and representations in play
- show increasing knowledge, understanding and skill in conveying meaning.

Outcome 4: Learning

Children develop a range of skills and processes such as problem solving, inquiry, experimentation, hypothesising, researching and investigating.

This is evident, for example, when children:

- apply a wide variety of thinking strategies to engage with situations and solve problems, and adapt these strategies to new situations
- create and use representation to organise, record and communicate mathematical ideas and concepts
- make predictions and generalisations about their daily activities, aspects of the natural world and environments, using patterns they generate or identify, and communicate these using mathematical language and symbols
- explore their environment manipulate objects and experiment with cause and effect, trial and error, and motion
- contribute constructively to mathematical discussions and arguments
- use reflective thinking to consider why things happen and what can be learnt from these experiences.

Links to the Victorian Curriculum

Levels F – 2.

This develops, for example, when children:

Engage in conversations and discussions, using active listening, showing interest, and contributing ideas, information and questions, taking turns and recognising the contributions of others. English: Literacy (L1) VCELY210

This develops, for example, when students: Recognise the importance of repetition of a process in solving problems. Mathematics: Number and Algebra (L1)
VCMNA094

Participate in guided investigations, including making observations using the senses, to explore and answer questions. Science: Science Inquiry Skills (F–L2) VCSIS051

Introduction to positional and directional language

Why is this important? How does it support assessment of children's mathematical understandings? Exploring position and direction during play enables children to demonstrate and communicate their understandings of the relationships between objects, others and themselves in space. Discussions with children highlight the relationships between these concepts, for example the position of an object can only be described in relation to someone or something in space. All mathematics is based on relationships (Moss et al., 2016). Children require many opportunities to demonstrate their existing knowledge of these concepts using gesture, words, and representations of space to support the communication of these understandings to others (Ferrara et al., 2011). Research tells us that spatial thinking supports *all* maths learning (Davis, et al., 2015; Uttal et al., 2015). By focusing on spatial thinking we can do two things at once, support the development of spatial skills *and* mathematics skills (Clements and Sarama, 2011).

Assessment Activity: From Here to There

During this assessment activity, children use spatial thinking to describe the position and direction of objects. For example: "The kangaroo hops over the log, and stops beside the tree."



1. Ask children to show you how the koala can get from here (show the starting point), to there (show the end point). Children may use words and/or gestures. You may also invite children to:
   "Tell me/show me how the koala moves from the tree to the log?" or
   "Tell me/show me how the platypus moves from the rock, to the log?"

2. Invite children to take a turn, and you can model the response.

3. You may also add extra steps, to lengthen a sequence. For example:
   "Would you like to tell/show me how the kangaroo moves from the log, and ends up beside the emu over here?"

Assessment: What to look and listen for

The child:

- uses positional language/gestures to describe the animal's location in relation to other objects: beside, on, under, below, above, between, over, beneath, in front of, behind, inside, outside.
- uses directional language or gesture when moving the animals. For example, the koala is climbing "up" the tree, the platypus is swimming "across" the water: over, down, around, through, in, out, turning left, right.
- engages in the activity with others and may use mathematical language to describe the activity.

Fill in the assessment record as you go. What did you notice? How did the outcomes of this assessment inform your planning?

Implementation and Assessment Record

The implementation and assessment record are provided as a guide for you to document the assessment outcomes. Copies of these records are provided with each of the activities. Please date, check the appropriate boxes and fill in the record each time you use this assessment. Please use one row per child for each assessment and note any impact this assessment activity has on your practice or planning in the comment box provided. If you make any variations or adaptations to the assessment activity, please document the changes and outcomes. The implementation and assessment records will be collected each fortnight, and new copies provided as required. You may choose to keep a journal for further comments.

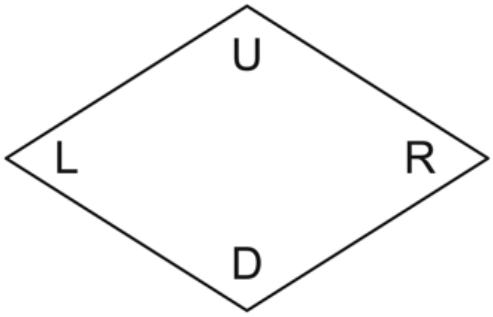
Implementation and Assessment Record: From Here to There

	Words to describe position and direction																	
Date & Child's Initial	beside	on	under	below	above	between	over	beneath	in front of	behind	inside	outside	down, up	around, through	in, out	turning left, right	Says/shows position of object eg. "on the log."	When moving object says/shows direction.

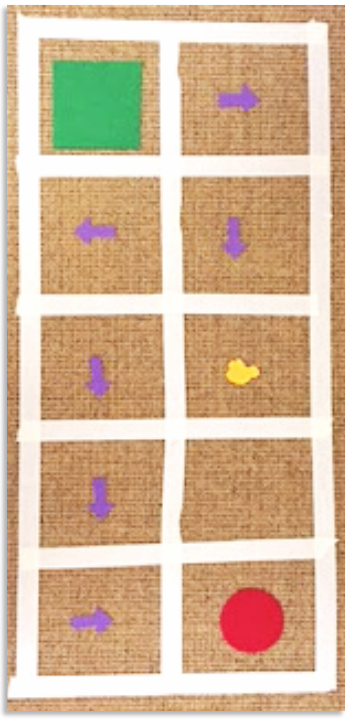
Comments:

Did the outcomes of this assessment impact upon your planning? If so, please note:

This template is from Moss et al, (2016) and may be useful to support your assessment strategies for left, right, up and down.

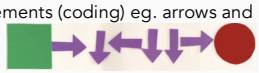


6. Assessment Activity: Mapping Pathways



For educators to observe children:

1. Using the pathway grid on the floor to map directions from start to finish.
2. Using positional and directional language: turn, left, right, move forwards, backwards.
3. Using symbols to document a sequence of movements (coding) eg. arrows and shapes.



What you will need:

- Assessment record.
- Tape to make grid on floor (2x5).
- Copy of grid paper (optional).
- Drawing materials.
- Stickers and a "bear" or object.
- Refer to pages 40 – 50 of the assessment guide.

Rationale and Purpose

Mapping enables children to demonstrate and communicate their understandings of location, position and direction in space. This assessment activity establishes the purpose of mapping, to provide 2D representations of the 3D world on a smaller scale. Children physically move through a 2D "map" or grid, experiencing scale and perspective. The child giving the instructions sees the grid from the other's point of view. This activity provides many opportunities to assess children's existing knowledge of spatial concepts and may bring to light how a 2D map provides a model for the world. The development of spatial reasoning is an essential skill for mapping (Uttal & Sheean, 2014). This activity also has direct links to coding, sequencing and problem solving (Davies et al., 2015). Young children require intentional teaching to develop these skills (Davis et al., 2015). This assessment is conducted with a small group of children in play-based settings.

Links to the EYLF

Outcome 4: Children are confident and involved learners – children develop a range of skills and processes such as problem solving, inquiry, experimentation, hypothesizing, researching and investigating. This is evident, for example, when children create and use representation to organize, record and communicate mathematical ideas and concepts (2009, p.35).

Outcome 5: Children are effective communicators – children begin to understand how symbols and pattern systems work. This is evident, for example, when children develop an understanding that symbols are a powerful means of communication and that ideas, thoughts and concepts can be represented through them.

Links to the VEYLDF

Outcome 5: Communication – Children begin to understand how symbols and pattern systems work:

This is evident, for example, when children:

- use symbols in play to represent and make meaning.
- develop an understanding that symbols are a powerful means of communication and that ideas, thoughts and concepts can be represented through them.
- begin to be aware of the relationships between oral, written and visual representations
- draw on memory of a sequence to complete a task
- draw on their experiences in constructing meaning using symbols.

Links to the Victorian Curriculum F – 2

Geography / Foundation to Level 2 / Geographical Concepts and Skills / Data and information.

Content description

Represent data and the location of places and their features by constructing tables, plans and labeled maps.

Elaborations

- making a map to show how a bird would see a place (birds-eye view), using pictures or models of objects.
- completing a table to show the significant features or uses of different places.
- locating on an outline map the places they are connected to, or the places they visit for shopping, recreation, family, personal or other reasons.
- investigating how symbols are used to represent categories of objects and categorising drawings or images of environmental features of the local place into natural, managed and constructed features.

Code

VCGGC061

Victorian Curriculum F – 2

Visualise, generate, and communicate design ideas through describing, drawing and modelling. Design and Technologies: Creating Designed Solutions (F–L2)

VCDSCD019

Links to the EYLF

Outcome 4: Children are confident and involved learners – children develop a range of skills and processes such as problem solving, inquiry, experimentation, hypothesizing, researching and investigating. This is evident, for example, when children create and use representation to organize, record and communicate mathematical ideas and concepts (2009, p.35).

Outcome 5: Children are effective communicators – children begin to understand how symbols and pattern systems work. This is evident, for example, when children develop an understanding that symbols are a powerful means of communication and that ideas, thoughts and concepts can be represented through them.

Links to the VEYLDF

Outcome 5: Communication – Children begin to understand how symbols and pattern systems work:

This is evident, for example, when children:

- use symbols in play to represent and make meaning.
- develop an understanding that symbols are a powerful means of communication and that ideas, thoughts and concepts can be represented through them.
- begin to be aware of the relationships between oral, written and visual representations
- draw on memory of a sequence to complete a task
- draw on their experiences in constructing meaning using symbols.

Links to the Victorian Curriculum F – 2

Geography / Foundation to Level 2 / Geographical Concepts and Skills / Data and information.

Content description

Represent data and the location of places and their features by constructing tables, plans and labeled maps.

Elaborations

- making a map to show how a bird would see a place (birds-eye view), using pictures or models of objects.
- completing a table to show the significant features or uses of different places.
- locating on an outline map the places they are connected to, or the places they visit for shopping, recreation, family, personal or other reasons.
- investigating how symbols are used to represent categories of objects and categorising drawings or images of environmental features of the local place into natural, managed and constructed features.

Code

VCGGC061

Victorian Curriculum F – 2

Visualise, generate, and communicate design ideas through describing, drawing and modelling. Design and Technologies: Creating Designed Solutions (F–L2)

VCDSCD019

Introduction to mapping

Why is it important to assess children's knowledge of mapping? Children benefit from engaging in activities that explore how to communicate location, position, orientation, direction, perspective and scale. Infants often begin exploring these spatial concepts by locating objects or others in space, and as young children are naturally curious about and interested in modeling understandings of their world (Moss et al., 2016). As these spatial skills develop, mapping provides a way to record these understandings and develop spatial reasoning (Davies et al., 2015). This is important as spatial relationships between objects and places can be described using mathematical language, reinforcing maths as part of our everyday communication (Erikson Institute, 2014). Children may express these ideas using words, gestures, drawings, making models during imaginative or block play, or using something to represent something else, like a symbol. Exploring symbolic representation also lays the foundations for understanding symbols in mathematics, for example numerals or algebra: =, -, +, ÷, x (Erikson Institute, 2014). Being able to visualise this information, or hold a series of directions or symbols in their "minds eye" can also support the necessary skills for coding (Moss et al., 2016), sequencing and problem solving. Assessment of children's spatial skills informs planning for next steps.

Children may begin to explore these concepts by making obstacle courses, looking at maps of local and familiar areas, identifying familiar landmarks or objects. Children need many opportunities to explore the mathematical language associated with location, direction, position and orientation.



Step one: Let's talk mapping!

Before using the assessment activity you may choose to introduce children to the idea of mapping and mathematical language.

1. Invite children to make an obstacle course or follow a pathway in/outside that provides children with opportunities to explore spatial language and actions. This helps to build familiarity with direction and position, for example up, down, across, over, between, on top, left/right.

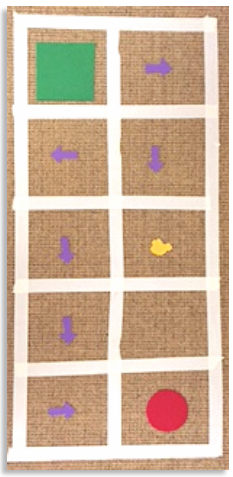
2. Children may enjoy working in pairs or small groups and give each other directions from one location to another. For example: "How can I get from the tree into the middle of the sandpit?" Children may say, "move forwards, turn this way, step over here", providing you with many opportunities to assess spatial understandings.



3. Reading "As the Crow Flies" by Gail Hartman, "Sam's Bush Journey" by Sally Morgan and Ezekiel Kwaymullina, or "Rosie's Walk" by Pat Hutchins can also provide insights into mapping and perspective.

Mapping introduces children to concepts of scale and perspective, for example seeing the world from a "birds eye" perspective, or from the point of view of another. Young children require intentional teaching and opportunities to practice and develop these skills (Davis et al., 2015).

Assessment Activity: Mapping Pathways

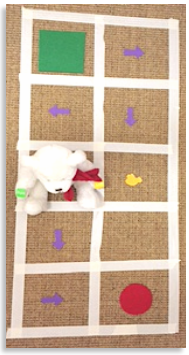


1. Create a large 5 x 2 grid on the floor using masking tape. Place a green object in one square and a red one in another. Green is the start and red is the finish.
2. Explain that one child gives the instructions, while another child follows the instructions, moving from start to finish. (You may model or go first as an example).
3. Discuss some rules that may be helpful, for example:
    - move one square at a time (for now)
    - turn left or right (use stickers if helpful)
    - only move forwards, backwards
4. The child starts by standing on the green square, and follows the instructions: eg. turn left, take one step forwards, turn right…
5. The child moves to each square to reach the finish.
6. Once children are familiar with the game and if there is interest, invite a child to place an obstacle on the pathway. You cannot step into this square, therefore directions will be given to avoid it.
7. Encourage children to discuss their movements, using spatial language and gesture. Take turns to be the instructor. This may be a "treasure hunt".

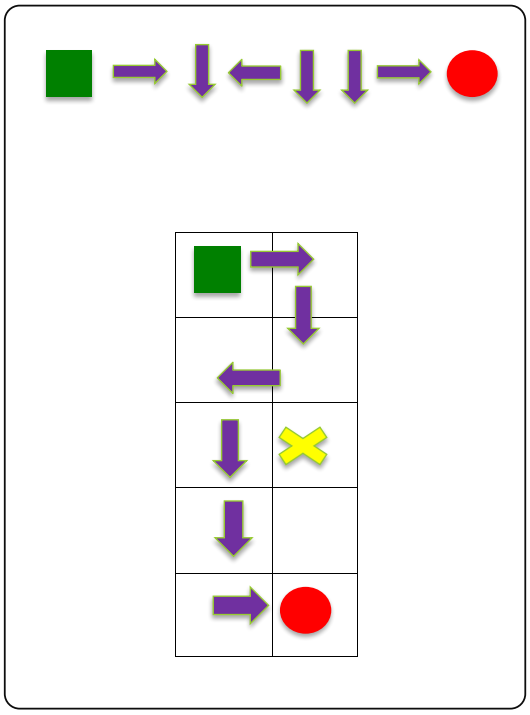
Children may choose to move a "bear" or "doll" one square at a time. If helpful, use the stickers: left, right, forwards, backwards to support understandings of direction.







Children may choose to document their pathway, using the grid paper as a guide. For example, the "code" may look like this:



Assessment: What to look and listen for

The child:

- uses the pathway grid on the floor to map directions from start to finish.
- uses positional and directional language: turn, left, right, move forwards, backwards.
- uses symbols (arrows and shapes) to document the sequence of movements (coding).
- Documents their pathway using the 2D symbols. May use grid paper if appropriate.

Fill in the assessment record as you go. What did you notice? How did the outcomes of this assessment inform your planning?

Implementation and Assessment Record

The implementation and assessment record are provided as a guide for you to document the assessment outcomes. Copies of these records are provided with each of the activities. Please date, check the appropriate boxes and fill in the record each time you use this assessment. Please use one row per child for each assessment and note any impact this assessment activity has on your practice or planning in the comment box provided. If you make any variations or adaptations to the assessment activity, please document the changes and outcomes. The implementation and assessment records will be collected each fortnight, and new copies provided as required. You may choose to keep a journal for further comments.

Implementation and Assessment Record Mapping Pathways													
	Words to describe location, position, direction, orientation										Mapping and Grid		
Date & Child's Initial	in, out	on top, up, down	over, under	behind, in front	around	beside, next to	turn left, right	across, through	backwards, forwards	far away, nearby	Orients self on grid, follows/gives instructions.	Demonstrates use of code on pathway floor grid.	Uses 2D symbols to document pathway.

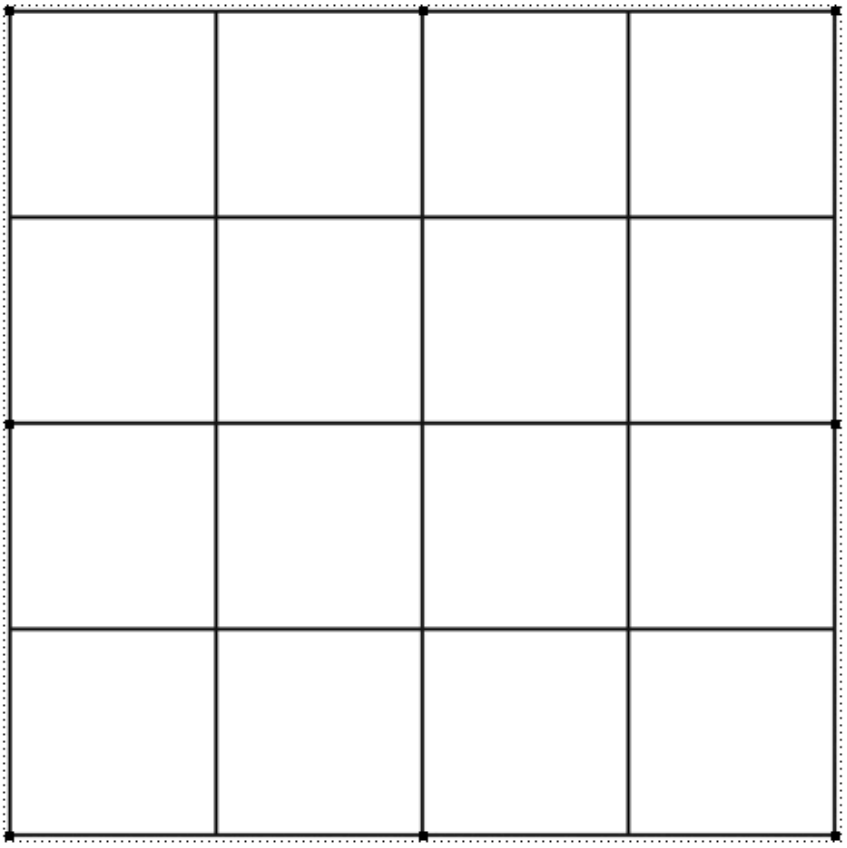
Comments:

Did these assessment outcomes impact upon your planning in way? If so, please note:

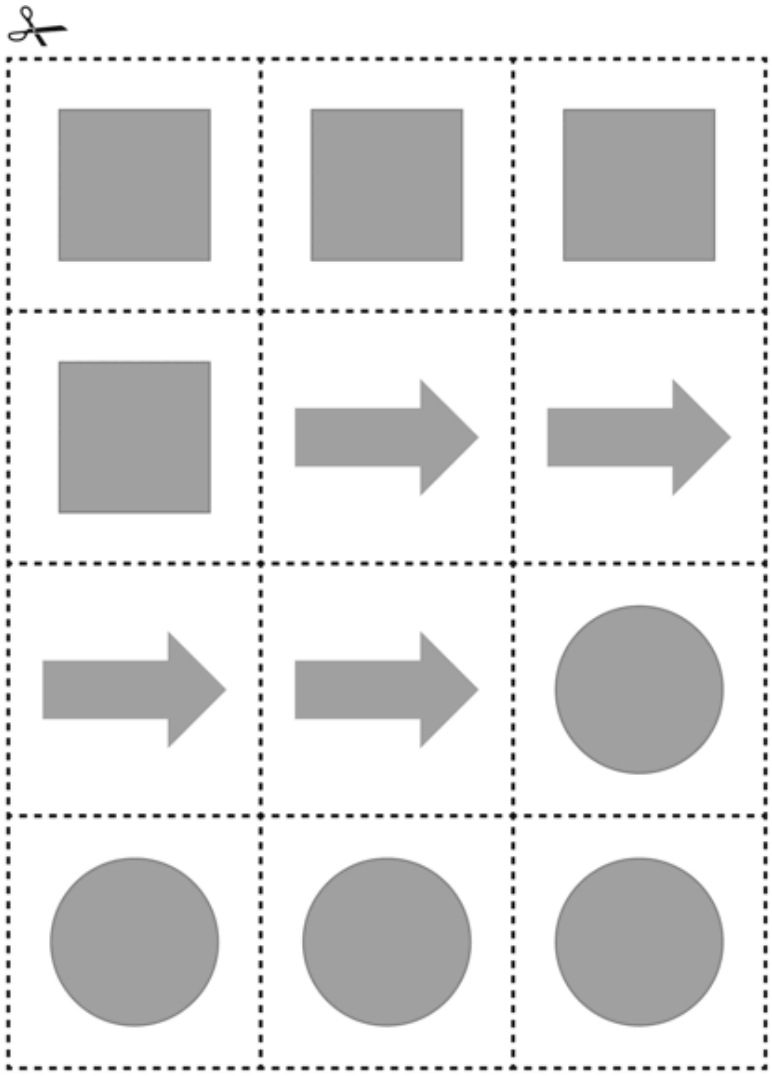
47

Grid template for introduction to mapping:

Grid template for mapping and coding:



Template for mapping and coding:



(These resources have been sourced from Moss et al., 2016 with permission of the author)

Appendix 2: Trial and Survey Outcomes Inform Workshop Design

Themes impacting on workshop design	**How the themes informed the workshop design**
Participants' beliefs and values about teaching mathematics	Ensured a play-based focus for the introduction of the activities
Participant confidence in mathematics ability	Low: paced theory and practice to ensure opportunities to enact theory in practice, demonstrate how it is achievable
Current mathematics knowledge	Wide range of knowledge: kept the language specific to the enactment of the activities and provided guidelines booklet outlining details of 'how to'
Examples of best practice and strategies for supporting children's mathematics learning	Evidence of current practice was used to support participant confidence
Examples of evidence of children's mathematical thinking	Evidence provided insights into participant's understandings of mathematics and children's mathematical thinking. Informed workshop discussions about mathematics in early childhood and what it looks like.
Assessment of and planning for children's mathematics learning	Evidence of current practice informed a need to focus on the link between observations, analysis and planning.
Amount of planning time spent on mathematics learning for children	Very low – workshop included ways to incorporate planning for mathematics.
Examples of mathematics language used with children	This language was included in the workshop discussions, assessment activities and guidelines
Examples of ways in which children's mathematics learning is intentionally supported in practice	Inclusion of intentional strategies in the workshop to assess and plan for mathematics learning.
Individual, small group or whole group focus when teaching mathematics concepts	Promoted a small group focus in the workshop as outcomes demonstrated children explored mathematical concepts mostly on their own.
Use of the frameworks in practice	Included specific links to the VEYLDF and EYLF in the workshop.
The top five things participants look for when observing and assessing children's mathematical thinking	Outcomes were addressed in the workshop and discussion highlighted other areas of mathematics to consider in play-based settings.
Average time spent on mathematics assessment in a typical week	Outcomes suggested this was low. Workshop focused on ways to integrate the assessment activities in play.
Types of mathematics activities and strategies currently used in the centre	Workshop addressed how current practice and extensions.
Types of mathematics assessment used and how often	Outcomes suggested the need for more frequent mathematics assessment, the workshop outlined a fortnightly assessment plan.
How often curriculum planning is discussed with other colleagues	A small group focus in the workshop helped to promote discussion and shared ideas for planning.
The importance of preparing for mathematics in primary school	Workshop discussion included the mathematical skills children need to enter primary school.

Appendix 3: Workshop Presentation, University of Melbourne: 23 July 2016

Phase Two: Implementation of the Six Assessment Activities

Phase two of the project focuses on the implementation of six assessment activities and how these activities impact on teaching practice, planning and teacher beliefs regarding mathematics in early childhood programs.

1. Assessment Activity: What Makes a Square?
2. Assessment Activity: Symmetry
3. Assessment Activity Pattern: What Comes Next?
4. Assessment Activity 3D Shape: Look, Think, Make!
5. Assessment Activity: From Here to There
6. Assessment Activity: Mapping Pathways

The Assessment Activities: What?

What are the maths assessment activities?

- six geometry-play-based activities designed to support mathematics assessment in ECE.
- are purposeful, enacted with small groups of children, linked to children's interests and embedded within daily EC practice.
- aim to make children's mathematical understandings visible and assessable, as knowing how to recognise mathematics in children's play can sometimes be a challenge.

"From number lines to arrays, even quantitative, numerical, and arithmetical ideas reason on a geometry base" (Clements and Sarama, 2014, p.134).

The Workshop Content for Today

The Assessment Activities: What, Why and How?

1. What are the assessment activities?
2. Why do they matter?
3. How are the activities, materials and assessment records used in daily practice?

Your Turn:

Time for us to use the assessment activities in small groups.

Reflect and Discuss:

Let's talk about what we observed and feedback to the group.

The Assessment Activities: Why?

Why do the maths assessment activities matter?

The activities matter because:

- they provide play-based strategies to support ECE in assessing children's existing maths knowledge.
- support the key role of gathering evidence of children's mathematical interests and skills, to plan for further learning.
- they are active, playful and integrate into existing programs, routines and play.

'Numeracy learning occurs best through "active exploration, inquiry and problem solving in authentic contexts' (National Council of Teachers of Mathematics, 2014, p. 29).

Teachers have a key role in assisting children to become mathematically literate through the communication of mathematical concepts and strategies to support children in expressing their ideas and discoveries' (VCAA, 2016, p.45).

The Assessment Activities: How?

How do I use the materials, assessment record and guidelines?

We will work with the activities together.

Each assessment activity has:

- a guide of what to look for when observing children using the materials,
- a list of what you will need (materials provided),
- a rationale and purpose,
- the assessment record.

The Assessment Guidelines Booklet has:

- background theory about the activity, VEYLDF/VC links,
- introduction ideas to "warm up" to mathematics assessment,
- an outline of the assessment activity,
- assessment elaborations and extensions.

1. Assessment Activity: What Makes a Square?

Shape Composition and Decomposition (Please turn to p. 4 of the Guidelines).



For educators to observe children:

1. Making a square using two or more pieces.
2. Recognising smaller shapes can combine to make larger shapes.
3. Saying "turn, flip, slide, rotate" when arranging shapes.
4. Using geometric language: triangle, square, parallelogram, angle, corner, face, long side, short side, large, small.
5. Identifying the attributes (rules) of shapes, for example a triangle always has three sides.

What you will need:

- Tangram puzzle pieces (one set is for three participants)
- Refer to pages 4 – 10 of the assessment guideline.

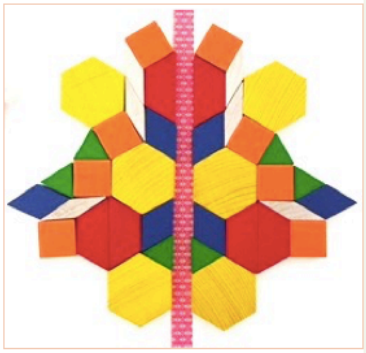
Assessment Record: What Makes a Square?

Date								Composes/ decomposes shape			Identifies shape and attributes				Makes square uses trial and error	
	flip	slide	turn	rotate	half turn 180° whole turn 360°	around	matching	triangle	square	parallelogram	angle	corner	side	face	part (half)	whole

Comments:

Please note any impacts on planning:

2. Assessment Activity: Symmetry



For educators to observe children:

1. Using words or actions to identify the line of symmetry.
2. Using shapes to match the design on either side of the line.
3. Using words or actions to describe symmetry, for example: both sides are the same when folded in half.
4. Using words: the same, side, face, corner, angle.
5. Using words or gestures: flip, slide, turn, rotate, across, over, beside, on top, behind, near, under.

What you will need:

- Assessment record
- Tape or ruler
- Shapes: hexagon, square, triangle, parallelogram, rhombus, trapezoid.
- Refer to pages 11 – 18 of the assessment guideline.

Assessment Record: Symmetry

	Symmetry							Identifies and creates symmetrical patterns		
Date	flip slide turn rotate	across over beside on top near	line of symmetry	the same matching equal	triangle square hexagon rhombus parallelogram trapezoid	side face corner point	Identifies and talks about lines of symmetry (fold)	Makes symmetrical design, says/shows why it is symmetrical (two sides matching)	Copies and understands the rules of symmetry

Comment:

Did the assessment outcomes impact on planning? Please note:

Your Turn

Your turn:

To use the assessment activities in small groups.

1. Assessment Activity: What Makes a Square?

2. Assessment Activity: Symmetry

Reflect and Discuss:

Let's think about how this informs planning, how does it matter to our planning? Let's discuss what we observed and feedback to the group.



Time for a break!

3. Assessment Activity Pattern: What Comes Next?

Repeating patterns…







For educators to observe children:

1. Making a repeating pattern and using words or actions to describe why it is a pattern.
2. Copying patterns and extending them further, responding to the question: "What comes next?"
3. Identifying the structure of the pattern, eg. yellow, green, yellow, green, yellow, green…
4. Counting the elements of the pattern.
5. Recognising a sequence of repetition eg. every 3rd counter is a square.
6. Completing the pattern when one piece is missing.

What you will need:

- Assessment record
- Materials
- Refer to pages 19 – 25 of the assessment guide.

Assessment Record Pattern: What Comes Next?

	Pattern and words									Identifies and Creates Patterns		
Date	after	before	again	repeat	add	next	pattern	counts 1, 2, 3	1st, 2nd, 3rd…	Copies a pattern and extends this further when asked what comes next?	Makes a repeating pattern, demonstrates understanding of the pattern rule.	Replaces the missing part of the pattern.

Comments:

Did the assessment outcome impact on planning? Please note:

4. Assessment Activity 3D Shape: Look, Think, Make!





For educators to observe children:

1. Identifying and describing one or more 3D shapes. For example: cube, cylinder, sphere, cone, rectangular prism, triangular prism, hexagonal prism, square pyramid, hemisphere, pentagonal prism.
2. Using words and actions when combining shapes. For example: flip, slide, turn, rotate.
3. Using words to describe position: beside, on, under, below, above, between, over.
4. Repeating the design from memory.
5. Identifies corner, edge, side, face, angle, curve, straight.

What you will need:

- Assessment record
- 3D shapes and a cloth
- Refer to pages 26 – 33 in the assessment guidelines.

Your Turn

Your turn:

To use the assessment activities in small groups.

3. Assessment Activity Pattern: What Comes Next?

4. Assessment Activity 3D Shape: Look, Think, Make!

Reflect and Discuss:

What do you see happening? How does this inform planning for learning? In our groups, let's talk about what we observed and then share with the group.

5. Assessment Activity: From Here to There

(Position and Direction)





For educators to observe children:

1. Using positional language when describing location of objects in relation to other objects: beside, on, under, below, above, between, over, beneath, in front of, behind, inside, outside.

2. Using directional language or gesture when moving objects. For example, the koala is climbing "up" the tree, the platypus is swimming "across" the water: over, down, around, through, in, out, turning left, right.

What you will need:

- Assessment record.
- Animals and objects.
- Refer to pages 34 – 39 in the assessment guide.

Assessment Record: From Here to There

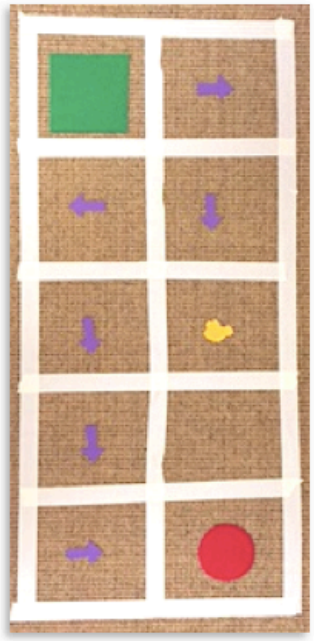
	Words to describe position and direction																	
Date	beside	on	under	below	above	between	over	beneath	in front of	behind	inside	outside	down, up	around, through	in, out	turning left, right	Says/shows position of object eg. "on the log."	When moving object says/shows direction.

Comments:

Did these assessment outcomes impact on planning? If so, please note:

6. Assessment Activity: Mapping Pathways

Mapping, sequencing and coding



For educators to observe children:

1. Using the pathway grid on the floor to map directions from start to finish.
2. Using positional and directional language: turn, left, right, move forwards, backwards.
3. Using symbols to document a sequence of movements (coding) eg. arrows and shapes: 

What you will need:

- Assessment record.
- Tape to make grid on floor (2x5).
- Copy of grid paper (optional) and drawing materials.
- Stickers and a "bear" or object.
- Refer to pages 40 – 50 of the assessment guide.

Assessment Record: Mapping Pathways

	Words to describe location, position, direction, orientation										Mapping and Grid		
Date	in, out	on top, up, down	over, under	behind, in front	around	beside, next to	between	across, through	nearby	far away	Orients self on grid, follows/gives instructions.	Demonstrates use of code on pathway floor grid.	Uses 2D symbols to document pathway

Comments:

Did these assessment outcomes impact upon your planning in way? If so, please note:

Your Turn

Your turn:

To use the assessment activities in small groups.

5. Assessment Activity: From Here to There

6. Assessment Activity: Mapping Pathways

Reflect and Discuss:

Let's think about how this informs planning… How does it matter to our planning? Let's discuss what we observed and feedback to the group.

To Conclude

The assessment activities are purposeful and aimed at forming part of your planning cycle. The implementation is to see how the activities impact on your assessment and planning.

You have the:

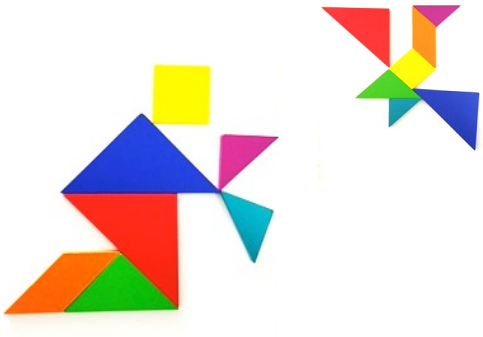
- Assessment Activities
- Implementation and Assessment Records
- Guidelines

Data collection takes place each fortnight from Friday August 5th up until Friday 25th of November (final data collection date). There are 9 data collection points:

August: Friday 5th, 19th
September: Friday 2nd, 16th, 30th
October: Friday 14th, 28th
November: Friday 11th, 25th (Final collection before final PD!)

Our final meeting is on November 26th 9.30am – 2.30pm same room! Please bring your journal, notes, planning outcomes and feedback.

PD Debrief



Thank you for attending today and for your ongoing commitment to this project

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http://www.vcaa.vic.edu.au/Documents/earlyyears/analysiscurriclearnfwlitreview.pdf)



Appendix 4: Study Design and Timeline

Stage 2016	Method	Purpose	Data	Analysis
Stage 1				
11 to 27 Apr	Pilot Survey (*n* = 38)	To gain participant feedback on the survey items and confirm outcomes were measurable.	Survey 1: Responses to open questions and scaled items.	Thematic analysis of qualitative responses. Statistical analysis of scaled items. Analysis informed refinement of the survey questions.
16 May to 27 Jun	Survey 1: A Survey Study of Early Childhood Educators' Beliefs and Confidence about Observing, Assessing and Teaching Mathematics (SECEBOAT), (*n* = 33)	To understand how mathematics assessment is understood and informs practice, planning and beliefs in early childhood.	As above	Themes emerged and informed the design of the assessment activities, implementation guidelines and workshop 1.
14 to 22 Jul	Trial of the Assessment Activities (n=3)	To make improvements and modifications to the assessment activities.	Assessment record outcomes. Documented planning, reflections, and verbal feedback.	Thematic analysis: Participants' documented feedback informed changes to the assessment record.
Stage 2				
23 Jul	Workshop (1): (*n* = 27)	To introduce participants to the mathematics assessment activities, implementation, and assessment records. For participants to discuss practice and planning and beliefs about mathematics and their use of and response to the assessment activities during the workshop.	Written notes	Thematic analysis: Identified emerging themes and sub groups of participants grouped by beliefs.
5 Aug to 25 Nov	Implementation data collection: Round 1 – 8 (*n* = 24)	What were the impacts of the intervention on practice, planning, assessment and beliefs about mathematics in early childhood?	Participant assessment records, observations, planning.	Qualitative and quantitative analysis of assessment records. Thematic and

				statistical analyisis. Changes in practice, planning, beliefs.
10 to 25 Nov	Survey 2: (SECEBCOAT), (*n* = 16)	To record and measure change pre- and post-survey outcomes.	Survey 2: Responses to open questions and scaled items.	Content and thematic analysis of qualitative responses. Statistical analysis of scaled items. Comparison of survey 1 & survey 2 outcomes and identification of impacts on practice, planning and beliefs.
15 to 29 Nov	Semi- structured interviews (*n* = 13)	To collect data on identified gaps in participant reported outcomes on beliefs, practice and planning.	Transcription of audio recorded interviews 30–50mins duration.	Thematic analysis, coded, themes identified and used to design the workshop content.
26 Nov	Workshop 2: (*n* = 13)	To compare and validate data outcomes with assessment records. To consolidate outcomes, finalise data collection, participant discussion of the intervention and implementation with group.	Written notes	Thematic analysis of participant responses to questions about practice, planning and beliefs.

Appendix 5: Number and Type of EC Settings Within Each Network

Networks	Kinder 3-5yrs	Kinder & CC 0-2yrs 3-5yrs	Bush Kinder 3-5yrs	Family daycare 0-2yrs 3-5yrs	ELC 0-2yrs 3-5yrs	Childcare 0-2yrs 3-5yrs	Co-op 0-2yrs 3-5yrs	Nursery 0-2yrs	Preschool 3-5yrs	Total
NW 1	13	4	1		10	19	2		8	57
NW 2	16	5		1	10	36	4	1	4	77
NW 3	21	2	1	(Montessori 1)	10	15	4	1	6	61
NW 4	15				4	9	5		2	35
NW 5	10	1			24	21	1	4	3	64
NW 6	13	2			13	14	3		3	48
Total	**88**	**14**	**2**	**2**	**71**	**114**	**19**	**6**	**26**	**342**

Note: Kindergarten is Kinder, CC is Childcare, Co-op is co-operative, and ELC is early learning centre.

Appendix 6: Participant Check List

Early childhood teacher check list for participation in the mathematics assessment implementation Term 3 & 4, 2016	Yes	No
▪ The early childhood teacher holds at minimum a diploma in early childhood education.	✓	
▪ Is a lead teacher in the room.		
▪ Is interested in participating in a study of mathematics assessment activities across Term 3 and Term 4.	✓	
▪ Is interested in sharing ideas and knowledge about assessment and planning during workshops.		
▪ Is interested in implementing the mathematics assessment activities and recording outcomes during Term 2 and 3 in their program.	✓	
▪ Has read the Plain Language Statement and signed the consent form.	✓	

Appendix 7: Participant Qualifications and Experience

Shaded area denotes more than one participant per centre taking part in the study:

Centre	EC teaching qualification	Other qualifications	Teaching experience	Setting	Age range taught	Position held in centre	EYLF/ VEYLDF	Highest level of formal mathematics education
1	Registered Teacher Early Childhood	Diploma of Teaching ECE	35 years	Community Kindergarten	4 -5 yrs	Lead Teacher	EYLF (withdrew 6/10/16)	Year 10
2	Bachelor of Education Primary	–	23 years	Kindergarten	4 -5yrs	Lead Teacher	VEYLDF	Year 10
3	Registered Teacher Early Childhood	–	11 years	Long Day Care and Kindergarten	4 -5 yrs	Lead Teacher	VEYLDF	Undergrad statistics
3	Bachelor of Education Early Childhood	–	11 years	Long day care and Kindergarten	4 -5 yrs	Teacher	EYLF, VEYLDF	Year 12
3	Master of Education Early Childhood	Bachelor of Education Early Childhood	15 years	Long day care and Kindergarten	4 -5 yrs	Lead Teacher	EYLF Textbook	Year 12
4	Registered Teacher Early Childhood	–	6.5 years	Child Care Co-operative	4 -5 yrs	Lead Teacher	EYLF, VEYLDF	Year 12
5	Registered Teacher Early Childhood	–	30 years	Early Learning Centre	4 -5 yrs	Lead Teacher	EYLF	Year 10
5	Registered Teacher Early Childhood	–	30 years	Early Learning Centre	4 -5 yrs	Lead Teacher	EYLF	Year 10
6	Diploma of Early Childhood Education and Care	–	2 years	Community Child Care Long day	4 -5 yrs	Teacher	EYLF	Year 9
7	Diploma of Early Childhood Education and Care	–	3 years	Long Day Care and Kindergarten	3 -5 yrs	Lead Teacher	EYLF	Year 12
8	Bachelor of Education Early Childhood	–	20 + years	Community Kindergarten	4 -5 yrs	Lead Teacher	EYLF, Textbook (Withdrew 14/9/16)	Year 11
9	Graduate Diploma of Educational Studies ECE	–	26 years	Early Learning Centre	4 -5 yrs	Lead Teacher	EYLF Australian Curriculum	Form 6
9	Master of Teaching Primary	Registered Teacher Primary, Masters in SLD	0 years	Early Learning Centre	4 -5yrs	Centre Director	EYLF, Australian Curriculum	Year 12

9	Bachelor of Education Early Childhood	Diploma of Early Childhood Education and Care	20 years	Early Learning Centre	4 -5 yrs	Lead Teacher	EYLF, VEYLDF	Secondary school
9	Bachelor of Education Early Childhood	Bachelor of Education Primary	12 years	Early Learning Centre	3 yrs	Lead Teacher	EYLF, VEYLDF	Undergrad
10	Diploma of Teaching Early Childhood	Graduate Diploma of Special Education	26 years	Early Learning Centre	4 -5 yrs	Lead Teacher	EYLF, Research	Year 11
11	Bachelor of Education,	Graduate Diploma Technology Education	20 years	Long day Childcare (P)	4 -5 yrs	Lead Teacher	EYLF, VEYLDF, Textbook, Scope & sequence	Year 12
12	Bachelor of Education Early Childhood	–	8 years	Kindergarten	4 -5 yrs	Teacher	EYLF, VEYLDF	Year 12
12	Bachelor of Education Early Childhood	–	7 years	Kindergarten	4 -5 yrs	Lead Teacher	EYLF	Year 10
12	Bachelor of Education Early Childhood	–	15 years	Kindergarten	4 -5 yrs	Lead Teacher	EYLF, VEYLDF	Year 11
12	Graduate Diploma of Teaching Early Childhood	_	6 months	Kindergarten	4 -5 yrs	Teacher	EYLF, VEYLDF	Undergrad economics
12	Master of Teaching Early Childhood	–	1 year	Kindergarten	4 -5 yrs	Teacher	EYLF, VEYLDF (withdrew 8/8/16)	A levels
13	Master of Teaching Early Childhood	–	1 year	Community Kindergarten	4 -5 yrs	Teacher	EYLF, VEYLDF, Textbook	Undergrad
14	Certificate III			Early Learning Centre	4 -5 yrs	Lead Teacher	EYLF, VEYLDF	Year 10
15	Diploma of Early Childhood Education and Care	_	32 years	Kindergarten	4 -5 yrs	Lead Teacher	VEYLDF	Year 10
15	Master of Education Early Childhood	–	15 years	Kindergarten	3 -5 yrs	Lead Teacher	EYLF	Year 12
15	Registered Teacher Early Childhood	–	20 years	Kindergarten	3 -5 yrs	Centre Director	EYLF, VEYLDF	Year 10

Appendix 8: Plain Language Statement for Centre Director



PLAIN LANGUAGE STATEMENT FOR CENTRE DIRECTOR

Mathematics and assessment in early childhood teaching practice

Dear Colleague,

Your centre is invited to participate in a research project, which I am undertaking as a PhD Candidate at the University of Melbourne Graduate School of Education. This project will be supervised by Professor Collette Tayler and Dr Caroline Cohrssen and has been approved by the Human Ethics Committee.

The Victorian Early Years Learning and Development Framework outlines learning outcomes for children, which include the teaching of numeracy concepts in early childhood. This research project is investigating the impact of the implementation of maths-based assessment activities with three to five year old children in early childhood settings on (1) teaching practice (including observations and planning), and (2) educator beliefs regarding maths education in early childhood programs. The aim of this study is to find out how these assessment activities support links to maths in play-based settings. We are also interested in how assessing children's mathematical thinking informs early childhood teaching practice. The study will be implemented across Term 3 and 4 in 2016.

If your centre agrees to participate in this study, the kinder teacher will be invited to take part in the following:

- Online survey which seeks to discover insights into teaching practice and beliefs regarding mathematics education in early childhood programs (15 minutes).
- Attend two professional development workshops held at the University of Melbourne to introduce and support the use of the assessment activities at your centre (4 hours per session).
- Keep a diary in which brief notes are written about how the use of the assessment activity impacts teaching practice and planning.
- Fill out the assessment record, and date each time the assessment activity is used in the setting.
- Attend a semi-structured interview at the conclusion of the study to reflect on the impact of the activities on practice, program and beliefs about mathematics in early childhood (audio-recorded with consent, 30 minutes).
- Complete a repeat of the online survey (15 minutes) to compare with the first survey responses.

During the first professional development workshop I will present the early childhood mathematics assessment activities that I have developed. The workshop will involve discussions about assessing children's mathematical thinking in the context of a play-based program. The educator will be given the assessment activities and materials to take back to your centre, and use in daily teaching practice and planning. At the second workshop the educator will be invited to discuss the assessment activity records, the diary notes and the effectiveness of the assessment activities in practice and planning and work with materials to revise the activities, based on the outcomes of the implementation so far.

During the workshops I will take notes of the key ideas arising in the discussion. The educator will also be required to hand in a copy of the assessment record and diary. With the centre's consent, photographs of educator's work may also be taken during the workshops. This information will be used to inform the content of the professional development workshops and improve the assessment activity to support teaching practice in play-based settings.

These findings will be used for teaching and research purposes and may be presented at academic conferences and in

research publications. In any written publications, I will remove references to personal information that might allow someone to identify the centre or educator; however you should note that as the number of study participants is small, it is possible that someone may still identify the educator. Photographs during the professional development workshops will be of the educator's work only, and educators will not be named. Images of the educator's work may be included and visible within the research report, however their work will remain anonymous. Your centre name and contact details will be kept in a separate, password-protected computer file. The data will be kept securely in the Melbourne Graduate School of Education for five years from the completion of the research project, before being destroyed. Once the report arising from this study has been completed, a brief summary of the findings will be available to you if you would like a copy.

Whilst undertaking this study, I am also employed as a Clinical Specialist on the Master of Teaching (Early Childhood) Network. Please note that your agreement to take part in this study will not affect your educator's employment in any way. Your centre's participation in this study is completely voluntary. Should you wish to withdraw at any stage, or to withdraw any unprocessed data the educator has supplied, you are free to do so without prejudice.

If you would like your centre to participate, please indicate that you have read and understood this information by signing the accompanying consent form and returning it to me. I will then contact you to confirm the dates of the two professional development workshops and the semi-structured interview.

Should you require further information, please do not hesitate to contact me or my Supervisors (details below). Should you have any concerns about the conduct of the project, you are welcome to contact the Executive Officer, Human Research Ethics, The University of Melbourne, on ph: 8344 2073 or fax: 9347 6739.

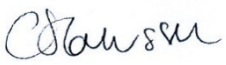
Yours sincerely,



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Appendix 9: Consent Form for Centre Director

CONSENT FORM FOR CENTRE DIRECTOR

PROJECT TITLE: Mathematics and assessment in early childhood teaching practice

The aim of this study is to evaluate how a suite of assessment activities designed to understand young children's (3 – 5 years) knowledge of mathematics, supports evidence-based links to maths understandings in play-based settings and informs early childhood educator's practice, planning and curriculum.

Name of Centre: _____

Name of Centre Director: _____

Name of researchers: Ms Rachel Pollitt, Professor Collette Tayler and Dr Caroline Cohrssen

1. I give consent in my Centre for this research project, the details of which have been explained to me, and I have been provided with a written plain language statement to keep.

   1.

2. I understand that although Rachel Pollitt is employed as a Clinical Specialist in a Master of Teaching (Early Childhood) Network, this will not affect my educator's employment in any way.

3. I understand that participation will involve educators employed in my Centre working with the assessment activities and attending two workshops as described in the plain language statement provided.

4. I agree that the researcher may use the results as described in the plain language statement.

5. I acknowledge that:

   (a) I have been informed that my Centre and/or my educators are free to withdraw from the project at any time without explanation or prejudice and to withdraw any unprocessed data they have provided;
   (b) I have been informed that the project is for the purpose of research and the development of a mathematics assessment activity;
   (c) I have been informed that the confidentiality of the information that I provide will be safeguarded subject to any legal requirements;
   (d) I have been informed that with our consent the data provided will be stored at University of Melbourne and will be destroyed after five years;
   (e) A pseudonym will be used in any publications arising from research;
   (f) I have been informed that a copy of the research findings will be forwarded to me, should I wish this.

I give consent for my Centre to take part in this research project (please circle): Yes No

I wish to receive a copy of the summary project report on research findings (please circle): Yes No

Signature of Director _____ Date: _____

Please provide an email to receive the link to the online survey _____

Appendix 10: Plain Language Statement for Educator

PLAIN LANGUAGE STATEMENT FOR EDUCATOR

Mathematics and assessment in early childhood teaching practice

Dear Colleague,

You are invited to participate in a research project, which I am undertaking as a PhD Candidate at the University of Melbourne Graduate School of Education. This project will be supervised by Professor Collette Tayler and Dr Caroline Cohrssen and has been approved by the Human Ethics Committee.

The Victorian Early Years Learning and Development Framework outlines learning outcomes for children, which include the teaching of numeracy concepts in early childhood. This research project is investigating the impact of the implementation of maths-based assessment activities with three to five-year-old children in early childhood settings on (1) teaching practice (including observations and planning), and (2) educator beliefs regarding maths education in early childhood programs. The aim of this study is to find out how these assessment activities support links to maths in play-based settings. We are also interested in how assessing children's mathematical thinking informs early childhood teaching practice. The study will be implemented across Term 3 and 4 in 2016.

If you agree to participate in this study, you will be invited to take part in the following:

- Online survey which seeks to discover insights into your teaching practice and teacher beliefs regarding mathematics education in early childhood programs (15 minutes).
- Attend two professional development workshops held at the University of Melbourne to introduce and support the use of the assessment activities in your program (4 hours per session).
- Keep a diary in which brief notes are written about how the use of the assessment activities impact your teaching practice and planning.
- Fill out the assessment record, and date each time an assessment activity is used in your program.
- Attend a semi-structured interview at the conclusion of the study to reflect on the impact of the activities on practice, program and beliefs about mathematics in early childhood (audio-recorded with consent, 30 minutes).
- Complete a repeat of the online survey to compare with the first survey responses (15 minutes).

During the first professional development workshop I will present the early childhood mathematics assessment activities that I have developed. The workshop will involve discussions about assessing children's mathematical thinking in the context of a play-based program. You will be given the assessment activities and materials to take back to your centre, and use in daily teaching practice and planning. At the second workshop you will be invited to discuss the assessment activity records, the diary notes and the effectiveness of the assessment activities in practice and planning and work with materials to revise the activities, based on the outcomes of the implementation so far.

During the workshops I will take notes of the key ideas arising in the discussion. You will also be required to hand in a copy of the assessment record and diary. With your consent, photographs of your work may also be taken during the workshops. This information will be used to inform the content of the professional development workshops and improve the assessment activity to support teaching practice in play-based settings.

These findings will be used for teaching and research purposes and may be presented at academic conferences and in research publications. In any written publications I will remove references to personal information that might allow someone to identify you; however you should note that if the number of study participants is small, it is possible that someone may

still identify you. Photographs during the professional development workshops will be of materials only, and will not be named. Images of your work may be included and visible within the research report, however your work will remain anonymous. Your name and contact details will be kept in a separate, password protected computer file, separate from any data concerning your centre. The data will be kept securely in the Melbourne Graduate School of Education for five years from the completion of the research project, before being destroyed. Once the report arising from this study has been completed, a brief summary of the findings will be available to you if you would like a copy.

Whist undertaking this study, I am also employed as a Clinical Specialist on the Master of Teaching (Early Childhood) Network. Please note that your agreement to take part in this study will not affect your employment in any way. Your participation in this study is completely voluntary. Should you wish to withdraw at any stage, or to withdraw any unprocessed data you have supplied, you are free to do so without prejudice.

If you would like to participate, please indicate that you have read and understood this information by signing the accompanying consent form and returning it to me. I will then contact you to confirm the dates of the two professional development workshops and the semi-structured interview.

Should you require further information, please do not hesitate to contact me or my Supervisors (details below). Should you have any concerns about the conduct of the project, you are welcome to contact the Executive Officer, Human Research Ethics, The University of Melbourne, on ph: 8344 2073 or fax: 9347 6739.

Yours sincerely,



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Appendix 11: Consent Form for Educator

CONSENT FORM FOR EDUCATOR

PROJECT TITLE: Mathematics and assessment in early childhood teaching practice

The aim of this study is to evaluate how a suite of assessment activities designed to understand young children's (3 – 5 years) knowledge of mathematics, supports evidence-based links to maths understandings in play-based settings and informs early childhood teacher's practice, planning and curriculum.

Name of Centre: _____

Name of Educator: _____

Name of researchers: Ms Rachel Pollitt, Professor Collette Tayler and Dr Caroline Cohrssen

1. I give consent for this research project to be conducted in my setting, the details of which have been explained to me, and I have been provided with a written plain language statement to keep.

2. I understand that although Rachel Pollitt is employed as a Clinical Specialist in a Master of Teaching (Early Childhood) Network, this will not affect my employment in any way.

3. I understand that participation will involve working with the assessment activities in my room, and attending two workshops as described in the plain language statement provided.

4. I agree that the researcher may use the results as described in the plain language statement.

5. I acknowledge that:

(g) I have been informed that I am free to withdraw from the project at any time without explanation or prejudice and to withdraw any unprocessed data I have provided;

(h) I have been informed that the project is for the purpose of research and the development of a mathematics assessment activity;

(i) I have been informed that the confidentiality of the information that I provide will be safeguarded subject to any legal requirements;

(j) I have been informed that with my consent the data provided will be stored at University of Melbourne and will be destroyed after five years;

(k) A pseudonym will be used in any publications arising from research;

(l) I have been informed that a copy of the research findings will be forwarded to me, should I wish this.

I agree to take part in this research project (please circle): Yes No

I wish to receive a copy of the summary project report on research findings (please circle): Yes No

Signature of Educator _____ Date: _____

Please provide an email to receive the link to the online survey _____

Appendix 12: Adaptation of the Survey Design

See A Survey Study of Early Childhood Teachers' Beliefs and Confidence about Teaching Early Math (Chen, McCray, Adams & Leow, 2014) for details regarding the adaptation of the final design for the survey outcomes. Jie-Qi Chen granted permission to include the survey in the study:

Early Childhood Educ J (2014) 42:367–377
DOI 10.1007/s10643-013-0619-0

A Survey Study of Early Childhood Teachers' Beliefs and Confidence about Teaching Early Math

Jie-Qi Chen · Jennifer McCray · Margaret Adams · Christine Leow

Published online: 2 November 2013
© Springer Science+Business Media New York 2013

Abstract This study reports on results from the Early Mathematics Beliefs and Confidence Survey, administered to 346 preschool teachers in a large public school system in the Midwest. Survey results depict a much more positive view of teachers' beliefs and confidence in early math teaching than previously reported. Results also suggest that teacher confidence varies with specific types of math knowledge and teaching abilities, and assessing math learning is a specific area where teachers lack confidence. Examining confidence in their math abilities and in teaching early math, results indicate that teachers are more confident teaching math and remain confident in teaching even when confidence in their abilities is low. Implications of results for early math professional development are discussed.

Keywords Early math teaching · Survey study · Professional development · Preschool teachers

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Introduction

The importance of early mathematics education has drawn increasing attention in recent years (Duncan et al. 2007; NRC 2009). While research evidence is clear that young children have the capacity to learn math and benefit from doing so (see NRC for a summary report 2009), it is largely unknown whether this is a belief commonly held by preschool teachers. Similarly, while early childhood teachers are generally described as lacking confidence in teaching math (Copley 2004), surprisingly few studies have examined teacher confidence in relation to teaching tasks such as planning learning activities or assessing children's math understanding. Lastly, while we know that young children's performance in mathematics depends on their teachers' mathematical proficiency (Sarama and DiBiase 2004), we know little about which specific math teaching tasks teachers feel proficient in. Our limited understanding of teachers' perspectives on early math teaching diminishes our ability to support teachers in the classroom and makes it difficult to meet their math professional development (PD) needs.

Responding to these gaps in the research literature, in this article we report on a survey of preschool teachers' beliefs and confidence designed to address three questions: (1) What do preschool teachers believe about teaching and learning math with preschoolers? (2) How confident are preschool teachers in helping preschoolers learn math? (3) How confident are preschool teachers about their own math abilities? Results and their implications for the design of early math professional development are discussed.

Teacher Beliefs About Early Math Teaching

Though agreement on a single definition of teacher beliefs has not been reached, investigators have developed



Rachel Pollitt Apr 4, 2016

Dear Jie-Qi Chen, I am a PhD student at the University of Melbourne (Australia) and my research investigates early childhood teacher belief and attitudes towards assessing math. This is with a view to creating a survey which informs a series of workshops, building on teacher's strengths in this area, while implementing a suite of maths assessment activities in their play-based settings.

I have been struggling to create a survey based on the work of Rosenfeld, D. (2010) and Platas, L. M. (2014) and I am finding it very challenging as I think I am trying to cover too many concepts. In reading your article I would be very interested in implementing your survey here in Melbourne throughout our Teaching Networks - It is an excellent survey, very clear and exactly what I am trying to create, as I find the respectful and positive approach play an important role in supporting and engaging teachers - ie. the workshops will be representative of their input, for the study.

Please let me know if this is possible as I appreciate the copy right implications, however I have never been through this process before and just thought I would ask. I would of course cite the survey and all authors, and acknowledge the ongoing contribution to the field.

With kindest regards, Mrs Rachel Pollitt (Masters of Teaching, University of Melbourne PhD Candidate 2016).



Jie-Qi Chen to you Apr 4, 2016

Dear Rachel,

Feel free to use the survey instrument cited in my article. Good luck to your dissertation process.

Best,

Jie-Qi Chen

Appendix 13: Pilot Survey

PILOT: A Survey Study of Early Childhood Educators' Beliefs and Confidence about Teaching Maths

Welcome and thank you for taking part in this pilot survey and sharing your experiences.

Early childhood educators watch what children make, say and do and listen to children's talk in order to understand children's knowledge. This survey will be used to develop workshops that focus on professional learning for educators in early childhood maths. We are especially interested in how early childhood educators include the assessment step in the observation and planning process.

For each of the following statements, please rate your agreement by checking the appropriate box or adding a comment.

Thank you for participating in this survey. Your response is highly valued.

1

PILOT: A Survey Study of Early Childhood Educators' Beliefs and Confidence about Teaching Maths

Beliefs about children and maths in early childhood education settings

Below are some ideas that have been shared by early childhood educators about children and maths. On this page please indicate what you think about these ideas.

1. *Most of the children in my room -*

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
(a) Start kinder with little maths knowledge	○	○	○	○	○
(b) Are able to learn maths	○	○	○	○	○
(c) Should be helped to learn maths during play-based activities	○	○	○	○	○
(d) Are very interested in learning maths	○	○	○	○	○
(e) Need to learn maths so they are ready for primary school	○	○	○	○	○
(f) Learn a great deal about maths through their everyday activities and routines	○	○	○	○	○
(g) Need planned maths activities to learn maths	○	○	○	○	○

2. Are any of these questions unclear? Please tell us which and explain why the question is unclear.

2

PILOT: A Survey Study of Early Childhood Educators' Beliefs and Confidence about Teaching Maths

Early childhood educator confidence in supporting children's maths learning

Recent studies suggest that some early childhood educators do not feel comfortable supporting children's maths learning. Some educators feel confident. Others say they are confident in some areas of maths but not others. On this page, please indicate how you feel about supporting children's maths learning.

3. *I am confident that I know -*

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
(a) What the children in my room know about maths	○	○	○	○	○
(b) Developmentally appropriate maths goals and how to plan for children's learning	○	○	○	○	○
(c) The best practices and strategies for supporting maths learning in early childhood	○	○	○	○	○
(d) How to apply the EYLF when planning maths based activities for children	○	○	○	○	○
(e) The best ways to assess children's maths knowledge and understandings	○	○	○	○	○
(f) How play-based maths learning in early childhood education supports children's transition to maths learning in school	○	○	○	○	○

3

4. *I am confident in my ability to -*

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
(g) Observe what children know about maths	○	○	○	○	○
(h) Incorporate maths learning into everyday play-based experiences	○	○	○	○	○
(i) Plan activities to help children learn maths	○	○	○	○	○
(j) Extend children's maths knowledge when they make spontaneous maths discoveries or comments	○	○	○	○	○
(k) Correct children's misunderstandings when they learn maths *(for example, when a child says a triangle standing on one point is not a triangle)*	○	○	○	○	○
(l) Translate observations and/or learning story analysis into curriculum planning	○	○	○	○	○

5. Are any of these questions unclear? Please tell us which and explain why the question is unclear.

4

PILOT: A Survey Study of Early Childhood Educators' Beliefs and Confidence about Teaching Maths

Early childhood educator confidence in personal maths abilities

Some early childhood educators say they aren't good at maths. Others say they love maths, although it depends on the specific area of maths being covered. On this page, please indicate how you feel about maths and your maths abilities.

6. *Confidence in your own maths abilities -*

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
(a) Maths was one of my favourite subjects in school	○	○	○	○	○
(b) Just the word "maths" can make me feel nervous	○	○	○	○	○
(c) I am not a "maths person"	○	○	○	○	○
(d) I can easily rotate objects in my mind *(for example, figuring out how something would look from another angle)*	○	○	○	○	○
(e) I enjoy coming up with creative ways to solve maths problems	○	○	○	○	○
(f) I can easily convert fractions into percentages and decimal numbers	○	○	○	○	○
(g) I can easily imagine how an object would look or feel if it was turned around	○	○	○	○	○

5

7. *Confidence in your own maths abilities(continued) -*

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
(h) I have a bad sense of direction	○	○	○	○	○
(i) I am good at recognising patterns and explaining why they are patterns	○	○	○	○	○
(j) I am good at estimating how tall something is or the distance between two locations	○	○	○	○	○
(k) I use the right maths words when talking with children and/or writing observations	○	○	○	○	○
(l) I can represent or describe the route from one landmark to another	○	○	○	○	○

8. Are any of these questions unclear? Please tell us which and explain why the question is unclear.

6

PILOT: A Survey Study of Early Childhood Educators' Beliefs and Confidence about Teaching Maths

Your feedback on the pilot survey and further information:

9. How long did it take you to complete this survey?

- ◯ Between 10 - 15 minutes
- ◯ More than 15 minutes
- ◯ Less than 10 minutes

10. Please provide your teaching qualification:

- ◯ Certificate III, Early Childhood Education and Care
- ◯ Diploma of Early Childhood Education and Care
- ◯ Bachelor of Education Early Childhood
- ◯ Bachelor of Education Primary
- ◯ Master of Teaching Early Childhood
- ◯ Master of Teaching Primary
- ◯ Master of Education Early Childhood
- ◯ Master level degree (other)
- ◯ Registered Teacher Early Childhood
- ◯ Registered Teacher Primary
- ◯ PhD in Early Childhood
- ◯ PhD level degree (other)
- ◯ None of the above

11. Please provide your years of teaching experience:

7

12. Please note any questions that came to mind while you were completing this survey:

13. Please tell us what you would do to find out about what children know and can do:

14. Do you have any further ideas to share about assessment of children's maths learning?

15. Do you have any further comments about how to improve this survey?

Thank you for taking the time to complete this survey. Your responses are greatly appreciated.

8

Appendix 14: Script for Recruitment—Pilot Survey

Each centre was provided with hard copies of the pilot survey, a sealed box and a poster describing the research project.

Script for phone conversation and recruitment:

Hello, my name is Rachel Pollitt and I am a PhD candidate at the University of Melbourne. I am interested in finding out how educators plan for maths learning in early childhood.

[Pause]

Do you think that some of your staff would be interested in completing a 10 – 15 minute online survey? It will be on survey monkey so they can do it any time and I am also happy to provide hard copies? The survey is looking at how Early childhood educators include maths in play-based activities and it is completely anonymous and can be done at any time.

YES:

Do you mind me just asking a couple more questions?

How many educators you have at your centre?

And how many have a diploma or bachelor degree?

Is it possible to come out to your centre this week and place some paper copies of consent forms and the survey in your staff room? This is just to make it easier for staff as they could do the survey during a lunch break. (Leave a sealed box for returns)

Thank you, I look forward to meeting you (?) - your involvement is greatly appreciated.

NO:

May I ask why?

Would you mind putting that in an email to me as it is great feedback?

Is it because of the online access?

I am happy to drop out hard copies of the survey if you would find this helpful and collect them?

Thank you for chatting to me, and I understand your…

Appendix 15: Poster for Pilot Survey

Early Childhood Survey

University of Melbourne PhD Research Project

Would you be interested in completing a short survey about how you plan for maths learning in early childhood?

The survey takes about 10 minutes to complete and is confidential. Copies of the survey are provided near this poster. Please fill one in and place it in the sealed box provided. Do not write your name on it!

Please ask you centre co-ordinator for more information or call me (Rachel Pollitt) directly on
(mobile number)

I will collect the completed surveys on (date)

Thank you!

Appendix 16: Pilot Survey Distribution and Participant Information (n = 38)

The following table demonstrates the distribution of the pilot survey (n = 38) throughout the networks, the type of setting, the number of surveys distributed and the number of completed surveys received, early childhood educator qualifications and experience. Any blank areas indicate information was not provided for this category:

Centres	# surveys	# completed	Qualifications	Experience
Long day care & Kindergarten Ages 0 – 5 years	8	6	Cert III ECEC	---------
			----------	---------
			Diploma ECEC	8.5 years
			Registered Teacher EC	15 years
			Registered Teacher EC & Primary	3 years
			Diploma ECEC	12 years
Kindergarten Ages 3 - 4 years	8	6	Diploma ECEC	26 years
			Diploma of Teaching EC	16 Years
			Grad Dip in EC Teaching/Masters Student	5 weeks
			Diploma ECEC	6 Years
			Bachelor of Education EC	25 Years
			Diploma of ECEC	-
Community based ECEC, Long Day Care & Kindergarten Ages 0 – 5 years	20	6	Diploma of ECEC	-
			Diploma of ECEC	-
			Bachelor of Education EC, Registered Teacher EC	5 Years
			Cert III, Diploma of ECEC	-
			Studying towards Dip ECEC	14 Years
			Bachelor of Education EC, Registered EC Teacher	6 Years
Long Day Care & Kindergarten Ages 0 – 5 years	20	13	Diploma ECEC	2 Years
			Cert III ECEC	10 Years
			Cert III ECEC	-
			Diploma ECE	1-2 Years
			Diploma ECE	5 Years
			Cert III ECEC, Diploma ECE	7 Years
			Cert III ECEC	3 Years
			Diploma ECEC	10 Years

			Bachelor of EC	17 Years
			Cert III ECEC	-
			Cert III ECEC	-
			Cert III ECEC, Diploma ECEC	8 Years
			Bachelor of Education EC	15 Years
Early Learning Centre Ages 3 – 5 years	13	2	Bachelor of Education EC	5 Years
			Bachelor of Education EC	30 Years
Early Learning Centre Ages 3 – 5 years	6	5	Diploma of ECEC	27 Years
			Bachelor of Education Primary, Registered Teacher EC & Primary, B.A., Dip Ed Primary, Grad Dip EC	> 35 Years
			Diploma of ECEC	> 10 Years
			Bachelor of Education EC, Bachelor of Education Primary	-------
			----------	-------
			Bachelor of Education EC, Bachelor of Education Primary	-------
Total	75	38 (50.66% response rate)		

Appendix 17: Thematic analysis

Teaching Practice:

Peer support was determined if the participant conducted the assessment in small groups and the observational data indicated children's conversation and participant interaction with more than one child.

Repeat assessment refers to when a participant intentionally repeats the assessment activity to assess children's ongoing mathematics learning and development.

English as an additional language refers to participants who conducted the assessment activities with children who have English as an additional language and reported if the activities were useful in this context.

Number of times an assessment was conducted in the setting was evidenced by the participant dates and number of children taking part in the assessment activity, for example the activity may have been repeated across several consecutive days, with different groups of children.

Evidence of impacts on practice refers to participants' documented shifts in practice and pedagogical approaches to mathematics in response to assessment outcomes.

Planning:

Evidence of impacts on planning refers to participants' documented outcomes based on links between the analysis of the assessment outcomes and planning for individuals or groups of children.

Extensions indicate if participants have planned for further extensions for children's learning based on specific assessment outcomes.

Links to the environment when planning to extend children's learning based on their interests.

Reporting to parents signifies if the participant is communicating the child's assessment outcomes with families/parents/carers and planning for learning in the home environment.

Time poor was a category indicating lack of time for assessment and planning in program planning.

Teacher Beliefs:

Changes in beliefs related to a documented shift in participant beliefs in assessing and planning for mathematics in early childhood education.

Changes in confidence and therefore beliefs reported by participants when using mathematical language.

Assessment:

Assessment record determined if an assessment record was completed and submitted each fortnight with the assessment outcomes and planning.

Child/peer support relates to evidence of small groups of children being assessed at one time, and if children supported the assessment process via peer interactions.

Outliers:

Equity refers to documented variations in participant implementation and mathematics assessment occurring across the fifteen centres represented in the study.

Centre support related to participants who received centre support allocated more time to implementing the assessment activities and provided more detailed and in depth outcomes in the assessment records, analysis and planning.

Appendix 18: Pilot Survey Analysis and Modifications to the Study Survey

Analysis of the pilot survey outcomes had a direct impact on the content of the pre-implementation study survey design and ongoing discussions with experts identified necessary modifications to the pilot survey: *A Survey Study of Early Childhood Educator's Beliefs and Confidence about Observing, Assessing and Teaching Mathematics* (including sections A: Q3, 6, 9, 11, 12; section B: Q2, 3, 12, 13, 17, 19, 20):

- Item response options were modified to allow for multiple responses.
- Comment boxes were included for specific items to allow for the provision of additional information.
- The midpoint measure - neither agree nor disagree - was removed to ensure participants had to decide between a scaled 'agree' or 'disagree' response for each item, as it was important for the research plan to ensure responses were not undecided or neutral.
- Statements were clarified and questions added based on educator feedback as outlined in detail section A: Q3, 6, 9, 11, 12; section B: Q2, 3, 12, 13, 17, 19, 20.

Modifications to the study survey based on pilot survey outcomes

Mid-point measure: As recommended by Garland (1991), the "*neither agree nor disagree*" response option was removed as this category attracted the highest response rate throughout the survey and demonstrated social desirability bias.

Questions 5, 6 and 18: Clarification on how mathematics was defined in play-based settings was addressed in question 5, 6 and 18 of the study survey, as requested by four participants in the pilot survey.

Question 3: The following statement was added to question 3 to improve qualitative responses and outcomes to questions 1 and 2: 'Please provide an example of best practice and strategies for supporting children's maths learning in your program'. An example was requested to provide information of understandings of best practice and mathematics learning to support quantitative data.

The following questions were added to the study survey:

Question 5: What do you see as evidence of children's maths thinking? Please provide an example. This question was added to determine what participants identified as mathematical thinking in their practice.

Question 6: How does your assessment of children's maths knowledge inform your planning? Please provide an example. This question was added to gain further information about the links between assessment, analysis and planning.

Question 7: During a typical week, what (%) of time do you estimate you spend on the following:

Administrative tasks

Spontaneously responding to children's maths interests

Planned maths activities

Repeating planned maths activities

Observing and assessing children's maths understanding

Routines and transitions

Planning time in general

It was important to identify how much time participants were spending on mathematics assessment and planning in contrast with daily routines and transitions:

Question 9: Please provide examples of the maths words you use when talking with children and/or writing observations? This question provided further qualitative data supporting evidence of the participants' recognition of mathematical concepts already occurring in teaching practice and daily programs.

Question 10: What are some of the creative ways to support children's maths learning during play? Please provide an example from your teaching practice? This question was added to determine what was occurring throughout early childhood centres to support children's mathematics learning; and to further establish if links between play, mathematics learning existed.

Question 11: During a typical week, how much time do you spend on planning maths experiences for children? This question determined how much time was already being

spent on planning for mathematics learning in early childhood programs and established if participants were intentionally planning for mathematics learning in their existing programs.

Question 12: Please tell us what you would do to find out what children know and can do during maths activities. It was necessary to determine what particpants were doing in practice to assess children's existing mathematics knowledge, to design and create the assessment activities. The assessment activities needed to build on participants' existing knowledge, to support the enactment of the activities in practice.

In response to pilot survey outcomes questions 13, 14, 15, 16, 17, 18, 19, 20, 21 and 22 were also modified (see Appendix 13 and 19). Question 10 in the study sruvey was structurally altered to allow for multiple responses, as many paricipants had more than one qualification.

Data also revealed the top five ranking mathematical activities in early childhood programs were counting, shape, number, incidental play and maths talk embedded in play. A question was added to the study survey to clarify these outcomes further: What are the top five things you look for when observing and assessing children's mathematical thinking?

Wording was revised to increase clarity, as per respondent feedback.

Comments directly impacting the play-based design of the assessment activities and guidelines were:

> "Many teachers/educators don't have the resources/play-based idea at hand to incorporate into their curriculum. There are many misconceptions about maths/readiness for school. There is not enough readily available maths experiences for ECE."

> "I don't think ch'n should know maths before they start school. Ch'n should learn in their own time but we as educators as well as parents/carers could be encouraging/extending through play based activities on what they already know".

“Define 'maths' - can a kindergarten child learn long division? No. Can they count? Yes”.

“Play based maths are a very strong need in kinder but if are talking about straight out maths then I strongly disagree at kinder level”.

“Question (e) Needs to learn Maths so they are ready for Primary School (How do we educate children?). Not clear”.

“Ch'n might start kinder with a lot of maths knowledge and I don't think you will be able to get the answer you want with this question worded in this way. E.g. Start kinder with some adequate developmentally appropriate maths knowledge. What is the definition of 'Maths' I believe that children should start school with adequate pre-literacy skills”.

“I plan very holistically, so no plan I do will feature specific maths planning, though there will be maths based devised learning outcomes (in regards to point g)”.

“What is maths knowledge? Awareness of number, size,... Outdoor play has so many experiences - lining up sticks, leaves etc... using nature”.

“It doesn't have to be planned experiences. What/how do you define Maths?”

Appendix 19: Study Survey

A survey study of early childhood educator's beliefs and confidence about observing, assessing and teaching mathematics:

A Survey Study of Early Childhood Educators' Beliefs and Confidence about Observing, Assessing and Teaching Maths

Welcome and thank you for taking part in this survey and sharing your experiences.

Early childhood educators watch what children make, say and do and listen to children's talk in order to understand children's knowledge. This survey will be used to develop workshops that focus on professional learning for educators in early childhood maths. We are especially interested in how early childhood educators include the assessment step in the observation and planning process.

For each of the following statements, please rate your agreement by checking the appropriate box or adding a comment.

Thank you for participating in this survey. Your response is highly valued.

1

A Survey Study of Early Childhood Educators' Beliefs and Confidence about Observing, Assessing and Teaching Maths

Beliefs about children and maths in early childhood education settings

Below are some ideas that have been shared by early childhood educators about children and maths. On this page please indicate what you think about these ideas.

1. *Most of the children in my room -*

	Strongly Agree	Agree	Disagree	Strongly Disagree
(a) Start kinder with little maths knowledge	○	○	○	○
(b) Are able to learn maths	○	○	○	○
(c) Should be helped to learn maths during play-based activities	○	○	○	○
(d) Are very interested in learning maths	○	○	○	○
(e) Need to learn maths so they are ready for primary school	○	○	○	○
(f) Learn a great deal about maths through their everyday activities and routines	○	○	○	○
(g) Need planned maths activities to learn maths	○	○	○	○

2

A Survey Study of Early Childhood Educators' Beliefs and Confidence about Observing, Assessing and Teaching Maths

Early childhood educator confidence in supporting children's maths learning

Recent studies suggest that some early childhood educators do not feel comfortable supporting children's maths learning. Some educators feel confident. Others say they are confident in some areas of maths but not others. On this page, please indicate how you feel about supporting children's maths learning.

2. *I am confident that I know -*

	Strongly Agree	Agree	Disagree	Strongly Disagree
(a) What the children in my room know about maths	◯	◯	◯	◯
(b) Developmentally appropriate maths goals and how to plan for children's learning	◯	◯	◯	◯
(c) The best practices and strategies for supporting maths learning in early childhood	◯	◯	◯	◯
(d) How to apply the EYLF when planning maths based activities for children	◯	◯	◯	◯
(e) The best ways to assess children's maths knowledge and understandings	◯	◯	◯	◯
(f) How play-based maths learning in early childhood education supports children's transition to maths learning in school	◯	◯	◯	◯

3. Please provide an example of best practice and strategies for supporting children's maths learning in your program:

3

4. *I am confident in my ability to -*

	Strongly Agree	Agree	Disagree	Strongly Disagree
(a) Observe what children know about maths	◯	◯	◯	◯
(b) Incorporate maths learning into everyday play-based experiences	◯	◯	◯	◯
(c) Plan maths activities to support children in achieving maths goals	◯	◯	◯	◯
(d) Extend children's maths knowledge when they make spontaneous maths discoveries or comments	◯	◯	◯	◯
(e) Correct children's misunderstandings when they learn maths *(for example, when a child says a triangle standing on one point is not a triangle)*	◯	◯	◯	◯
(f) Translate observations and/or learning story analysis into planning for maths curriculum	◯	◯	◯	◯

5. What do you see as evidence of children's maths thinking?
Please provide an example:

6. How does your assessment of children's maths knowledge inform your planning?
Please provide an example:

4

7. During a typical week in your setting what percentage (%) of time do you spend on the following:

Administrative tasks

Educator-led maths learning

Child-led maths learning

Instructional support and repetition of maths concepts

Children's independent maths learning

Planning for children's maths learning

Maths assessment

Routines and transitions

Curriculum planning

Other

5

A Survey Study of Early Childhood Educators' Beliefs and Confidence about Observing, Assessing and Teaching Maths

Early childhood educator confidence in personal maths abilities

Some early childhood educators say they aren't good at maths. Others say they love maths, although it depends on the specific area of maths being covered. On this page, please indicate how you feel about maths and your maths abilities.

8. *Confidence in your own maths abilities -*

	Strongly Agree	Agree	Disagree	Strongly Disagree
(a) Maths was one of my favourite subjects in school	○	○	○	○
(b) Just the word "maths" can make me feel nervous	○	○	○	○
(c) I am not a "maths person"	○	○	○	○
(d) I can easily rotate objects in my mind *(for example, figuring out how something would look from another angle)*	○	○	○	○
(e) I enjoy coming up with creative ways to solve maths problems	○	○	○	○
(f) I can easily convert fractions into percentages and decimal numbers	○	○	○	○
(g) I can easily imagine how an object would look or feel if it was turned around	○	○	○	○
(h) I have a bad sense of direction	○	○	○	○
(i) I am good at recognising patterns and explaining why they are patterns	○	○	○	○
(j) I am good at estimating how tall something is or the distance between two locations	○	○	○	○
(k) I use the right maths words when talking with children and/or writing observations	○	○	○	○
(l) I can represent or describe the route from one landmark to another	○	○	○	○

9. Please provide an example of the maths words you use when talking with children and/or writing observations?

6

10. What are some creative ways to solve maths problems with children during play? Please provide an example from your teaching practice:

7

A Survey Study of Early Childhood Educators' Beliefs and Confidence about Observing, Assessing and Teaching Maths

Early childhood educator confidence in personal maths abilities

11. During a typical week, how much time do you spend planning maths experiences for children?

◯ Less than 10 mins ◯ 15 mins or more ◯ 30 mins or more ◯ Over an hour ◯ More than two hours

12. Please tell us what you would do to find out what children know and can do during maths activities:

*** 13. Please provide the highest level of early childhood teaching qualification you have completed:**

◯ Certificate III, Early Childhood Education and Care
◯ Diploma of Early Childhood Education and Care
◯ Bachelor of Education Early Childhood
◯ Bachelor of Education Primary
◯ Master of Teaching Early Childhood
◯ Master of Teaching Primary
◯ Master of Education Early Childhood
◯ Master level degree (other)
◯ Registered Teacher Early Childhood
◯ Registered Teacher Primary
◯ PhD in Early Childhood
◯ PhD level degree (other)
◯ None of the above

Other (please specify)

14. Please provide a response to the following questions:

How many years of teaching experience do you have?

What is the highest qualification you have completed?

In which year did you complete this qualification?

At which year level did you stop studying maths?

What is the highest level of formal maths education you have completed?

15. When engaged in maths activities how often do children -

	Never or almost never	Sometimes	Most of the time	Every time
Work individually without assistance from an educator?	◯	◯	◯	◯
Work individually with assistance from an educator?	◯	◯	◯	◯
Work as a group with an educator?	◯	◯	◯	◯
Work as a group without an educator?	◯	◯	◯	◯
Work in pairs or small groups without an educator?	◯	◯	◯	◯
Work in pairs or small groups with an educator?	◯	◯	◯	◯

16. When planning for maths learning, do you use the:

- [ ] EYLF
- [ ] VEYLDF
- [ ] Australian Curriculum - Mathematics
- [ ] Textbook

Other (please specify)

17. When finding out about children's maths knowledge, how often do you ask children to do the following:

	Never or almost never	Sometimes	Most of the time	Everytime
Explain the reasoning behind their thinking	◯	◯	◯	◯
Represent their maths thinking using charts, tables or graphs	◯	◯	◯	◯
Write equations to represent relationships	◯	◯	◯	◯
Practice problem solving with computers or iPads	◯	◯	◯	◯
Engage in problem solving during play	◯	◯	◯	◯

18. What are the top five things you look for when you are observing and assessing children's mathematical thinking?

1.
2.
3.
4.
5.

19. Approximately how many minutes a week would you spend on assessing children's maths understandings?

10

20. Please indicate what types of maths activities you do with children during a typical week in your setting:

- [ ] Puzzles
- [ ] Construction and block play
- [ ] Counting, number words and numerals
- [ ] Making and completing patterns
- [ ] Drawing 2D shapes from memory
- [ ] Quantity and counting sets
- [ ] 2D and 3D shape
- [ ] Addition, subtraction
- [ ] Use words to describe the relationships between objects in space
- [ ] Number lines
- [ ] Spatial thinking
- [ ] Counting strategies
- [ ] Ordering numbers, objects
- [ ] Measurement: area, volume, angle
- [ ] Measurement: length, width, height
- [ ] Verbal and object counting
- [ ] Drawing/describing 3D Shape from memory
- [ ] Visualising and mentally rotating objects
- [ ] Problem solving
- [ ] Remembering and describing the location of objects in space
- [ ] Representing situations with algebra
- [ ] Comparison and estimation
- [ ] Representations of data in graphs, charts, tables
- [ ] Mapping
- [ ] Solving simple equations
- [ ] Small investigations or gathering data
- [ ] Composing and decomposing shape
- [ ] Describing the route from one location to another
- [ ] Fractions
- [ ] Role playing and perspective taking
- [ ] Moving in space and describing movements
- [ ] Discussing actions during block play
- [ ] Other (please specify)

21. During a typical week in your setting, please indicate how much time you spend with children during these activities:

	None	15 mins	30 mins	1 hour	2 hours
Puzzles	○	○	○	○	○
Construction and block play	○	○	○	○	○
Counting, number words and numerals	○	○	○	○	○
Making and completing patterns	○	○	○	○	○
Drawing 2D shapes from memory	○	○	○	○	○
Quantity and counting sets	○	○	○	○	○
2D and 3D shape	○	○	○	○	○
Addition, subtraction	○	○	○	○	○
Use words to describe the relationships between objects in space	○	○	○	○	○
Number lines	○	○	○	○	○

	None	15 mins	30 mins	1 hour	2 hours
Spatial thinking	◯	◯	◯	◯	◯
Counting strategies	◯	◯	◯	◯	◯
Ordering numbers, objects	◯	◯	◯	◯	◯
Measurement: area, volume, angle	◯	◯	◯	◯	◯
Measurement: length, width, height	◯	◯	◯	◯	◯
Verbal and object counting	◯	◯	◯	◯	◯
Drawing/describing 3D Shape from memory	◯	◯	◯	◯	◯
Visualising and mentally rotating objects	◯	◯	◯	◯	◯
Problem solving	◯	◯	◯	◯	◯
Remembering and describing the location of objects in space	◯	◯	◯	◯	◯
Representing situations with algebra	◯	◯	◯	◯	◯
Comparison and estimation	◯	◯	◯	◯	◯
Representations of data in graphs, charts, tables	◯	◯	◯	◯	◯
Mapping	◯	◯	◯	◯	◯
Solving simple equations	◯	◯	◯	◯	◯
Small investigations or gathering data	◯	◯	◯	◯	◯
Composing and decomposing shape	◯	◯	◯	◯	◯
Describing the route from one location to another	◯	◯	◯	◯	◯
Fractions	◯	◯	◯	◯	◯
Role playing and perspective taking	◯	◯	◯	◯	◯
Moving in space and describing movements	◯	◯	◯	◯	◯
Discussing actions during block play	◯	◯	◯	◯	◯

22. In assessing children's maths understandings, how much weight do you give each of the following types of assessment?

	None	Little	Quite a lot	A great deal
Standardised tests conducted outside of the setting	◯	◯	◯	◯
Formative assessment tasks that are educator-led and require children to describe or explain their reasoning	◯	◯	◯	◯
Observations of children	◯	◯	◯	◯
Summative assessment tasks that may require 'yes/no' answers	◯	◯	◯	◯
Learning stories	◯	◯	◯	◯

23. Please provide an example of how you assess children's maths learning?

24. How often do you use the assessment information you gather from children to:

	Never	Sometimes	Quite a lot	Most of the time
Plan for maths learning	◯	◯	◯	◯
Discuss and report to parents	◯	◯	◯	◯
Identify gaps in children's maths learning	◯	◯	◯	◯
Analyse children's maths understandings	◯	◯	◯	◯
Inform curriculum planning	◯	◯	◯	◯

25. About how often do you have meetings with other educators to discuss curriculum planning?

- ◯ Never
- ◯ Once or twice a year
- ◯ Every month
- ◯ Once a week
- ◯ Two or three times a week
- ◯ Almost every day

26. To be good at mathematics in Primary school, how important do you think it is for children to:

	Not important	Important	Very important
Understand mathematical concepts, principles and strategies	◯	◯	◯
Be able to think creatively	◯	◯	◯
Understand how mathematics is used in the real world	◯	◯	◯
Be able to provide reasons to support problem solving solutions	◯	◯	◯
Communicate maths understandings and ideas	◯	◯	◯
Apply maths concepts to everyday situations	◯	◯	◯
Use more than one representation to explain maths thinking	◯	◯	◯

Thank you for taking the time to complete this survey. Your responses are greatly appreciated.

Appendix 20: Semistructured Interview Questions, November 2016

Background:

How about we begin by talking a little about your teaching background, your setting and your program…

The assessment activities:

Now that the project is drawing to an end, what do you think about the mathematics assessment activities? Please discuss.

Practice:

Were the assessment activities useful in daily practice? If so, did you need to modify them?
Did the assessment activities contribute to your understandings of children's mathematics knowledge? Please tell me more.

Planning:

Do you think these types of play-based assessment activities were useful to your planning? Please tell me more.
How did you use the outcomes of the assessment records? Please discuss.

Beliefs:

Over the past 6 months, have your beliefs about assessing and teaching mathematics in early childhood changed in any way? Please tell me more about this.
Have the assessment activities affected your confidence in identifying mathematics in children's daily activities in any way? Please discuss further.

Implementation:

How often were the activities used? Were they used simply as activities, rather than as assessment activities? Please discuss.

Final thoughts:

Looking back on the project, what has been important to you? Please tell me more.

Is there anything we haven't covered which you would like to discuss further?

(Thank you for taking the time to discuss these questions and share your thoughts, ideas and experiences).

Appendix 21: Educators Report Being "Time Poor"

1. "We have been flat out the last few weeks with preparation for Father's day (we are expected to make presents for everyone!), making 25 presents for visiting year 5 girls and collecting/collating work for a newsletter and the yearbook. I've had to polish up on my filming and editing skills with our pattern making for the yearbook- lots of very late nights. As a result, I have only just managed to start working on the next assessment today. I haven't included any planning in it as yet. I would like to do more assessments and see how things go from there. Hopefully from next week I can have a free run. We only have one more week of term with a three week break so I will do my best". (MN, 2/9/16)
2. "Sorry for the delay in returning these. I have been very busy with second year applications, school readiness programs and lots of referrals. Will get onto more asap. (OR, 2/9/16)
3. "Here is my maths assessment for the fortnight. Sorry I couldn't get more data for you, my children really weren't that interested and I didn't have time with father's day prep to really hunt some people down! I think this could be something to do as a group time activity quite a bit first, using the language, and then incorporate into the program". (OQ, 2/9/16)
4. "I am sorry – I have been unable to complete the pattern work this fortnight. My co-worker broke her elbow and so I have had different agency staff with me. It's been a bit frantic to be honest and I'm sorry to say your task was put on hold. We did do quite a lot of pattern work in Term 2, I have attached some work from then if you're interested. You will be pleased to know some of the language is beginning to resonate with the children. During Term 3 each child makes an art piece for an exhibition. One boy in my class made his own Lino molds and then printed them. When he finished he said, "Hey XXX! It's a symmetrical pattern." I am sorry it didn't fit in this time". (TB, 4/9/16)
5. "I do apologise for my lack of professionalism not being in contact with you. To start with I have been implementing to the best of my ability the maths experiences and have data to send you. An opportunity arise where I was seconded to cover a 6 week long service leave position as well as my own position which wasn't on my agenda and aligned with this project so has been challenging from a different perspective. The position has now finished so just catching up on everything". (QL, 6/9/16)
6. "Whilst I feel like I am not providing you with much data, participating in this project has been a real eye opener for me in terms of my practice, room dynamics and the impact the wider service activity calendar has on the room curriculum. I look forward to having a bit of a debrief next time we get a chance to chat!". (DH, 6/9/16)
7. "I am so sorry this is late. I could make up excuses but I am sure you are just as time poor as the rest of us! I have enjoyed the tasks so far with the children however I unfortunately feel like I am struggling to find the time to really get as involved as we

could be with each individual task. I am sure this is a curse with most teachers!". (OP, 19/8/16)

8. [In response to email suggestions to assess in smaller groups] "Thanks, I think I will do a smaller group with the next and see how I go. I am assessing them in small groups or individually but it is time consuming. Saying this I am enjoying the challenge as are the children, all waiting desperately for their turn!". (OP, 19/8/16)

9. "Apologies for sending this in so late. I have not been feeling great and my team at school have been away. I have been under the pump and therefore found this task quite tricky to set up and follow through. The data is minimal but under the circumstances that is all I could manage. I thank you for your understanding and the next task is set and ready to go. I am back in control. PS: I hope the visuals help you from an opinion about how "tricky" it actually was. (or maybe not) I will most certainly be returning to this activity as I find it fascinating how some children struggle to give instruction, how some are so accurate and then there were those children who could not follow any or little what was asked of them". (MP, 5/9/16)

10. "I did try calling your mobile earlier unfortunately we didn't get to chat. This decision hasn't been easy because when I make a commitment I like to follow through. I have been trying really hard to keep up with the data but have now fallen behind and feeling very overwhelmed and have come to the decision over this last week that the best thing for me to do personally is to withdraw from the project as I don't see my workload changing much between now and next term and collecting the data within the session can be tricky within my group. I have been feeling anxious and stressed about this decision and feel that I have let you down but I have to consider my own wellbeing at this stage. I have attached the data I did collect if it is of any value or use to your project". (QL, 15/9/16)

11. "Please find attached the assessment record for 3D shapes. Unfortunately, due to a very busy two weeks there was limited time to focus on it. I hope there is enough information for you to sort through". (LS, 16/9/16)

12. "Please find detail attached for the 3D shapes. Apologies about the lack of detail and depth to the assessment. Yesterday was a particularly busy day". (IY, 16/9/16)

13. "Also attached is an image from AB on 13/9/16 (3YO group). I had the tangram book and shapes set up at a small table and had aimed to be able to scaffold/support/assess children at this experience, but due to other factors in the room was unable to do this during the session. That said, AB had been at the table for a while and came up to me, called me over and said, "I've made a rocket" and then identified the squares and triangles she used. The rocket is of significance as this was identified as a key theme in the children's dramatic play and became a starting point for inquiry a few weeks back". (DH, 18/5/16)

14. "Apologies, I don't have any data for the past fortnight as I have been off sick (again!) and I only have one day of teaching in the next fortnight due to PDs and events.

Participating in this project and putting a focus on specifically incorporating maths assessment into my program has allowed me to identify the large number of center wide events we run. These take up such a large portion of time, that there is little time left for much else. We are having a discussion on our yearly calendar of events at our next staff meeting, so this reflection is very timely for me" (DH, 17/10/16).

15. "I am sorry I haven't communicated. I was sick before the end of term and we had our annual art show which seemed to take up too much time! So far, I only have one set of data from one of the activities. I think it might be best if I withdraw as I am so behind already. Attached is what we have collated so far. Sorry for my lack of commitment and I hope the project is a success. Where can I return your resources?" (PC, 6/10/16)

16. "I am sorry that I do not have any assessments to send you this time. I have been working with individual children on their transition statements which were due in yesterday. I did tape a grid on the floor last week but only had the time to give one child a turn before I had to focus on one of our children with challenging behaviour again. We didn't get back to it but the children (all 27) try and seat themselves inside it every group time, which is rather funny to see. I saw one child trying to teach a year nine boy to play hopscotch inside it. I should have a much more successful time next week. I will send you some notes as soon as I get some done. Sorry that I seem to have excuses every fortnight lately". (MN, 29/10/16)

Appendix 22: Letter of Approval from the Ethics Committee

18 January 2016

Prof Collette Tayler
Melbourne Graduate School of Education
The University of Melbourne

Dear **Prof Tayler**

I am pleased to advise that the **Melbourne Graduate School of Education Human Ethics Advisory Group (MGSE HEAG)** has approved the following **Minimal Risk** application:

Project title:	**Spatial reasoning and assessment in early childhood teaching practice.**
Researchers:	**Collette Tayler, Caroline Cohrssen and Rachel Pollitt**
Ethics ID/HREC:	**1545972**
MGSE HEAG ID:	**252.15**

The project has been approved for the period: **18 January 2016** to **31 December 2016,** and **subject to provision of evidence of required external approvals**.

It is your responsibility to ensure that all people associated with the Project are made aware of what has actually been approved.

Research projects are normally approved to 31 December of the year of approval. Projects may be renewed yearly for up to a total of five years upon receipt of a satisfactory annual report. If a project is to continue beyond five years a new application will normally need to be submitted.

Please note that the following conditions apply to your approval. Failure to abide by these conditions may result in suspension or discontinuation of approval and/or disciplinary action.

(a) **Limit of Approval:** Approval is limited strictly to the research as submitted in your Project application.

(b) **Amendments to Project:** Any subsequent variations or modifications you might wish to make to the Project must be notified formally to the Human Ethics Advisory Group for further consideration and approval before the revised Project can commence. If the Human Ethics Advisory Group considers that the proposed amendments are significant, you may be required to submit a new application for approval of the revised Project.

(c) **Incidents or adverse affects:** Researchers must report immediately to the Advisory Group and the relevant Sub-Committee anything which might affect the ethical acceptance of the protocol including adverse effects on participants or unforeseen events that might affect continued ethical acceptability of the Project. Failure to do so may result in suspension or cancellation of approval.

(d) **Monitoring:** All projects are subject to monitoring at any time by the Human Research Ethics Committee.

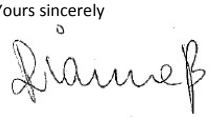
(e) **Annual Report:** Please be aware that the Human Research Ethics Committee requires that researchers submit an annual report on each of their projects at the end of the year, or at the conclusion of a project if it continues for less than this time. Failure to submit an annual report will mean that ethics approval will lapse.

(f) **Auditing:** All projects may be subject to audit by members of the Sub-Committee.

Please quote the ethics registration number and the name of the Project in any future correspondence.

On behalf of the Ethics Committee I wish you well in your research.

Yours sincerely



Associate Professor Dianne Vella-Brodrick
Chairperson, Melbourne Graduate School of Education Human Ethics Advisory Group
Phone: 83440254, Email: dianne.vella-brodrick@unimelb.edu.au

cc: **Caroline Cohrssen, Rachel Pollitt and Human Research Ethics Committee (HREC), The Office for Research Ethics and Integrity.**

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GLOSSARY

Assessment: Assessment for children's learning refers to "the process of gathering and analysing information as evidence about what children know, can do and understand. It is part of an ongoing cycle that includes planning, documenting and evaluating children's learning" (DEEWR, 2009, p. 17).

Beliefs: are defined as: "psychologically held understandings, premises, or propositions about the world that are thought to be true. Beliefs might be thought of as lenses that could affect one's view of some aspect of the world or as dispositions toward action" (Philipp, 2007, p. 259).

***Curriculum*:** refers to "all the interactions, experiences, activities, routines and events, planned and unplanned, that occur in an environment designed to foster children's learning and development" (DEEWR, 2009, p. 9).

Early childhood educator or ***educator:*** all adults employed in early childhood settings, regardless of level of qualification.

Evidence-based planning: planning based on evidence of children's current knowledge.

Explicit teaching: is teaching "children explicit subject matter (e.g. mathematical, literary, musical, scienti c, artistic) and associated skills to deepen and extend their knowledge, understanding and values" (DET, 2016, p. 15).

***Learning framework*:** "a guide which provides general goals or outcomes for children's learning and how they might be attained. It also provides a scaffold to assist early childhood settings to develop their own, more detailed curriculum" (DEEWR, 2009, p. 46).

***Numeracy*:** "broadly includes understandings about numbers, patterns, measurement, spatial awareness, data, mathematical thinking, reasoning and counting" (DEEWR, 2009, p. 43).

Observations: gathering information or data about children, looking and listening for what is meaningful in the child's context as evidence of children's learning.

***Pedagogy*:** "early childhood educators professional practice, especially those aspects that involve building and nurturing relationships, curriculum decision-making, teaching and learning" (DEEWR, 2009, p. 9). It also includes "practices that are intended to promote children's learning" (DET, 2016, p. 9).

Planning: planning to support the pedagogy includes planning for individuals and groups, routines, experiences, interactions, inside, outside. Planning is intentional and based on evidence (DEEWR, 2009).

Play-based learning: learning based on children's interactions with people, their interests and engagement in their environments during play.

Play: "is a context for learning that allows for the expression of personality and uniqueness, enhances dispositions such as curiosity and creativity, enables children to make connections between prior experiences and new learning, assists children to develop relationships and concepts, stimulates a sense of wellbeing" (DEEWR, 2009, p. 10).

Spatial reasoning: involves either mentally or physically locating and moving objects or ourselves in space. For the purposes of this study, spatial reasoning is applied to the mathematics strand of geometry with a focus on spatial relationships in patterns, composition and decomposition of shape, mapping and perspective taking.

STEM: Science, Technology, Engineering and Mathematics subjects in early childhood. STEM for early learning refers to "the creation of learning environments in which children's curiosity about the world can thrive via systematic, authentic investigations that utilise a range of design thinking skills and scientific knowledge and processes" (Yelland, 2016, p. 10).